MANUFACTURING PLANNING AND CONTROL SYSTEMS

MANJUNATH NARAYAN RAO
DR. RAMACHANDRA GOPAL

ALEXIS PRESS
JERSEY CITY, USA

MANUFACTURING PLANNING AND CONTROL SYSTEMS

MANUFACTURING PLANNING AND CONTROL SYSTEMS

Manjunath Narayan Rao

Dr. Ramachandra Gopal

ALEXIS PRESS

ALEXIS PRESS

Published by: Alexis Press, LLC, Jersey City, USA
www.alexispress.us

First Published 2022

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication Data

Includes bibliographical references and index.

Manufacturing Planning and Control Systems by *Manjunath Narayan Rao, Dr. Ramachandra Gopal*

ISBN 978-1-64532-959-6

CONTENTS

CHAPTER 1

ELEMENTS OF OPERATIONS CONTROL: STRATEGIES, PRACTICES AND PERFORMANCE OPTIMIZATION

Mr. Manjunath Narayan Rao
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India.
Email Id: manjunath.n@presidencyuniversity.in

ABSTRACT:

In order to satisfy demand while keeping costs to a minimum, organisations must identify the best production levels, labour needs, and inventory levels via the strategic process known as aggregate planning. In order to manage and improve operational performance inside organisations, this research study examines the components of operations control. Planning, monitoring, quality control, process control, inventory control, resource allocation, risk management, and continuous improvement are just a few of the important elements and actions covered in the research. It looks at the methods and techniques used in each component to improve productivity, quality, and operational effectiveness. The study assesses the performance effects of efficient operations management, including higher customer satisfaction, lower costs, better resource utilisation, and more competitiveness. The research offers insights into the efficient use and integration of operations control aspects via an investigation of case studies, best practises, and theoretical frameworks. The research helps advance a thorough knowledge of operations control, enabling evidence-based decision-making and operational excellence across a range of sectors.

KEYWORDS:

Inventory Management, Chase Strategy, Level Strategy, Mixed Strategy, Production Levels, Workforce Planning, And Aggregate Planning.

INTRODUCTION

Production plans are made in advance at the highest level, while production control is handled on the shop floor, where the actual production is happening. The important elements may be listed as following.

1. Materials: organising the purchase of raw materials, components, and replacement parts in the appropriate quantities and specifications at the right time from the right source at the right location. The additional operations related to material include purchasing, storing, inventory management, standardisation, variety reduction, value analysis, and inspection [1]–[3].

2. Method: selecting the most effective processing technique from a range of options. It also involves planning for tooling, jigs, and fixtures, among other things, as well as choosing the optimal order of activities (process plan).

3. Machines and equipment: Production systems' available production facilities are connected to the manufacturing processes used in those systems. It covers the allocation and utilisation of plant and equipment, machineries, and the design of facilities and capacity.

4. Manpower: preparing for a workforce with the requisite knowledge and experience (at both the management and labour levels).

5. Routing; choosing the order of operations or processing stages as well as the flow of work and material handling in the plant. This has to do with taking into account the best shop layout, the best plant layout, the temporary storage site for raw materials, components, and semi-finished items, as well as the materials handling system.

Route Sheet

Route Sheet: A route sheet is a document that contains details and guidelines for turning raw materials into completed components or goods. It lays out the exact path or route that the product will take throughout the conversion process and outlines each phase of the manufacturing processes. Route sheet includes the following details The action necessary in their preferred order The tools or machinery that will be needed for each operation Tools, jigs, and fixtures needed for operations Estimated set-up time and operating time per component Detailed drawings of the component, subassemblies, and final assemblies Specifications for the raw material to be utilized Specifications for the speed, feed, etc. to be used in machine tools for the operations to be performed. Packing and handling instructions for moving components and subassemblies through the operating phases. Inspection technique and metrology instruments necessary for inspection.

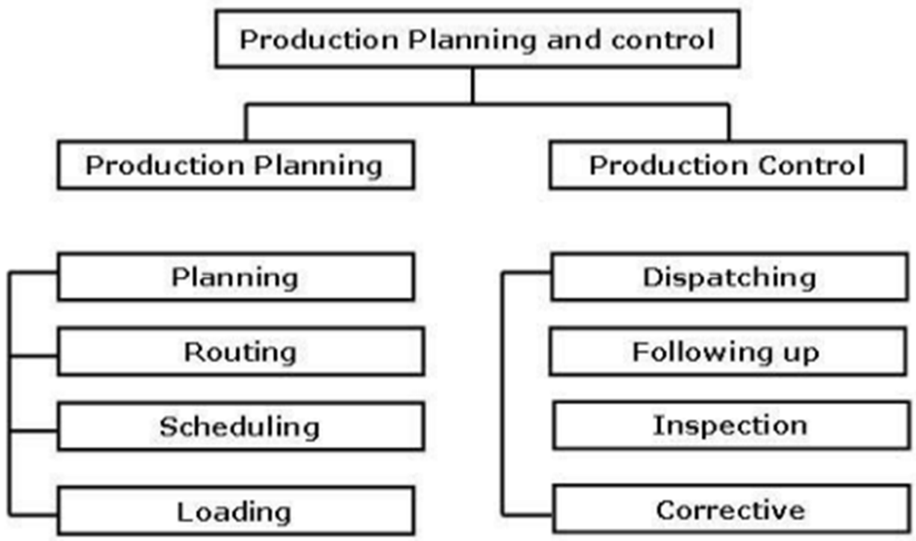

Figure 1: Represents the steps of Production Planning and Control.

Estimating

By establishing operating hours, performance criteria for both workers and machinery are fixed. On the basis of a sales prediction, estimation entails determining the amount of the product that must be produced and the associated costs. Prior to creating a budget for resources, it is important to estimate the amount of labour, machinery capacity, and material needed to reach the anticipated production objectives. The process of translating an operation schedule into practises in combination with routing is known as loading. According to relative priorities and capacity utilisation, machine loading refers to the process of allocating specified tasks to machines, workers, or work centres. Loading ensures that productive facilities are used to their fullest potential and prevents production bottlenecks. To guarantee optimal resource utilisation, it's vital to either overload or underload the buildings, work centres, or machinery. Scheduling guarantees that finished items, subassemblies, and components are completed by the specified delivery dates. It offers a schedule for production operations.

DISCUSSION

Requirements for an effective Operations Control System. Any organisation that implements a control-based operation system gains a number of benefits for a range of functional operations, including the following: Last-minute rush is prevented: Production is carefully planned and managed in accordance with the provided time schedules. Therefore, production control lowers the amount of overtime and emergency orders on the plant, which lowers overhead. Production control balances the line and flow of work, reducing bottleneck problem areas and preventing work-in-transit from piling up. Effective production control increases the utilisation of people and machines, which keeps process inventories at a satisfactory level, improves the control of raw material inventories, lowers storage and handling costs, aids in maintaining quality, and reduces the number of rejects, ultimately lowering the unit cost of production [4]–[6]. Optimal resource utilisation: It decreases the amount of time employees lose while waiting for supplies and makes the best use of equipment. Better coordination of plant operations: PPC coordinates plant activities, which results in a concentrated effort by the workforce to control. Benefits to employees: PPC improves productivity and efficiency, which results in enough pay, steady employment, job security, improved working conditions, and ultimately great morale.

Better customer services

PPC assures production in accordance with time schedules, which in turn ensures that deliveries are delivered in line with the agreed schedules.

Scope of Operational Controlling System

a) Inputs' nature: Various inputs are employed in the production of a product. The kind of inputs utilized determines the quality of the final result. As a result, planning—a challenging process—is carried out to ascertain the nature of different sorts of inputs.

b) Input Quantity: Determining the number of inputs and their makeup is crucial for achieving a certain degree of output. Only when the needed input composition is estimated can a product be created.

b) Proper Coordination: It makes sure that the workers, machinery, and equipment are properly coordinated. This prevents waste and ensures a smooth manufacturing process.

d) Better Control: The technique of control is production planning. A better control requires planning, which is a prerequisite. Only then can one compare performance and determine the variances that lead to production control.

e) Ensure Uninterrupted Production: The regular supply of raw materials and other components is guaranteed by the materials planning. The consistent flow of supplies and materials aids in the production's continuity.

f) Capacity Utilisation: It's important to make efficient use of the resources at hand. It aids in reducing a number of manufacturing expenses.

g) Timely Delivered: If there is effective planning and management of the manufacturing process, timely production will occur, and the final product will be sent to the market on schedule. Additionally, it guarantees improved customer interactions**.** The translation of certain inputs into certain outputs that have some value for the end users is the focus of the operations department in a manufacturing or service organisation. There are several different production system types used in manufacturing organisations, including mass, process, batch, and job production systems. The choice of system is mostly based on two factors: 1) The product's nature.

The production method. The last stage of planning before a plan is actually carried out is scheduling. Production schedulers monitor how well activities f6ollow the established timetable. This is crucial because the master scheduler assesses production planners based on the amount of customer service they provided in relation to their product-related duties. 6Different scheduling approaches are required for different types of settings. Line design and balance are usually used for scheduling in high-volume environments. In a low-volume setting, priority criteria are often used in scheduling. Techniques used in the shop for loading included infinite and finite loading. Jobs are loaded using a finite loading system up to a preset capacity. Both forward and backward scheduling options are available for loading. Scheduling choices are based on priority rules. The average number of jobs in the system and the mean job flow times are always minimised by SPT. Rules pertaining to deadlines have the tendency to reduce the maximum tardiness of the work. Monitoring the way the plans are being carried out is done via operations control. It performs a number of crucial tasks, including

a) Ensuring that all events begin at the designated locations and times.

b) Monitoring the activities' progress and accurately documenting it.

b) Comparing the recorded data to the projected results and calculating the deviations.

d) Taking prompt remedial action to lessen the negative effects of plan deviations.

e) Giving the planning section feedback on the information that was captured in order to enhance future plans.

Concept of JIT

Companies use just-in-time (JIT) inventory strategies to boost productivity and save waste by only ordering products when they are really required for manufacturing, which lowers inventory expenses. Producers must be able to predict demand correctly in order for this strategy to work. the efficient manufacture and distribution of just the necessary number of components in the required quality, at the appropriate time and location, while using the least amount of facilities, tools, supplies, and labour. The graphic below makes it clear that with a JIT system, orders and delivery happen at the same time. The buffer stockpiles don't need to be kept up at any point. A excellent example would be a car manufacturer that relies on its supply chain to provide the components it needs to construct automobiles while maintaining extremely low inventory levels.

The components required to make the automobiles are delivered at the precise moment they are required, neither before nor later. The former “just in case” method, where manufacturers kept big stockpiles in case increasing demand had to be satisfied, has been replaced by this inventory supply system.

An Information system that permeates the production environment Is the operations planning and control system. Despite having a shared system structure, systems operate differently depending on the environment. For instance, in contexts where products are made to order rather than to order, general purpose machines are employed. While a general purpose machine must be set up before manufacturing a particular item, dedicated production lines may be constructed in a balanced fashion with minimum setups to maximise the flow rate of the materials. The material flow is halted during setup activities [7]–[10].

Planning and control systems may be made more straightforward and efficient by altering the manufacturing environment. For instance, items are blended in a specific manufacturing line with minimal settings and are engineered to have high processing similarity. This converts a make-to-stock product into a make-to-order product by reducing lead times. Justin-Time (JIT) is a method of improving the industrial environment as well as a control strategy. Only JIT environments are suitable for JIT control systems. For a business, implementing Kanban processes in a non-JIT environment is meaningless.

CONCLUSION

Operations control includes a number of crucial components that are necessary for the efficient administration and development of 5rioritizing5l operations. Monitoring is the ongoing monitoring and evaluation of several operational factors to make sure they are operating as planned. To determine operational effectiveness and pinpoint problem areas, measurement entails measuring and assessing performance measures. Giving people or teams information and insights on their performance and the overall operational results is a critical component of feedback.

To optimise performance and achieve desired results, adjustment entails making the appropriate tweaks and changes to operations based on feedback and measurement findings. By supplying precise and timely information, allowing data-driven decision-making, and permitting proactive changes, technology, such as real-time monitoring systems, data analytics, and automation, plays a vital role in improving operations control. Improved operational efficiency, greater quality control, lower costs, and more customer satisfaction are all results of effective operations management. Organisations may achieve operational excellence, react to changing market dynamics, and retain a competitive advantage in their particular sectors by prioritizing and implementing strong operations control practises.

REFERENCES

[1] Y. Chen, S. J. Treado, and J. I. Messner, "Building HVAC control knowledge data schema - Towards a unified representation of control system knowledge," *Autom. Constr.*, 2016, doi: 10.1016/j.autcon.2016.08.036.

[2] B. Sadhu *et al.*, "A 28-GHz 32-Element TRX Phased-Array IC with Concurrent Dual-Polarized Operation and Orthogonal Phase and Gain Control for 5G Communications," *IEEE J. Solid-State Circuits*, 2017, doi: 10.1109/JSSC.2017.2766211.

[3] D. Kaczorowska *et al.*, "A case study on battery energy storage system in a virtual power plant: defining charging and discharging characteristics," *Energies*, 2020, doi: 10.3390/en13246670.

[4] P. Zawadzki and K. Zywicki, "Smart product design and production control for effective mass customization in the industry 4.0 concept," *Manag. Prod. Eng. Rev.*, 2016, doi: 10.1515/mper-2016-0030.

[5] S. Ngumar, F. Fidiana, and E. D. Retnani, "Implications Of Islamic Governance On Islamic Bank Fraud," *J. Reviu Akunt. dan Keuang.*, 2019, doi: 10.22219/jrak.v9i2.8735.

[6] S. Grillner and A. El Manira, "Current principles of motor control, with special reference to vertebrate locomotion," *Physiol. Rev.*, 2020, doi: 10.1152/physrev.00015.2019.

[7] R. A. C. Diaz, M. Ghita, D. Copot, I. R. Birs, C. Muresan, and C. Ionescu, "Context Aware Control Systems: An Engineering Applications Perspective," *IEEE Access*, 2020, doi: 10.1109/ACCESS.2020.3041357.

[8] J. A. C. Bokhorst and J. Slomp, "Lean production control at a high-variety, low-volume parts manufacturer," *Interfaces (Providence).*, 2010, doi: 10.1287/inte.1100.0503.

[9] D. Zapała *et al.*, “The Impact of Different Visual Feedbacks in User Training on Motor Imagery Control in BCI,” *Appl. Psychophysiol. Biofeedback*, 2018, doi: 10.1007/s10484-017-9383-z.

[10] R. W. Heeres *et al.*, “Implementing a universal gate set on a logical qubit encoded in an oscillator,” *Nat. Commun.*, 2017, doi: 10.1038/s41467-017-00045-1.

CHAPTER 2

DETERMINATION OF CONTINUOUS IMPROVEMENT: STRATEGIES AND IMPLEMENTATION

Dr. Chinnakurli S Ramesh
Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India.
Email Id: rameshcs@presidencyuniversity.in

ABSTRACT:

Continuous improvement is the practise of making small, methodical adjustments over time to enhance an organization's processes, services, and products. This essay examines the idea of continuous improvement. In order to promote a culture of continuous improvement inside organisations, the strategies, implementation techniques, and performance results are examined in this research study, which focuses on the determination of continuous improvement. The research examines the fundamental ideas and practices of continuous improvement, including as performance indicators, process analysis, employee involvement, and problem-solving methodologies. It examines the methods used to carry out efforts for continuous improvement, including Lean Six Sigma, Kaizen, and total quality management (TQM). The study looks at the performance benefits of efficient continuous improvement, such as higher productivity, less waste, better customer happiness, and improved quality. It assesses the difficulties and factors to be taken into account while establishing and maintaining a culture of continuous improvement. The results provide a thorough knowledge of continuous improvement and provide guidance for practises that maximise organisational performance and competitiveness.

KEYWORDS:

Organizational culture, Kaizen, Lean, Six Sigma, effectiveness, Continuous development.

INTRODUCTION

As opposed to business process re-engineering (BPR), which significantly alters the industrial system, JIT makes improvements gradually. The APICS Dictionary describes this slow continuous improvement as "one less at a time": a method of progressively lowering the number of items in the production pipeline in order to identify, prioritise, and remove waste. The continual, methodical approach of "one less at a time" is what makes JIT effective in any industrial setting. JIT is not one giant stride forward, but a never-ending succession of little, deliberate ones. According to the JIT concept, various items are produced repeatedly using the same process rather than repeatedly producing the same product [1]–[3]. The "one less at a time" process goes like this.

a) Stop if the inventory is zero; otherwise, continue.

b) Pick the process that needs to be improved the most.

c) Make the process better

d) Is the procedure cost-effective

e) Slightly reduce the inventory;

f) go to step

The following stages may be used to breakdown the third step in the technique above, "Improve the process The results of having "One inventory less" are shown in the diagram below. Because items must be manufactured more often to maintain reduced inventory levels, reducing inventory pushes setup times to drop. Processes must be made more flexible, and people must be taught to do a variety of tasks, in order to reduce setup times. The necessity for quicker setup times necessitates fewer things as well. The number of things may be decreased by using more universal parts and modules in various products. Smaller lot sizes and shorter lead times result from faster setup times.

More frequent product deliveries and a reduction in the requirement for precise forecasting and planning boost schedule stability when lead times are shorter. People are forced to minimize paperwork and material movement distances as well as create better material handling and transportation systems as a result of more frequent distribution. A higher quality standard, a zero-defect procedure, and better preventative maintenance are required when there is less inventory. In addition to requiring fewer stocks, improved departmental, customer, and supplier communication also necessitates fewer suppliers.

(1) Problem as opportunity: According to JIT philosophy, difficulties are really opportunities. A challenge is a chance for growth. JIT highlights issues rather than hiding them.

(2) Source-level quality: Defects might appear during the design phase, at any workstation along the assembly line, or in the facilities of the suppliers. Inspection does not provide quality. It also doesn't originate from manufacture. Quality is the result of excellent design. A product's quality is decided during the design phase, which includes process and product design. Good quality can never come from a bad design. It is insufficient to verify the goods at the conclusion of a manufacturing line. Before the components are sent on to the next phase, the operators themselves should conduct inspections at each stage of the line. There is no need for the operator at the workstation over to check an arriving component. Immediately after the occurrence of a flaw, it must be ruled out. Before delivery, the examination for acquired components should be completed. No incoming inspection is necessary.

(3) Simplifying: Manufacturing success depends on simplicity. Products have to be made to be simple to produce, set up, and fix. The bill of materials should only have 2 or 3 tiers. Purchase orders are not necessary since suppliers provide the supplies on a regular basis. Picking orders are not necessary since materials are kept at the point of use (POU). Work centres don't need shop orders; they make the goods as they are used. Until the final items are reported complete, material inventory data are not updated. JIT's guiding principle is to simplify the system as much as possible.

(4) Visual Control: Whenever feasible, control methods that are visible are used. Examples of visual control methods include cards affixed to the supplies, visible containers, tags in the stock showing order points, etc. Human intellect processes these messages at the speed of light.

DISCUSSION

JIT as an Environment

JIT offers an atmosphere in which items are produced more simply in addition to philosophical ideas.

Repetitive manufacturing

Production of discrete objects on a production line with predetermined routing is known as repetitive manufacturing. A product or a series of goods might be the things. The product is manufactured from standard modules or is a standard product. Make-to-order (MTO) or assemble-to-order (ATO) manufacturing processes are used. The manufacturing line contains of workstations that are arranged sequentially and near to one another. Materials move at a relatively steady pace from one workstation to the next. The materials are typically moved down the production line from one step to the next using material handling equipment. The manufacturing line's capacity is typically maintained at a suitable level. The continuous flow of materials is the foundation of repeated production.

Total Quality Management

A management strategy called total quality management uses customer happiness as a means of quality improvement and long-term success. All employees participate in TQM, which aims to raise the standard of all operations, goods, services, and company culture. To increase quality, TQM practises use a plan-do-check-action (PDCA) cycle. The issue is identified, the symptoms are described, and the primary performance indicators are chosen in the "plan" stage. The reason of the symptoms is found in the "do" stage. Until the core cause is found, the reasons of the causes are also looked at. The problem-solving strategy is then created and put into practise. In this phase, the performance metrics may be modified. The "check" stage uses performance measurements to evaluate the success of the suggested strategy. The findings are examined in the "action" stage to ascertain what was discovered and what may be anticipated. The approach for improvement is standardised to be used for comparable issues. The phases in the PDCA cycle are not always carried out exactly in order. For instance, we may go straight to the "do" stage to modify the suggested strategy if the "check" stage reveals that it is not positive Total Productive Maintenance (TPM): The word "preventive maintenance" limits our ability to think creatively and critically. TPM stands for preventative maintenance and refers to on-going efforts to alter, adapt, and improve equipment in order to maximise flexibility, minimise material handling, and encourage continuous flows. All competent staff participate in all maintenance tasks in this operator-oriented maintenance model. In 1995, Acices [4]–[6]

Employee Total Involvement (TEI)

The core principles of the JIT concept are waste elimination and continual improvement. Only with the help of the workforce can they be completed. Everyone in the organisation should work together to create a successful JIT environment. Operators often follow management's directions and do the tasks assigned to them, with management being in charge of planning, overseeing, inspecting, etc. In a JIT setting, operators are in charge of monitoring the machinery, checking for quality, addressing deviations, maintaining the equipment, and enhancing the workflows. Under JIT, many of the functions that were previously performed by the management are now the responsibility of the line employees. Managers are coaches, not players; queue employees are the players in the game. A coach's responsibility is to instruct the players. Supplier Partnership: A strong and trustworthy connection with the suppliers is crucial for establishing a continuous flow of supplies into the business. Establishing a working connection with a supplier in which the two organisations function as one is known as supplier partnership. Relationships with the suppliers should be built on a foundation of mutual trust, teamwork, and dedication over the long term.

JIT as a Control Technique

Total Productive Maintenance (TPM): The word "preventive maintenance" limits our ability to think creatively and critically. TPM stands for preventative maintenance and refers to on-going efforts to alter, adapt, and improve equipment in order to maximise flexibility, minimise material handling, and encourage continuous flows. All competent staff participate in all maintenance tasks in this operator-oriented maintenance model. In 1995, Acices

Employee Total Involvement (TEI)

The core principles of the JIT concept are waste elimination and continual improvement. Only with the help of the workforce can they be completed. Everyone in the organisation should work together to create a successful JIT environment. Operators often follow management's directions and do the tasks assigned to them, with management being in charge of planning, overseeing, inspecting, etc. In a JIT setting, operators are in charge of monitoring the machinery, checking for quality, addressing deviations, maintaining the equipment, and enhancing the workflows. Under JIT, many of the functions that were previously performed by the management are now the responsibility of the line employees. Managers are coaches, not players; queue employees are the players in the game. A coach's responsibility is to instruct the players.

Supplier Partnership

A strong and trustworthy connection with the suppliers is crucial for establishing a continuous flow of supplies into the business. Establishing a working connection with a supplier in which the two organisations function as one is known as supplier partnership. Relationships with the suppliers should be built on a foundation of mutual trust, teamwork, and dedication over the long term.

Characteristics of JIT

Production is divided up into manufacturing work cells, each of which creates a certain product or product category. Every employee in every cell is capable of supporting jobs and is familiar with all of the equipment in that cell. This lessens the downtime brought on by malfunctions and personnel absenteeism. 6Multi-skilled workers: Employees that have received cross-functional training to undertake a range of activities and duties as required to ensure a smooth production flow. shorter setup periods a reduction in the time needed to prepare materials, machinery, and tools for a manufacturing run. shortened production lead times a shorter period of time between placing an order and producing the completed product.N dependable vendors Careful supplier vetting to assure timely, high-quality product delivery for just-in-time usage, maybe within a day or less. Because inventory levels are kept low in a JIT system, supplier dependability is essential.

Long-term contracts are typically negotiated to lower order costs. This is because the company must have a very close relationship with its suppliers to ensure that the supplier makes frequent deliveries of smaller amounts of inventory. Electronic data exchange (EDI), a technology that gives the supplier access to the customer's online inventory management system, facilitates the connection between the buyer and the supplier. As a result, electronic communications take the role of paper documents (such as sales invoices and purchase orders), making it easier to coordinate the parties' production schedules and delivery.

Merits and Demerits of JIT

JIT is popular among businesses because it is seen to be a more cost-effective way to keep stock. Its goal is to reduce the number of products you have at any one moment, and doing so offers a lot of benefits. Less room is required since you don't need as much warehouse or storage space to keep your items because stock turns over more quickly. As a result, there will be less storage that an organisation will need to purchase or rent, freeing up money for other areas of the company. Waste reduction: Quicker stock turnover keeps products from deteriorating or going out of style while they are in storage, which cuts down on waste. Again, this prevents the purchase of superfluous stock and lessens the need to replace it, saving money.

Smaller investments: JIT inventory management is perfect for smaller businesses that lack the resources to make large, one-time stock purchases. In order to have a healthy cash flow, stock should be ordered as required**.**

Demerits

JIT, however, has a lot of potential drawbacks that, if they materialise, might seriously harm the business. Risk of running out of stock: Because you don't carry a lot of stock, it's critical that you have the right processes in place to make sure that stock can be made swiftly and easily accessible. You must have solid ties with your supplier(s) in order to do this. It could be necessary to negotiate an exclusive contract with suppliers that commits them to prioritising your business and providing the items within a particular time limit. JIT makes you very dependent on the reliability of your supply chain. What if your provider has trouble meeting your demands or fails to survive? Can you immediately get the goods from another source? Lack of control over time: If you depend on your suppliers to fulfil orders on time, you run the danger of making your consumers wait longer to get their purchases. If you don't live up to your consumers' expectations, they could go to a competitor, which would have a significant negative effect on your firm if this happens often [7]–[10].

More preparation is needed: It's critical for businesses to fully comprehend their sales patterns and fluctuations while using JIT inventory management. The majority of businesses have seasonal sales periods, which means that particular items will need a larger stock level at certain times of the year owing to an increase in demand.

As a result, you must take it into account when making plans for inventory levels and make sure suppliers can satisfy various volume demands at various periods. JIT inventory management is regarded as one of the finest methods of managing inventory when carried out effectively, if not the best. While not without hazards, it offers substantial returns and is best suited for individuals who can plan meticulously in advance and cultivate close relationships with suppliers.

CONCLUSION

A key element of developing and maintaining organisational excellence is continuous improvement. It entails using a methodical methodology to pinpoint problem areas, make adjustments, and assess the effects of those changes. The frameworks and tools provided by continuous improvement approaches like Kaizen, Lean, and Six Sigma help an organisation increase productivity, reduce waste, and improve quality. Organisations may encourage staff to actively look for possibilities for improvement, exchange ideas, and work together to solve problems by establishing a culture of continuous improvement. This not only boosts operational effectiveness but also lowers costs, improves product and service quality, and boosts customer pleasure.

A supportive organisational culture, leadership commitment, employee involvement, and good communication are necessary for the successful implementation of continuous improvement. Organisations may achieve long-term success, adjust to changing market needs, and maintain competitiveness in their sector by embracing continuous improvement as a fundamental principle and continually aiming for incremental improvements.

REFERENCES

[1] G. Hwang, J. H. Han, And T. W. Chang, “An Integrated Key Performance Measurement For Manufacturing Operations Management,” *Sustain.*, 2020, Doi: 10.3390/Su12135260.

[2] R. O'flaherty *Et Al.*, "Mammalian Cell Culture For Production Of Recombinant Proteins: A Review Of The Critical Steps In Their Biomanufacturing," *Biotechnology Advances*. 2020. Doi: 10.1016/J.Biotechadv.2020.107552.

[3] S. Sudiarti, "Pengaruh Perbaikan Berkesinambungan Terhadap Kinerja Karyawan (Studi Kasus Di Pt.Rentang Buana Niagamakmur Tasikmalaya)," *J. Maps (Manajemen Perbank. Syariah)*, 2019, Doi: 10.32483/Maps.V3i1.28.

[4] R. Kala, E. Samkova, L. Pecova, O. Hanuš, K. Sekmokas, And D. Riaukiene, "An Overview Of Determination Of Milk Fat: Development, Quality Control Measures, And Application," *Acta Universitatis Agriculturae Et Silviculturae Mendelianae Brunensis*. 2018. Doi: 10.11118/Actaun201866041055.

[5] S. Sudiarti, "Pengaruh Perbaikan Berkesinambungan Terhadap Kinerja Karyawan (Studi Kasus Di Pt.Rentang Buana Niagamakmur Tasikmalaya)," *J. Maps (Manajemen Perbank. Syariah)*, 2019, Doi: 10.32627/Maps.V3i1.202.

[6] A. A. A. M And K. Mandala, "Pengaruh Implementasi Total Quality Management Terhadap Kepuasan Pelanggan," *E-Jurnal Manaj. Univ. Udayana*, 2019, Doi: 10.24843/Ejmunud.2019.V08.I12.P02.

[7] M. A. Nieto-Taype, X. Garcia-Ortega, J. Albiol, J. L. Montesinos-Seguí, And F. Valero, "Continuous Cultivation As A Tool Toward The Rational Bioprocess Development With Pichia Pastoris Cell Factory," *Frontiers In Bioengineering And Biotechnology*. 2020. Doi: 10.3389/Fbioe.2020.00632.

[8] B. L. Nannenga, D. Shi, A. G. W. Leslie, And T. Gonen, "High-Resolution Structure Determination By Continuous-Rotation Data Collection In Microeded," *Nat. Methods*, 2014, Doi: 10.1038/Nmeth.3043.

[9] S. Katagiri And Y. Yamamoto, "Technology Of Precise Orbit Determination," *Fujitsu Sci. Tech. J.*, 2008.

[10] A. Lier *Et Al.*, "Validating Comprehensive Next-Generation Sequencing Results For Precision Oncology: The Nct/Dktk Molecularly Aided Stratification For Tumor Eradication Research Experience," *Jco Precis. Oncol.*, 2018, Doi: 10.1200/Po.18.00171.

CHAPTER 3

DETERMINATION OF CONTINUOUS IMPROVEMENT: PERFORMANCE OUTCOMES

Dr. Chinnakurli S. Ramesh
Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India.
Email Id: rameshcs@presidencyuniversity.in

ABSTRACT:

In order to establish and maintain a continuous improvement culture inside organizations, this research study focuses on the definition of continuous improvement and examines the strategies, implementation tactics, and performance assessment techniques involved. The research dives into the essential elements of continuous improvement, such as commitment from the leadership, employee involvement, process analysis, problem-solving methods, and performance evaluation. It looks at the methods and techniques used to promote a culture of ongoing improvement, including Kaizen, Lean Six Sigma, and Total Quality Management (TQM). The study assesses the implementation difficulties and contributing variables to efforts for continuous improvement. Additionally, it looks at how successful continuous improvement affects key performance indicators including improved product quality, lower costs, and higher operational efficiency. The results support a culture of continuous learning and development inside organisations, guide evidence-based decision-making, and contribute to a thorough knowledge of continuous improvement.

KEYWORDS:

Organizational Culture, Kaizen, Lean, Six Sigma, Effectiveness, And Continuous Development.

INTRODUCTION

It is preferable for the sections of the casting that are furthest from the liquid metal supply to freeze first and for solidification to advance from these remote regions towards the riser(s) in order to minimise the harmful effects of shrinkage. This will ensure that molten metal is always accessible from the risers, preventing shrinkage gaps during freezing. This characteristic of freezing and the techniques employed to manage it are referred to as "directional solidification. "By following Chvorinov's rule in the design of the casting itself, its orientation inside the mound, and the design of the riser system that feeds it, the necessary directional solidification is accomplished. For instance, by placing portions of the casting that have lower V/A ratios further from the riser, freezing will occur first in these areas and the supply of liquid metal for the remainder of the casting will stay open until these bulkier portions freeze [1], [2].

Utilising chills internal or external heat sinks that quickly freeze off a portion of the casting is another method for promoting directional solidification. Small metal components called internal chills are inserted into the cavity before to pouring so that the molten metal will solidify first around these components. Making the internal chill from the same metal as the casting itself will make it easier to obtain the desired chemical similarity between the internal chill and the metal being poured. External chills are metal inserts in the mould cavity's walls that may quickly remove heat from the liquid metal in order to encourage solidification. They are often employed successfully in areas of the casting where feeding liquid metal is challenging, promoting quick freezing in these areas while the link to liquid metal is still open. It shows how external chills may be used as well as what would probably happen to the casting if no chills were applied. It is crucial to start freezing in the proper areas of the cavity, but it is equally crucial to prevent premature solidification in the areas of the mould closest to the riser. The path between the riser and the main cavity is particularly problematic. The riser's molten metal would be isolated from the casting if this connection were to freeze before the casting, which is against the rules of design. The cross-sectional area must be adequate to postpone the beginning of freezing, even if it is normally preferable to lower the volume in the connection (to reduce wasted metal). Making the route short helps achieve this aim by allowing it to absorb heat from the molten metal in the riser and the casting [3], [4] .

The atomic power industry was where the process first started in the 1950s. When welding was initially established, it had to be done in a vacuum chamber to reduce the chance of air molecules interfering with the electron beam. Due to the time needed to clear the chamber before welding, this need was, and still is, a significant production hindrance. Depending on the size of the chamber and the needed vacuum, the pump-down time, as it is known, may take up to an hour. Today, certain EBW activities may be carried out without a hoover because to advancements in the field. There are three types of welding that can be distinguished: (1) high-vacuum welding (EBW-HV), which involves performing the process in the same vacuum as beam generation; (2) medium-vacuum welding (EBW-MV), which involves carrying out the process in a separate chamber with only a partial vacuum; and (3) nonvacuum welding (EBW-NV), which involves performing the procedure at or close to atmospheric pressure. There is a cost associated with this benefit, however the pump-down time during workpart loading and unloading is decreased in medium-vacuum EBW and minimised in nonvacuum EBW. The equipment used for the latter two procedures must include one or more vacuum dividers (very tiny orifices that block air flow but allow electron beam passage) to split the work chamber from the beam generator, which needs a high vacuum. Additionally, in nonvacuum EBW, the work must be situated 13 mm (0.5 in) or less from the electron beam gun's orifice. Last but not least, lower vacuum methods are unable to produce welds with the exceptional weld quality and depth-to-width ratios achieved by EBW-HV [5], [6].

Any metal that can be arc welded, as well as certain refractory and challenging-to-weld metals that are not suitable for AW, may be welded by EBW. Thick plate to thin foil is among the work sizes. The automobile, aerospace, and nuclear sectors are where EBW is most often used. Aluminium manifolds, steel torque converters, catalytic converters and gearbox parts are all included in EBW assembly for the automobile sector. Electron-beam welding is renowned for producing high-quality welds with deep and/or narrow profiles, a small heat-affected zone, and little thermal distortion in these and other applications. In comparison to other continuous welding procedures, welding rates are fast. No flux or shielding gases are required, and no filler metal is employed. The expensive equipment cost, the need for exact joint preparation and alignment, and, as we've previously said, the limits of completing the procedure in a vacuum are all drawbacks of EBW. Additionally, there are security issues since EBW produces X-rays that people must be protected against [7], [8].

DISCUSSION

Molds And Mold Making

Silica (SiO_2) or silica combined with other minerals make up foundry sands. Good refractory qualities. The ability to withstand high temperatures without melting or otherwise degrading should be present in the sand. Grain size, grain size distribution in the combination, and grain shape are further crucial characteristics of sand. Large grain size is more porous (to enable gases to escape during pouring), whereas small grain size offers a higher surface quality on the cast item. Interlocking causes moulds constructed of irregularly shaped grains to be stronger than moulds built of spherical grains, although interlocking also tends to limit permeability.

Sand particles used to create the mould are bound together by a solution of water and bonding clay. A typical combination contains 90% sand, 3% water, and 7% clay (measured by volume). Clay may be replaced with other bonding agents, such as organic resins (such as phenolic resins) and inorganic binders (such as sodium silicate and phosphate). In addition to sand and glue, additives are sometimes added to the mixture to improve the mold's strength and/or permeability. The conventional process for creating the mould cavity involves compacting the moulding sand around the cope and drag patterns in a flask-shaped container. There are several techniques used in the packaging process. The easiest is hand ramming, which is carried out by a foundry employee manually. Additionally, a number of devices have been created to automate the packaging process. These machines work in one of several ways, including: (1) using pneumatic pressure to squeeze the sand around the pattern; (2) jolting, which involves repeatedly dropping the sand in the flask containing the pattern to pack it into place; or (3) slinging, which involves impacting the sand grains against the pattern at high speed.

Flaskless moulding, which makes use of a single master flask in a mechanised system of mould creation, is an alternative to conventional flasks for each sand mould. The same master flask is used to make each sand mould.For this more automated process, mould manufacturing rates of up to 600 per hour are stated The quality of the sandmold is assessed using a number of metrics: (1) permeability the capacity of the mould to allow hot air and gases from the casting operation to pass through the voids in the sand; (2) strength the ability of the sand at the surface of the mould cavity to resist cracking and buckling upon contact with the molten metal; (3) thermal stability ability of the sand at the surface of the mould cavity to maintain its shape and resist erosion caused by the flow of molten metal; and (4) collapsibility. These methods are sometimes conflicting; for instance, a stronger mould is less collapsible.

Green-sand, dry-sand, or skin-dried moulds are common categories for sand moulds. Sand, clay, and water are combined to create greensand moulds, which get their name from the moisture that is present within them when concrete is poured into them. Green-sand moulds are the least costly of the moulds and have adequate strength for the majority of uses. They are also easily collapsed, permeable, and reusable. Despite being the most prevalent mould kind, they are not without issues. Depending on the metal and component shape, moisture in the sand might result in flaws in certain castings. Instead of utilising clay, an organic binder is used to create a dry-sand mould, which is then baked in a big oven at temperatures between 200C and 320C (392F and 608F). Baking in the oven makes the mould more durable and hardens the cavity surface. Compared to green-sand moulding, a dry-sand mould offers superior dimensional control in the cast result. However, because to the prolonged drying process, dry-sand moulding is more costly and has a lower production rate.Applications are often restricted to big and medium castings at low to moderate production rates. In a skin-dried mould, the benefits of a dry-sand mould are partly realised by employing torches, heating lamps, or other methods to dry the surface of a green-sand mould to a depth of 10 to 25 mm (0.4-1 in) at the mould cavity surface. To fortify the cavity surface, certain bonding elements must be added to the sand mixture.

The mould types listed above all make use of traditional binders, such as clay and water or those that must be heated to cure. In addition to these divisions, chemically bonded moulds that are not based on any of these conventional binder components have been created. These "no-bake" methods make use of phenolics, alkyd oils, and furan resins, which are composed of furfural alcohol, urea, and formaldehydep[9]. No-bake moulds are becoming more and more common because they provide exceptional dimensional control in high-volume applications.

The method of shell moulding has various benefits. Compared to a traditional green-sand mould, the shellmold cavity's surface is smoother, which makes it easier for molten metal to flow during pouring and improves the surface quality of the finished casting. It is possible to get 2.5mm (100m-in) finishes. Additionally, good dimensional precision is attained, For small-to medium-sized items, tolerances of 0.25 mm (0.010 in) are feasible. Having a fine finish and precision often eliminates the need for further machining. In most cases, themold's ability to collapse is enough to prevent casting ripping and cracking. One drawback of shell moulding is that the equivalent metal design for green-sand moulding is more costly. As a result, shell moulding is challenging to economically justify for single-part production. Shell moulding is particularly cost-effective for big quantities and may be mechanised for mass manufacturing. It appears to be especially well suited to steel castings weighing under 20 lb. Gears, valve bodies, bushings, and camshafts are a few items created utilising shell moulding[10].

Expanded Polystyrene Process

The method of shell moulding has various benefits. Compared to a traditional green-sand mould, the shellmold cavity's surface is smoother, which makes it easier for molten metal to flow during pouring and improves the surface quality of the finished casting. It is possible to get 2.5mm (100m-in) finishes. Additionally, good dimensional precision is attained, For small-to medium-sized items, tolerances of 0.25 mm (0.010 in) are feasible. Having a fine finish and precision often eliminates the need for further machining. In most cases, the mold's ability to collapse is enough to prevent casting ripping and cracking.

One drawback of shell moulding is that the equivalent metal design for green-sand moulding is more costly. As a result, shell moulding is challenging to economically justify for single-part production. Shell moulding is particularly cost-effective for big quantities and may be mechanised for mass manufacturing. It appears to be especially well suited to steel castings weighing under 20 lb. Gears, valve bodies, bushings, and camshafts are a few items created utilising shell moulding. Prior to creating the moulds for casting, an automated moulding process may be set up to mould the patterns. To give the design a smoother surface and increase its durability to high temperatures, it is often coated with a refractory material. Bonding agents are often included in moulding sands.

The pattern tree is typically dipped into a slurry of extremely fine grained silica or another refractory (nearly in powder form) combined with plaster to glue the mould into shape in order to coat with refractory (step 3). The refractory material's fine grain size creates a smooth surface and effectively captures the complex intricacies of the wax design. By periodically dipping the tree into the refractory slurry or by carefully packing the refractory around the tree in a container, the final mould (step 4) is created. To solidify the binder, the mould must air dry for around 8 hours. 6Investment casting has several benefits, including the ability to cast parts with high levels of complexity and intricateness, close dimensional control with tolerances of 0.075 mm (0.003 in), the ability to achieve good surface finishes, the ability to reuse wax, and the lack of usual need for additional machining since this is a net shape process. This casting method requires a lot of processes, hence it is a somewhat costly process. Although pieces with complicated geometries weighing up to 75 lb have been successfully cast, investment castings are typically modest in size. Investment casting is possible for all metal kinds, including steels, stainless steels, and other high temperature alloys. Complex machinery parts, turbine engine blades and other parts, jewellery, and dental fittings are a few examples of parts.

Similar to sand casting, plaster-mold casting uses a mould formed of plaster of Paris (gypsum, CaSO4-2H2O) rather of sand. The plaster is blended with additives like talc and silica flour to regulate contraction and setting time, reduce cracking, and boost strength. The plaster mixture and water are poured over a plastic or metal design in a flask and allowed to cure in order to create the mould. Due to the prolonged contact with water in the plaster, wood designs are often undesirable. The plaster mixture may easily flow around the design because to its fluid nature, capturing all of its nuances and surface gloss. For these reasons, the cast product in plaster moulding is renowned. One of the drawbacks of this procedure, at least in large production, is the plaster mould curing.

The design cannot be removed until the mould has been set for roughly 20 minutes. After that, the mould is baked for a long time to get rid of the moisture. Not all of the moisture in the plaster is eliminated even after baking. The challenge encountered by foundrymen is that although too much plaster dehydration reduces mould strength, too much moisture might result in casting flaws. Between these bad options, there must be balance. Plaster moulds also have the drawback of being impermeable, which prevents gases from the mould cavity from escaping as easily.

Similar to sand casting, plaster-mold casting uses a mould formed of plaster of Paris (gypsum, CaSO4-2H2O) rather of sand. The plaster is blended with additives like talc and silica flour to regulate contraction and setting time, reduce cracking, and boost strength. The plaster mixture and water are poured over a plastic or metal design in a flask and allowed to cure in order to create the mould. As a result of the prolonged contact with water in the plaster, wood designs are often undesirable. The plaster mixture may easily flow around the design because to its fluid nature, capturing all of its nuances and surface gloss. For these reasons, the cast product in plaster moulding is renowned.

CONCLUSION

A key element of developing and maintaining organisational excellence is continuous improvement. It entails using a methodical methodology to pinpoint problem areas, make adjustments, and assess the effects of those changes. The frameworks and tools provided by continuous improvement approaches like Kaizen, Lean, and Six Sigma help an organisation increase productivity, reduce waste, and improve quality. Organisations may encourage staff to actively look for possibilities for improvement, exchange ideas, and work together to solve problems by establishing a culture of continuous improvement. This not only boosts operational effectiveness but also lowers costs, improves product and service quality, and boosts customer pleasure.

A supportive organisational culture, leadership commitment, employee involvement, and good communication are necessary for the successful implementation of continuous improvement. Organisations may achieve long-term success, adjust to changing market needs, and maintain competitiveness in their sector by embracing continuous improvement as a fundamental principle and continually aiming for incremental improvements.

REFERENCES

[1] M. J. Makrygianni, “Aircraft accident evaluation using quality assessement tools,” *Aviation*, 2018, doi: 10.3846/aviation.2018.5995.

[2] D. Yoshioka *et al.*, “Changes in End-Organ Function in Patients With Prolonged Continuous-Flow Left Ventricular Assist Device Support,” *Ann. Thorac. Surg.*, 2017, doi: 10.1016/j.athoracsur.2016.12.018.

[3] S. Y. Chen, “Use of green building information modeling in the assessment of net zero energy building design,” *J. Environ. Eng. Landsc. Manag.*, 2019, doi: 10.3846/jeelm.2019.10797.

[4] J. A. Dominitz and C. W. Ko, "Managing the Measurement of Colonoscopy Quality," *American Journal of Gastroenterology*. 2019. doi: 10.14309/ajg.0000000000000307.

[5] S. J. Y. Macalino, V. Gosu, S. Hong, and S. Choi, "Role of computer-aided drug design in modern drug discovery," *Archives of Pharmacal Research*. 2015. doi: 10.1007/s12272-015-0640-5.

[6] S. Audia, N. Grienay, M. Mounier, M. Michel, and B. Bonnotte, "Evans' syndrome: From diagnosis to treatment," *Journal of Clinical Medicine*. 2020. doi: 10.3390/jcm9123851.

[7] M. Top and S. Tekingündüz, "Patient Safety Culture in a Turkish Public Hospital: A Study of Nurses' Perceptions About Patient Safety," *Syst. Pract. Action Res.*, 2015, doi: 10.1007/s11213-014-9320-5.

[8] F. Sayinzoga and L. Bijlmakers, "Drivers of improved health sector performance in Rwanda: A qualitative view from within," *BMC Health Serv. Res.*, 2016, doi: 10.1186/s12913-016-1351-4.

[9] Y. Abdelouadoud, E. Lucas, P. Krummenacher, D. Olsen, and B. Wellig, "Batch process heat storage integration: A simple and effective graphical approach," *Energy*, 2019, doi: 10.1016/j.energy.2019.06.180.

[10] E. Monsieurs, O. Dewitte, and A. Demoulin, "A susceptibility-based rainfall threshold approach for landslide occurrence," *Nat. Hazards Earth Syst. Sci.*, 2019, doi: 10.5194/nhess-19-775-2019.

CHAPTER 4

PLANNING FOR HIGH VOLUME STANDARDIZED PRODUCTS: A REVIEW STUDY

Dr. Devendra Dandotiya
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India.
Email Id: devendradandotiya@presidencyuniversity.in

ABSTRACT:

This research study examines the strategies, difficulties, and performance optimizations techniques involved in successfully managing the planning process for such big volume, standardized items. Demand forecasting, manufacturing capacity, inventory control, and supply chain coordination are some of the main factors and factors to be taken into account while planning for large volume standardized goods. It examines the methods used in the development of planning, including sophisticated planning systems, demand-driven methods, and cooperative planning. The study looks at issues including demand variability, manufacturing effectiveness, and cost optimizations while planning for big volume, standardized items. Additionally, it assesses how well-planned operations affect key performance indicators including customer satisfaction, lead times, inventory levels, and profitability. The research advances our knowledge of planning for large volume, standardized goods and informs practices for streamlining the planning process and attaining operational excellence.

KEYWORDS:

High Volume Standardized Products, Mass Production, Economies of Scale, Quality Control, Supply Chain Management, Production Planning.

INTRODUCTION

By that point, we had all come to understand what production meant. Production may be thought of as the methodical transformation of one kind of material into another via mechanical and chemical processes in order to generate or improve the usability of the product for the consumer. Manufacturing standardised goods like automobiles, buses, motorcycles, radios, and TVs are a few instances of production. The term "production system" truly refers to a collection of numerous techniques, programmes, plans, and operations that are necessary to collect (collect) the inputs, process or reprocess the inputs, and produce the marketable output (goods). The production system makes use of resources such as labour, capital, infrastructure, and raw materials to generate the things that are needed. There are several kinds of manufacturing methods. The diversity of the items to be produced, the volume of production, and the level of flexibility needed all play a role in choosing the manufacturing method [1]–[3].

Different Types of Production Systems:

The kind of production system is chosen after the process choice. Production systems may be categorised based on the process, as indicated in the figure below. Figure 1 representing manufacturing system.

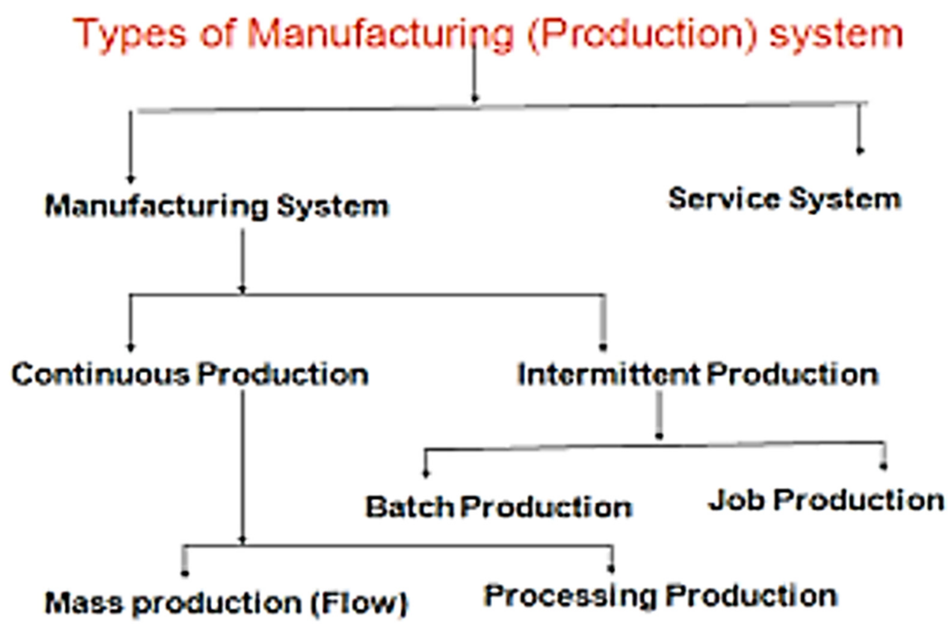

Figure 1: Representing Manufacturing system.

Job Shop Production

Job shop production is defined as the creation of a single or small number of items that are created and manufactured in accordance with client specifications in a certain amount of time and money. The low volume and wide ra6nge of items are what set this apart. General purpose machines are divided into many sections in a work shop. Every work has certain technical needs and necessitates processing on equipment in a particular order.

Characteristics

1. When there is a limited volume of production and a high diversity of items, the job-shop manufacturing method is used.
2. Utilisation of all-purpose equipment and resources.
3. Highly competent workers who can rise to the challenges presented by each profession.
4. Large stockpile of supplies, equipment, and components.
5. The sequencing of each product's needs, each work center's capacity, and order priority depends on meticulous planning.

DISCUSSION

Batch Production

Batch production is described as "a form of manufacturing in which the job passes through the functional departments in lots or batches and each lot may have a different routing" by the American Production and Inventory Control Society (APICS). It is distinguished by the production of a small quantity of items that are stockpiled in anticipation of sales and produced at regular intervals [4]–[6].

Continuous Production

manufacturing facilities are organized according to the order of manufacturing processes, starting with the initial activities and ending with the final product. Through the use of material handling equipment like conveyors, transfer devices, and other similar devices, the things are made to move through the sequence of processes.

Mass Production

His first mobile assembly line was created by Henry Ford. and transformed the production procedures in 1913. Henry wanted to build the most automobiles feasible with the most basic design at the lowest cost. The assembly line evolved as the gold standard for industrial mass production techniques. The process of creating items in huge numbers at a cheap cost per unit is known as mass production. However, mass manufacturing does not always imply bad quality, even when it permits cheaper costs. Instead, standardized mass-produced things are made from interchangeable, precisely manufactured pieces. the use of interchangeable components and machinery. The growth of the machine tool industry, or the building of machines to create other machines, established the structural foundation for mass production. The assembly line is a setup of tools, equipment and employees where a product is put together by having each work on an unfinished item as it goes by in a sequence of steps arranged in a straight line.

Line Balancing Rules in Mass/ Assembly Line Production

Since the product is standardized and the volume of production is extremely large in the mass production system, also known as the assembly line system, all workers, equipment, and machines must be set up in a certain order according to the specifications of the product to be produced. As seen in the image below, bulk manufacturing is done in a queue. The assembly line is a manufacturing line where assembly work is done as material is continually moved through a number of workstations.

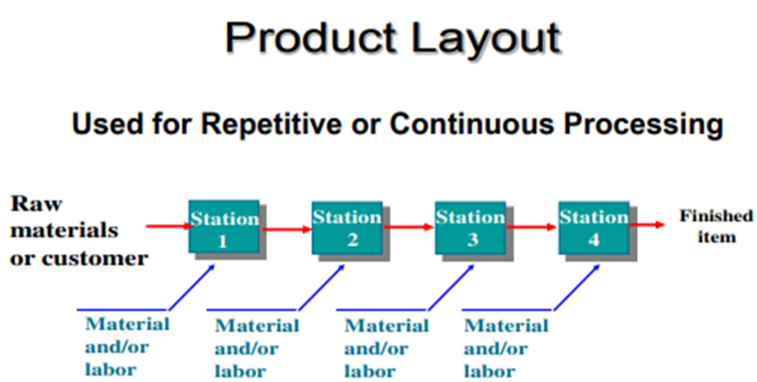

Figure 2: Represent the Product Layout

Line Balancing Problem in Assembly Line Production

It is essential that this line be balanced because in assembly line manufacturing, all labour, tools, and workstations are placed in a line in accordance with the needs of the process and the product. In order to maintain continuous production, time spent at each work station must be equal and, ideally, equal to cycle time. It is important to set up the various processing and assembly jobs at the workstations in such a way that the overall time spent at each workstation is about equal. To achieve perfect equilibrium is almost unattainable.

Design of an Assembly Line

The assembly line balancing process seeks to cut down on machine downtime. It refers to the fewer operators needed to complete a job. Parts of the complete assembly have been separated. Any of the following models might be used for an assembly line: The mass production system is given diversity by using a concept like modular manufacturing. A minimal number of pieces or processes are designed and manufactured in such a system. Modules are what they are. They may be mixed together in many ways to provide diversity. Group Technology: In a group technology plant structure, the components needed for a certain activity are divided into several groups. Each machine is allocated to the production of one group because of the way the machines are set up. Automation: In such a system, equipment, supplies, and control are all integrated.

Parameters of Production Planning in Assembly Line Production

Production planning is concerned with creating the plans, which include the precise task scheduling, workload distribution among machines (and workers), routing, and the actual flow of work through the system. Plans are established in conjunction with other departments, such as production, marketing, logistics, warehousing, and other departments depending on the structure of the organization, since manufacturing is an o6rganised activity of transforming raw resources into useable goods. Planning is constantly done while taking into consideration the goals and objectives of the manufacturing process [7]–[9].

Production control is concerned with how well the plans are carried out. The two most fundamental, vital, and interrelated functions are planning and control. Prior to carrying out the design or the process, the plan for the activity is created. Planning occurs before every operation. Control is carried out after the intended layout and method have been carried out or implemented. The nervous system of the industrial operation may be considered as production planning and control. Prior to production, the optimal use of resources and information must be made, and when production is complete, the performance of labor and equipment must be evaluated and assessed. Setting up a control mechanism is the only way to allow for a critical evaluation. The basic objectives of production planning and control are:

1. to assess and appraise the input-stage resources, such as the labour, raw materials, data, and procedures needed for a manufacturing process, and to project their amount and quality
2. To carry out the preplanned process in a manner that results in maximum productivity, maximum efficiency, and minimal waste.

Parameters of Production Planning:

The many aspects of production planning may be stated as follows: Materials: To guarantee the proper start and end for each operation and continuous production, raw materials, completed parts, and purchased components should be made available in the needed amounts and at the required times. The job description also involves judgements on whether to manufacture or purchase as well as the specification of materials (quality and quantity), delivery deadlines, variety reduction (standardization), and procurement. Due to the constant nature of production on an assembly line and the lack of frequent process changes, material planning is fairly simple.

The complete examination of the production facilities that are now available, equipment downtime, maintenance policy procedures, and timetables are all part of this activity. worried about the cost of jigs and fittings and the accessibility of equipment. Consequently, the tasks include analysing the facilities to ensure their availability with the least amount of downtime due to failures. The examination of options and choice of the optimal technique while taking into account any given limits are the focus of this function. Creating process specifications is a crucial part of production planning and determining the order of activities. The assembly line is the simplest since all of the machinery, tools, and labour are placed in a line to create workstations. Routing is the process of choosing the most efficient route from machine to machine and department to department so that the raw material takes on its final form. Routing is connected to layout, material handling, and temporary in-process inventory storage. Due to the product type of layout, where the machines are positioned in accordance with the sequence of activities that must be done on the components, routing is not an issue in continuous production businesses.

The number of activities and their order are standardised since the manufacturing uses standardised goods. The automated material handling systems have the machines set up in a sequential order. Routing becomes a normal and mechanical task as a result of the ongoing and steady manufacturing. Routing is still straightforward and managed automatically under automation.

Advantages of Routing

Costs associated with production are reduced; the quantity and quality of the output are improved; and a foundation for scheduling and loading is provided. Estimating: The operations times are estimated when the general technique and sequence of operations have been established and process sheets for each operation are available. This task is completed by thoroughly analysing operations, procedures, and routes. A standard operating time is developed utilising work measuring techniques. Scheduling involves preparing machine loads and determining the beginning and end dates for each activity. Machines must be loaded in accordance with their capacity and ability to do the assigned job. As a result, the tasks comprise

(a) loading the machines in accordance with their capacity and competence.
(b) Establishing the times at which each operation will begin and end.
(c) To arrange delivery schedules with the sales department.

This is the planning process' implementation stage. By issuing orders and instructions, it is the process of starting up manufacturing activity. By providing the operator with supplies, parts, tools, fixtures, and instruction manuals, it approves the beginning of production operations [10].

CONCLUSION

High volume standardised goods are important in many sectors because they provide dependable and affordable solutions to fulfil client requests. Because these items are produced in large quantities, economies of scale allow businesses to cut manufacturing costs and increase productivity. In order to achieve consumer expectations, consistency and adherence to specifications are vital factors to take into account while producing big volume standardised goods.

A seamless flow of commodities, prompt delivery, and efficient inventory management are all dependent on supply chain management. Planning the manufacturing process is essential for resource optimisation, bottleneck reduction, and effective output. Businesses who successfully manage the manufacturing of large volume standardised goods get a competitive edge in the market, higher profitability, and enhanced customer satisfaction. To handle shifting consumer expectations, market trends, and technology improvements, it is crucial to continuously review and modify production processes.

Organisations may succeed in the manufacturing of vast volumes of standardised goods by using economies of scale, investing in quality control systems, and putting into practise reliable supply chain and production planning methods.

REFERENCES

[1] A. C. Schuermann and N. P. Kannan, “A production forecasting and planning system for dairy processing,” *Comput. Ind. Eng.*, 1978, doi: 10.1016/0360-8352(78)90025-6.

[2] N. Boysen, M. Fliedner, and A. Scholl, “A classification of assembly line balancing problems,” *Eur. J. Oper. Res.*, 2007, doi: 10.1016/j.ejor.2006.10.010.

[3] D. V. Kapulin and P. A. Russkikh, “Analysis and improvement of production planning within small-batch make-to-order production,” 2020. doi: 10.1088/1742-6596/1515/2/022072.

[4] N. Boysen, M. Fliedner, and A. Scholl, “Assembly line balancing: Which model to use when?,” *Int. J. Prod. Econ.*, 2008, doi: 10.1016/j.ijpe.2007.02.026.

[5] M. C. S. Wong *et al.*, “Incidence and mortality of kidney cancer: Temporal patterns and global trends in 39 countries,” *Sci. Rep.*, 2017, doi: 10.1038/s41598-017-15922-4.

[6] R. Duray, “Mass customization origins: Mass or custom manufacturing?,” *Int. J. Oper. Prod. Manag.*, 2002, doi: 10.1108/01443570210417614.

[7] A. P. Hameri and J. M. Lehtonen, “Production and supply management strategies in Nordic paper mills,” *Scand. J. Manag.*, 2001, doi: 10.1016/S0956-5221(99)00042-1.

[8] S. Basu, B. Saboury, D. A. Torigian, and A. Alavi, “Current evidence base of FDG-PET/CT imaging in the clinical management of malignant pleural mesothelioma: Emerging significance of image segmentation and global disease assessment,” *Molecular Imaging and Biology*. 2011. doi: 10.1007/s11307-010-0426-6.

[9] C. Hicks and D. Powell, “Integrating lean and ERP in engineer/make-to-order subsea companies,” 2013.

[10] J. Östlin, “On Remanufacturing Systems: Analysing and Managing Material Flows and Remanufacturing Processes,” 2008.

CHAPTER 5

PROCEDURE AND DOCUMENTATION IN PRODUCTION PLANNING AND CONTROL (PPC)

Mr. Ajay Mishra
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India.
Email Id: ajaykumarmishra@presidencyuniversity.in

ABSTRACT:

This study examines the best practices, implementation strategies, and performance results connected to efficient PPC processes and documentation. It focuses on the process and documentation in production planning and control (PPC). Production scheduling, capacity planning, material requirement planning, and shop floor control are some of the main PPC components and procedures that are examined in the research. It examines the value of paperwork in PPC, including routing sheets, work orders, and bill of materials (BOM). The study looks at cross-functional cooperation, standardised templates, and digital systems as top practises for establishing PPC processes and documentation. Additionally, it assesses the performance benefits of well applied PPC policies and documentation, such as increased productivity, shorter lead times, less mistakes, and better decision-making. The results add to a thorough knowledge of PPC procedure and documentation, guiding practises for improving production planning and control processes and decision-making based on evidence.

KEYWORDS:

Production Scheduling, Material Requirement Planning, Capacity Planning, Job Instructions, Production Planning and Control (PPC), Method, Documentation.

INTRODUCTION

Our attention will now be on the many forms of information, reports, and documents needed in the production planning and control exercise. The idea of production planning and control was covered in depth in earlier chapters. For upcoming productions, production plans are created in which the facilities required are identified and set up. Periodically, for a certain amount of time known as the planning horizon, a production planning is prepared. Production Planning may be defined as a strategy for anticipating each stage in a lengthy production process, executing those steps at the appropriate time and to the appropriate degree, and attempting to execute operations as efficiently as possible.

The planning of industrial operations incorporates four factors, according to Kimball & Kimball what work will be done, how the work will be done, when the work will be done, and wherethe work will be done.

Production control is the process that closely monitors the production flow, resource size, and location, looking for any deviation from the current action and setting up the rapid adjustment so that the production may proceed in accordance with the original or amended schedule. Production control, in the words of Henry Fayol, "means ensuring that everything happens in accordance with the rules established and instructions issued [1]–[3]. Planning production in a manufacturing organization prior to the start of actual production activities and enforcing control measures to make sure the planned production is realized in terms of quantity, quality, delivery schedule, and cost of production are the main components of production planning and control. A manufacturing or operating system's general organization is a component of production planning.

Designing the product, deciding on equipment and capacity needs, planning the layout of physical facilities, designing the material and material handling system, deciding on the sequence and nature of the operations to be performed along with time requirements, and specifying specific production quantities and quality levels are just a few of the activities involved in production planning. The primary goal of production planning is to create a physical structure and a set of operational rules for the effective transformation of raw materials, labour, and other inputs into completed goods.

An Overview of Production Planning and Control

Since the late 19th century, modern production planning techniques and technologies have been established. The job for each individual and each machine is predetermined under scientific management. Production planning has been used for more than a century. The need for data for internal planning and control, according to Kaplan (1986), "appears to have arisen in the first half of the 19th century when firms, such as textile mills and railroads, had to devise internal administrative procedures to coordinate the multiple processes involved in the performance of the basic activity (the conversion of raw materials into finished goods by textile mills, the transportation of passengers and freight by the railroads)." Herrmann (1996) goes on to elaborate on the conditions under which novel techniques for internal planning and control emerged. "The initial factories were rather basic and compact. Large quantities of a limited number of items were made. By removing time-consuming fitting procedures, replaceable components have increased productivity. Manufacturing companies during the late 1800s focused on increasing the output of the pricey production machinery. Maintaining high utilisation was a key goal.

In charge of organising all the tasks required for the few items that were within their purview, foremen controlled their shops. They handled manufacturing, recruited workers, bought supplies, and shipped the finished good. They planned production, not a separate team of clerks, and they were professionals with better technical abilities. Even when they expanded, factories just increased in size rather than complexity. Herrmann (1996) recalls that "production scheduling also began simply when talking about production planning. When schedules were utilized at all, they just indicated when work on an order should start or when it is due. They didn't provide any details on how long each procedure will take or how long the order as a whole should take. Mr. Owens' observation that "Production planning is rapidly becoming one of the most vital necessities of management" was quoted in Industrial Management in 1923. Every institution, regardless of size, has some type of production planning, but a significant portion of them lack planning that ensures an equitable flow of materials and a minimal amount of money is locked up in inventory.

Importance of Production planning and Control:

The following justifies the importance of production planning and control: For Increasing Production: Arranging inputs is the primary goal of production planning. A production control plan reduces machine and human inactivity. Thus, it contributes to increasing industrial production. For Coordinating Plant Activity: During planning, several procedures are used to carry out the production; as a result, activities are synchronized for efficient operation. For Cost management: A well-planned production system will aid in cost management by not only maximizing the use of different inputs but also by raising output and reducing overhead costs per unit. In production planning, the procedure of bringing in raw materials and turning them into completed items is planned in such a manner that everything is done in sequence or routinely. It controls input flow to maintain a productive system.

DISCUSSION

Procedure of Production Planning:

In a manufacturing organization, planning is completed prior to the commencement of production. A manufacturing or operating system's general organization is a component of production planning. The primary goal of planning is to create a physical system and a set of operational rules for the efficient conversion of raw materials, labour, and other inputs into completed goods. The following are the primary planning activities: Materials: Organizing the purchase of components, spare parts, and raw materials in the appropriate quantities, according to the right specifications, at the right time, from the right source, at the right price. The additional operations related to material include buying, storing, inventory management, standardisation, variety reduction, value analysis, and inspection. Planning for Materials & Resources will be covered in more depth later.

Methods: Selecting the most effective processing technique from a range of options. It also includes planning for tooling, jigs, and fixtures, among other things, as well as choosing the optimal order of activities (process plans). Machines and equipment: The production facilities that are available in the production systems are connected to the manufacturing procedures. It includes planning for facilities, capacity, plant and equipment allocation, and machine use, among other things. Manpower planning involves ensuring that both management and labour force members have the necessary knowledge and skills [4]–[6].

Procedure of Production Control

Production planning and control go hand in hand. Production control is the process that closely monitors the production flow, resource size, position, and any deviations from the current action in order to set up the fast adjustment so that the production may proceed in accordance with the original or updated schedule. Production control, in its simplest form, is the process of ensuring that everything that happens does so in accordance with the guidelines and directives outlined in the plans. Control includes the following steps:

Routing

Establishing the order of operations or processing processes as well as the flow of work and material handling at a facility. It has to do with taking into account the best layout for the shop and the plant, as well as temporary storage places for raw materials, components, and semi-finished items, and materials handling systems. A "route sheet" is a document that contains the information mentioned above.

This is a document that outlines the steps to take in order to turn raw resources into completed components or goods. It establishes the specific path or route via which the product will flow throughout the conversion process and describes each phase of the industrial activity. It is a manufacturing unit's plan for the whole production process. It reveals the precise location of the unit's numerous processes.

The sequence or organisation of several departments inside a facility is determined by a route sheet. A route sheet is thus a document that contains information and data inputs as well as a step-by-step breakdown of all the activities or transactions carried out. Additionally, it has information like the date, time, notes, log-in and log-out times, point of contact, etc. Route sheet includes the following details.

The necessary steps and the intended order of those steps

Specifications, dimensions, tolerances, surface finishes, and quality standards to be achieved; Specification of raw material to be used; Speed, feed, etc. to be used on machine tools for the operations to be carried out; Inspection procedure; Machine or equipment to be used for each operation; Estimated set-up time and operation time per piece; Tools, jigs, and fixtures required for the operation; Detailed drawings of parts, sub-assemblies, and final assemblies.

Estimating

Setting up run durations that result in performance criteria being fixed for both human and machine performance. On the basis of a sales prediction, estimation entails choosing the number of items to be produced and the associated costs. Before allocating funding for resources, the primary actions include estimating the amount of labor, machine capacity, and materials needed to reach the anticipated production objectives. Machine loading: Based on relative priorities and capacity utilization, machine loading is the process of allocating specified tasks to machines, workers, or work centres. Loading ensures that productive facilities are used to their fullest potential and prevents production bottlenecks. To maintain optimal resource utilisation, it's vital to prevent either overloading or underloading the buildings, workspaces, or machinery.

Scheduling

This guarantees that components, subassemblies, and final goods are produced in accordance with the specified delivery dates. It offers a schedule of manufacturing operations. The following are the primary goals of scheduling: To avoid an uneven distribution of time across work centres and departments.

To use workers in a way that ensures output is generated within designated lead or cycle times in order to deliver the goods on schedule and finish production at the lowest possible cost. This relates to carrying out the planned duties. It grants the required permission to begin a certain task that has previously been planned out using routing and scheduling mechanisms. Release of orders and directives for the commencement of production in line with route sheets and schedule charts is known as dispatching.

Inspection

This task relates to upholding production quality and assessing the effectiveness of procedures, techniques, and labour in order to make adjustments to meet the quality requirements established by product design. Evaluating: Performance improvement is the goal of evaluation. In order to enhance performance, workers, procedures, and machines are all reviewed. Cost control in manufacturing is achieved by the elimination of waste, value analysis, inventory management, and effective use of all resources.

Measuring Effectiveness

The primary responsibility of the production planning and control department is to coordinate the work of the many support departments for the production department, such as purchasing, stores, industrial engineering, quality control, design, and maintenance. Therefore, the success of the company in meeting demand and its capacity to produce quality products and deliver them in the delivery schedules desired by the customers at a reasonable price that is acceptable to customers can generally be measured by the company's ability to achieve maximum customer satisfaction. The efficiency of the planning and control function may be evaluated in four distinct areas:

Inventory levels

The value of average inventory held annually, the value of obsolete inventory, the value of non-moving and surplus inventories, and the inventories and the inventory turnover ratio are indicators of efficiency in inventory management. Delivery: This can be measured by determining the number of deliveries that were affected on time and those that got delayed over a period of time. Evaluation of anticipated and actual results: Production is a measure of how well planning and management are executed. The quantity of overtime hours worked, the machine utilisation rate, and other factors are also indicators of this function's efficacy. The costs associated with performing the different planning and controlling tasks in relation to the production values and sales revenue realised [7]–[10].

Materials & Resource Requirement Planning

An effective production plan is essential to the success of any organization's production or operations department. The method for planning material and resource requirements is one of the most important components of a production plan. This is crucial to assembly-line manufacturing. A system-based technique called material requirement planning organises all necessary manufacturing materials. An information system for production planners called material requirement planning is based on inventory control. As one of its outputs, it produces a variety of reports, all of which are very important to production planners. The following are the fundamental elements of material planning: The availability of all necessary goods and raw materials for manufacturing is confirmed by material planning.

1. Material planning guarantees that inventory levels are kept to a minimum.
2. Additionally, it makes sure that the necessary supplies and goods are accessible whenever manufacturing is planned, which helps in balancing supply and demand.
3. Material planning not only gives data on shipment and stocking but also on production planning and scheduling.

CONCLUSION

To maintain seamless and effective production operations, Production Planning and Control (PPC) relies heavily on procedure and documentation. In order to fulfil customer needs and use resources more effectively, production scheduling entails developing a plan that specifies the order and time of production processes. In order to reduce stockouts and excess inventory, material requirement planning focuses on figuring out the amounts and time of the materials required for production. Capacity planning assists in finding and assigning resources, such as personnel, equipment, and facilities, to efficiently fulfil production demands. Work instructions provide employees comprehensive information on the particular duties and procedures involved in production. Coordination, communication, and mistake reduction in production activities are all facilitated by effective procedure and documentation in PPC. By automating data collection, analysis, and reporting, technology such as manufacturing execution systems (MES) and enterprise resource planning (ERP) software improves the accuracy and efficiency of process and documentation. Organisations may improve production control, improve quality, save costs, and increase customer satisfaction by establishing strong process and documentation practises in PPC.

REFERENCES

[1] P. P. Napitu And D. Kartikasari, “Studi Tentang Penerapan Administrasi Perencanaan Dan Pengendalian Produksi Pada Pt Sanwa Engineering Batam,” *J. Appl. Bus. Adm.*, 2018, Doi: 10.30871/Jaba.V1i2.623.

[2] A. Fredriksson, C. Wänström, M. I. Johansson, And L. Medbo, "A Structured Procedure For Materials Planning During Production Transfer," *Prod. Plan. Control*, 2015, Doi: 10.1080/09537287.2014.971534.

[3] N. Semenyshena, N. Khorunzhak, O. Adamyk, I. Sadovska, K. Nahirska, And V. Zhuk, "The Methodology For Calculating Baseline Indicators For Budgeting Expenditures Of Budgetary Institutions: The Case Of Ukraine," *Intellect. Econ.*, 2019, Doi: 10.13165/Ie-19-13-1-04.

[4] N. Stefanović, S. Milijić, And N. D. Hristić, "System Approach In Process Of Planning And Project Documentation Preparation For Highway Corridors As An Instrument For Establishing The Trans-European Transport Network," In *Transportation Research Procedia*, 2020. Doi: 10.1016/J.Trpro.2020.03.043.

[5] L. Dai, M. Rausand, And I. B. Utne, "Availability Centred Maintenance For Offshore Wind Farms," *J. Qual. Maint. Eng.*, 2015, Doi: 10.1108/Jqme-08-2013-0058.

[6] N. Gnyp, "Institutional And Managerial Principles Of Financial Planning At The Enterprise," *Econ. Ann.*, 2015.

[7] M. Shweel, A. Elshafei, R. M. E. D. Abdelrahman, And M. Nassar, "Evaluation Of Lacrimal Drainage System Obstruction Using Combined Multidetector Ct And Instillation Dacryocystography," *Egypt. J. Radiol. Nucl. Med.*, 2012, Doi: 10.1016/J.Ejrnm.2012.04.005.

[8] R. E. Jones, R. H. Wilson, And T. L. Caton, "On Constraints In Assembly Planning," *Ieee Trans. Robot. Autom.*, 1998, Doi: 10.1109/70.736770.

[9] J. Jose *Et Al.*, "The Development And Implementation Of Radiation Oncology Iq Script Enabled Plans At The Odette Cancer Centre," *J. Med. Imaging Radiat. Sci.*, 2018, Doi: 10.1016/J.Jmir.2018.03.003.

[10] M. Schonhoff, A. Heinze, J. Carrillo, A. Lopinski, D. Großkreutz, And S. Hanusek, "Development And Manufacturing Of A Custom Made Implant Regarding The New European Medical Device Regulation," *Curr. Dir. Biomed. Eng.*, 2019, Doi: 10.1515/Cdbme-2019-0064.

CHAPTER 6

INVENTORY MANAGEMENT IN PLANNING AND CONTROL: STRATEGIES, OPTIMIZATION AND PERFORMANCE IMPLICATIONS

Mr. Narender Singh
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India.
Email Id: narendersingh@presidencyuniversity.in

ABSTRACT:

In order to satisfy consumer expectations while keeping expenses to a minimum, inventory management is essential to planning and control procedures inside an organization. This essay examines the idea of inventory management in planning and control, covering methods for replenishment, forecasting, inventory planning, and inventory control. This study examines methods, optimisation approaches, and performance effects related to efficiently managing inventories inside organisations with an emphasis on planning and control. Demand forecasting, order quantity determination, lead time management, and safety stock optimisation are some of the main topics covered in the research.

It looks at techniques including just-in-time (JIT) inventory systems, economic order quantity (EOQ) models, and material needs planning (MRP) that are used to balance inventory levels with customer service. The study assesses the optimisation techniques used to reduce inventory holding expenses while maintaining adequate stock availability. It also looks at how good inventory control affects performance in terms of fewer stockouts, more customer happiness, better cash flow, and more efficient operations. The results aid in a thorough knowledge of inventory management, supporting better planning and control procedures inside organisations, and directing evidence-based decision-making.

KEYWORDS:

Planning and Controlling Inventory, Predicting Inventory, Replenishment Techniques, Inventory Control.

INTRODUCTION

The production planners rely heavily on information from inventory data. Inventory management, as we are all aware, is essential to supply-chain management. They are crucial in assuring timely delivery of products and services. time for clients. Inventory also covers a variety of expenses, investments, space management, etc. There is a danger that the firm would incur additional costs if the stored merchandise is destroyed or stolen. As a result, a company has to have a strong inventory management system.

Inventory Holding

The following factors make inventory holding crucial for an organization: Inventory holding guarantees that delivery delays won't affect consumers.

1. Additionally, it guarantees that the business can meet peaks or fluctuations in product demand.
2. It guarantees that manufacturing may be flexible.

3. It makes sure that any delays from suppliers won't interfere with how the business operates.

The next phase for the business is to make inventory-related decisions in light of the aforementioned inventory holding goals. The amount of raw materials ordered and the time of placing such orders are the two main factors to be taken into account when making an inventory decision [1]–[3].

Inventory Models

The independent demand inventory model and the dependent demand inventory model are the two fundamental concepts on which inventory management is built. The Independent Demand Inventory Model discusses finished products or raw material demand that is based on current market circumstances and is unrelated to any raw materials that the organization is presently using. A suitable example of an independent demand inventory model is a completed item. The Dependent Demand Inventory Model discusses the demand for raw materials, which are essential to production and play a significant role in the allocation of material resources. For instance, the demand for raw materials might serve as the foundation for the demand for completed goods.

Inventory Costs

Holding cost, ordering cost, and set up cost are the three main types of costs related to inventory. Holding costs are the long-term holding costs related to inventories. They consist of things like insurance, warehousing, interest, more personnel, etc. Costs related to ordering and receiving raw supplies are referred to as ordering costs. Forms, order processing, office supplies for maintenance, and personnel involved in ordering are among them. Set-up costs are expenses related to installing an equipment for use in production. They consist of modification, retooling, and clean-up costs. In a nutshell, inventory management makes sure that businesses may reduce expenses while maximizing revenue.

The production planning and control system must be integrated for a manufacturing unit of an organization to operate efficiently, effectively, and economically. After modifying a product's design and perfecting a manufacturing method, production planning and subsequent production control take place. Inventory control, resource utilization, and poor productivity are essential issues that are addressed through production planning and control. Scheduling, dispatch, inspection, quality control, inventory management, supply management, and equipment management all depend on production planning. Production control guarantees that the production team will be able to meet the desired production goal, make the most use of available resources, manage quality, and save money. A successful operating unit requires careful planning and execution.

Enterprise Resource Planning

an international, socio-technical analysis of Enterprise Resource Planning (ERP) deployment methods. This chapter focuses on the selection, tactics for deployment, and consequences of ERP systems for organizational success rather than the technology itself.

It contains a critical analysis of the functionality evaluation of ERP systems' usefulness for small-to-medium-sized firms (SMEs), practical use of ERP for attaining organisational performance, and practical application of ERP for supporting knowledge management activities in organisations. This demonstrates how to incorporate better business processes processes that provide your organisation a competitive advantage into your organisation. Currently, ERP systems are being used by companies of all sizes. Manufacturing, logistics, distribution, accounting, finance, and human resource departments of a firm all benefit from the integration and automation of several internal business processes and information systems provided by ERP, which acts as a cross-functional enterprise backbone. In order to provide a conceptual framework and a spark for reengineering their business processes, major corporations all over the globe started installing ERP systems in the 1990s. ERP also acted as the crucial software engine required to combine and complete the resulting cross-functional operations. In order to achieve the efficiency, agility, and responsiveness needed to compete in today's changing business climate, many firms now recognize that ERP is a crucial component.

DISCUSSION

Concept of Enterprise Resource Planning (ERP)

A business management system that integrates all functional aspects of an organisation, such as logistics, production, finance, accounting, and human resources, is known as an enterprise resource planning system. In order to utilise resources like people, materials, money, and machines as effectively as possible, it organises and integrates operational processes and information flows. With enterprise resource planning, one database, one application, and one user interface are all promised. When used by a manufacturing organisation, ERP software often processes data from and keeps track of sales, inventory, shipping, and invoicing, as well as projects the needs for raw materials and human resources. The primary application components of an ERP system are shown in the figure below. This also shows some of the main ERP system-supported cross-functional business process flows. Figure 1 represents the major components of ERP demonstrate the cross functional approach of ERP systems.

Figure 1: Represents the major components of ERP demonstrate the cross functional approach of ERP systems.

ERP connects manufacturing, order processing, and inventory management procedures to a shared database that is managed by a database management system, providing a corporation with an integrated real-time view of these key business activities. No matter which department (manufacturing, purchasing, sales, accounting, etc.) entered the data into the system, ERP tracks business resources (such as cash, raw materials, and production capacity), as well as the status of commitments made by the business (such as customer orders, purchasing orders, and employee payroll).

ERP software systems often include integrated modules for applications in sales, manufacturing, distribution, accounting, and human resources. Planning for production, capacity, and material requirements are a few examples of manufacturing processes that are supported. Sales analysis, sales planning, and price analysis are a few of the sales and marketing operations handled by ERP, whereas common distribution applications include order management, buying, and logistics planning. ERP systems facilitate the majority of necessary financial record-keeping and management accounting applications, as well as a number of crucial human resource procedures, such as planning for staff needs and administering salaries and benefits [4]–[6].

Evolution of ERP:

The following expectations are put on the industry in the ever-expanding business environment: aggressive cost control activities; a necessity to examine costs/revenues on a product or customer basis; and flexibility to adapt to shifting business requirements. Changes in corporate practices and better-informed managerial decision-making. For overcoming certain obstacles and attaining growth, one or more apps and planning systems have been brought into the corporate sector.

These are what they are: Enterprise-Wide Systems (EWS), Management Information Systems (MIS), Integrated Information Systems (IIS), Executive Information Systems (EIS), Corporate Information Systems (CIS), Manufacturing Resource Planning (MRP II), and Money Resource Planning (MRP III). With the integration of information between Vendor, Customer, and Manufacturer via networks such as LAN, WAN, and the Internet, etc., ERP has grown from the system known as MRP II (Manufacturing Resource Planning) system. The MRP (Material Requirement Planning) system developed into the MRP II system. The master production schedule (MPS), which is derived from the bill of materials (BOM) for the given product structure, bursts the end-product needs into a calendar of anticipated orders that takes the available inventory into account.

Enabling Technologies:

An ERP system cannot be imagined without a well-developed information technology backbone. It is stated that older ERP systems were only designed to function with enormous mainframe computers. The introduction of client-server technology, the new era of personal computers, and scalable Relational Database Management Systems (RDBMS) The majority of ERP systems make use of the three-tier client-server architecture. Workflow, Workgroup, Groupware, Electronic Data Interchange (EDI), Internet, Intranet, Data warehousing, and others are additional crucial enabling technologies for ERP systems.

ERP Characteristics:

For a system to be considered a legitimate ERP solution, it must include a few essential qualities.

The following are these qualities

1) Flexibility: An ERP system has to be adaptable to meet the changing demands of an organization. Through Open Database Connectivity (ODBC), client server technology allows ERP to function across different database back ends.

2) Modular & Open: An open system design is required for an ERP system. Accordingly, any module may be interfaced or detached anytime necessary without impacting the other modules. For businesses with a diverse array of systems, it needs to support a variety of hardware platforms. It must also support certain add-ons from other parties.

Features of ERP

1. ERP offers capabilities for many platforms, multiple sites, multiple production modes, several currencies, and multiple languages.
2. It supports operational planning and execution, strategic and business planning, and the development of materials and resources.
3. ERP includes all functional areas such as production, sales, and distribution, as well as accounts payable, accounts receivable, inventory, and human resources.
4. ERP enhances the business image by carrying out essential tasks and improving customer service.
5. ERP fills up the information chasm between enterprises.
6. ERP offers total system integration not just between departments but also across businesses managed by the same person.
7. The answer to improved project management is ERP.
8. The newest technologies, such as Electronic Fund Transfer (EFT), Electronic Data Interchange (EDI), Internet, Intranet, Video Conferencing, E-Commerce, etc., may be introduced automatically with the use of ERP.
9. The majority of company issues, such as material shortages, productivity gains, customer service, cash management, inventory issues, quality issues, fast delivery, etc., are eliminated by ERP.
10. ERP offers sophisticated corporate solutions including executive information systems, data mining, decision support systems, and user-friendly technologies to facilitate smarter judgements.

Need to Undertake ERP

Every organization nowadays has to use an ERP system for the reasons listed below:

a) Integrate financial data: The CEO may come across several conflicting accounts of the company's performance as he attempts to grasp its overall performance. Because everyone uses the same system, ERP provides a single, unquestionable version of reality.

b) Integrate customer order data: ERP systems may house client orders from the moment a customer service agent receives them up to the point at which the loading dock distributes the goods and finance sends an invoice. Companies may manage orders more efficiently and concurrently coordinate production, inventory, and delivery across several sites by combining this information in a single software system [7]–[10].

c) Standardise and speed up production processes: production businesses, particularly those that enjoy mergers and acquisitions, often discover that several business divisions use various procedures and computer systems to complete the same transaction, record, or report. Standard techniques for automating various industrial process processes are included with ERP systems.

d) Decrease inventory: ERP enhances visibility of the order fulfilment process inside the organisation and helps the production process run more smoothly. This may result in lower inventories of the raw materials required to produce items (work-in-progress inventory) and better delivery planning by users, which can lower the stock of completed goods in warehouses and shipping ports.

e) Standardise HR data: Especially in businesses with different business units, HR may not have a streamlined, straightforward system for monitoring workers' time and informing them of perks and services. ERP can address this.

CONCLUSION

In order to effectively satisfy customer requests while reducing inventory costs, inventory management is a crucial part of planning and control procedures. Inventory planning is calculating the ideal stock levels based on lead times, demand projections, and other pertinent variables.

The ability to predict future demand and adjust inventory levels correspondingly depends on accurate forecasting. Organisations may manage acceptable stock levels by using replenishment techniques like just-in-time (JIT) or economic order quantity (EOQ), which guarantee timely replenishment without causing an excessive inventory increase.

ABC analysis, safety stock management, and stock rotation are just a few of the inventory control approaches that help businesses increase order fulfilment and optimise inventory performance.

Inventory management operations are supported by technology by real-time visibility, demand insights, and automated inventory control, such as data analytics and inventory management systems.

Through timely product availability, efficient inventory management increases operational effectiveness, lowers carrying costs, and improves customer satisfaction. By optimising inventory levels, reducing stockouts, and boosting profitability, companies with strong inventory management procedures may gain a competitive edge.

REFERENCES

[1] R. Uzsoy, J. W. Fowler, and L. Mönch, “A survey of semiconductor supply chain models Part II: demand planning, inventory management, and capacity planning,” *International Journal of Production Research*. 2018. doi: 10.1080/00207543.2018.1424363.

[2] “Inventory management and production planning and scheduling,” *J. Manuf. Syst.*, 1999, doi: 10.1016/s0278-6125(99)90116-4.

[3] R. Azara, *Buku Ajar Manajemen Operasional Dan Implementasi Dalam Industri*. 2020. doi: 10.21070/2020/978-623-6833-48-3.

[4] G. K. Rand, “Inventory Management and Production Planning and Scheduling (Third Edition),” *J. Oper. Res. Soc.*, 2001, doi: 10.1057/palgrave.jors.2601154.

[5] M. N. J. Toft, Y. Adeyeye, and J. F. Lund, “The use and usefulness of inventory-based management planning to forest management: Evidence from community forestry in Nepal,” *For. Policy Econ.*, 2015, doi: 10.1016/j.forpol.2015.06.007.

[6] A. L. Milliken, “Linking Demand Planning & Inventory Management For Optimal Stock Levels,” *J. Bus. Forecast.*, 2020.

[7] G. K. Rand, R. Peterson, and E. A. Silver, “Decision Systems for Inventory Management and Production Planning,” *J. Oper. Res. Soc.*, 1979, doi: 10.2307/3009437.

[8] C. Barnhart, P. Belobaba, and A. R. Odoni, “Applications of operations research in the air transport industry,” *Transp. Sci.*, 2003, doi: 10.1287/trsc.37.4.368.23276.

[9] N. Susarla and I. A. Karimi, "Integrated production planning and inventory management in a multinational pharmaceutical supply chain," in *Computer Aided Chemical Engineering*, 2018. doi: 10.1016/B978-0-444-63963-9.00022-1.

[10] L. Mönch, R. Uzsoy, and J. W. Fowler, "A survey of semiconductor supply chain models part III: master planning, production planning, and demand fulfilment," *International Journal of Production Research*. 2018. doi: 10.1080/00207543.2017.1401234.

CHAPTER 7

DETERMINATION OF BUSINESS PROCESS REENGINEERING: METHODOLOGIES, CHALLENGES AND PERFORMANCE IMPACTS

Mr. Basavaraj Devakki
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India.
Email Id: basavarajdevakki@presidencyuniversity.in

ABSTRACT:

This research study examines the approaches, difficulties, and performance effects connected with the effective implementation of BPR initiatives with an emphasis on the determination of Business Process Reengineering (BPR). The analysis, redesign, and implementation of BPR's essential elements and phases are all included in the research. Value stream mapping, process mapping, and technology integration are just a few of the techniques and approaches examined in this BPR study.

The study looks at issues including stakeholder alignment, organizational culture, and change resistance that arise during BPR implementation. Additionally, it assesses how well BPR performs in terms of increased operational effectiveness, cost savings, customer satisfaction, and competitiveness.

The results add to a thorough knowledge of BPR and provide guidance for practices for organizational change as well as evidence-based decision-making.

KEYWORDS:

Business Process Reengineering (BPR), Process Improvement, Efficiency, Change Management.

INTRODUCTION

A contemporary enterprise's conception of how the information system should be set up for the demanding surroundings of new business prospects led to the development of ERP. However, just having an information system in place is insufficient. Every business that plans to deploy ERP must in some way reengineer its procedures.

Business process reengineering (BPR) is the name of this procedure. BPR, or business process redesign, is the basic rethinking and radical restructuring of processes to generate dramatically better results in crucial, modern performance indicators including cost, quality, service, and speed.

Dramatic accomplishment entails achieving an 80% or 90% decrease rather than only a 5% or 10% reduction (in delivery time, work in progress, or rejection rate, for example. When BPR undergoes a radical makeover, it is reinventing rather than upgrading or improving. Briefly stated, a "cleansiate approach" of BPR asserts that "Whatever you were doing in the past is all wrong," and that you should not get biassed by it or reconstruct your new system to create it from scratch.

Asking "why do you do what you do" is a key component of fundamental rethinking since it leads to the complete elimination of any business activity that does not provide value to the client [1]–[3].

Business Engineering

Business engineering is the result of the fusion of two ideas:

1) Information technology: Information technology aids in the creation of business models, which help to rethink corporate procedures.

2) Business Process Reengineering: This is the process of redesigning business processes in order to increase output, output velocity, and output quality of goods or services.

The effective redesign of businesses' value-added chains is the core goal of business engineering. Value added chains are a set of interconnected processes that flow through a business and, when successfully completed, create value to the company and its clients. corporate engineering is a technique for creating corporate processes that adapt to changing needs.

Business Management

company process reengineering, complete quality management, mass customization, service orientation, and virtual corporations are just a few examples of frequent company management concerns that ERP integrates extremely well with The main goal of executing an ERP programme is to create the infrastructure architecture and applications that fully and efficiently support the business strategy and operational procedures of the Enterprise. When in organization's business processes are not optimised, process reengineering is required for the ERP installation in order to incorporate specialists' knowledge into the system and boost productivity significantly.

The creation of a business process model that depicts business processes as one big system with connections between and a flow of the business subsystems or processes that power it is the first stage in implementing ERP. First, a model of the key business operations or activities of the company must be created. This is a diagram that shows how a company operates as a sizable system with interconnected subsystems or operations. There are two components to the data model:

ERP implementation:

The degree to which implementation consultants, users, and suppliers collaborate to meet the organization's overarching goals is a key factor in an implementation's success. The implementation consultants must comprehend the demands of the users, the current business realities, and create the business solutions with these considerations in mind. The implementation will be driven by the users, thus all of these considerations will be important.

The overall effectiveness of implementation depends on active participation at all phases. It is important to keep in mind that ERP is an enabling tool that improves one's job, which inevitably requires more labour. The standard package may change throughout implementation, and these changes might be minor or significant in terms of "functionality." Customization is the process of putting these modifications into action.

Modules are the name for the package's contents, and modules are further subdivided into Components. Employees must accept new processes and procedures configured in the system laid out in the ERP system and must have a clear understanding of their roles and responsibilities. At the same time, these processes and procedures must be straightforward and user friendly. A well-managed and deployed ERP software may provide a 200 percent return on investment, but one that is not properly handled can only provide a 25 percent return on investment.

DISCUSSION

"Big Bang" or Phased Implementation

Having all modules implemented simultaneously across all locations is known as a "big bang" implementation. This approach's characteristics include the lack of a need for temporary interfaces, the reduced need to maintain old software, cross-module capability, and overall cost assuming no unexpected circumstances happen. Phased implementation, usually taking place in one place at a time and one person or group at a time. A streamlined resource demand, the opportunity to concentrate on a specific module, the availability of existing legacy systems as a fallback, decreased risk, the knowledge acquired with each step, and the value of a proven functional system are all advantages of the strategy. The wave approach: This strategy applies several waves of change to various business divisions or geographical areas.

Parallel implementation

This strategy includes operating an existing system alongside ERP for a while. Instant cutovers (flip-the-switch): While this strategy is less expensive, it tends to be dangerous, stressful for users, and requires extensive contingency planning. It also eliminates the need for duplicate systems.

Evaluation of various ERP packages

The following factors are used to evaluate ERP packages: Flexibility: It should allow organisations to adjust rapidly by using changes to their advantage, allowing them to focus on strategically growing to take on new goods and markets. It ought to be used in all shapes, sizes, and professions.

It should have comprehensive characteristics in accounting and controlling, production and materials management, quality management and plant maintenance, sales and distribution, human resources management, and project management. Beyond the business: With customers, suppliers, banks, governments, and business partners, it should support and facilitate inter-enterprise business activities. It should also construct whole logistical chains that span the entire supply to delivery pathway across various locations, currencies, and business regulations from various nations. Best business practises: The software should make it possible to incorporate all business operations into a comprehensive system for planning, controlling, and monitoring.

It should also provide a selection of numerous pre-made business processes, including best business practises, which are based on the requirements, suggestions, and experiences of top companies across industries. In other words, it ought to be naturally rich in organisational and commercial knowledge [4]–[6]. Modern and future-proof technology should be included into product development, along with measures to assure interoperability with the Internet and other newer technologies. Examples include object orientation. Gather together; it should be Y2K and Euro compatible.

1. The package's existence worldwide is another issue to take into account.
2. Presence locally.
3. The package's target market.
4. The package's cost.
5. The package's obsolescence.
6. The package's ease of implementation.
7. The price of execution.
8. The availability of post-implementation assistance.

Post-Implementation

Let's start at the beginning and say that false expectations and concerns are the root of many post-implementation issues. Corporate management's hopes and worries for an ERP have been well documented. Of course, the ERP providers and their pre-implementation sales pitch share part of the responsibility for this. Several of the common anticipations are:

1. A boost to the procedures
2. A rise in output across the board.
3. Complete automation, including the elimination of all manual procedures.
4. An increase in each important performance metric.
5. Complete discontinuation of manual record-keeping.
6. On-demand real-time information systems for interested parties.
7. Complete operating integration.
8. The introduction of ERP also raises a lot of concerns. Among them is job redundancy.
9. Loss of significance since access to knowledge is no longer a personal choice.
10. A change in job description.
11. A concern inside the organisation for losing adequate authority and control.
12. More transparency leading to more stress.
13. An individual's concern of losing power.
14. It's crucial for the implementation process to strike a balance between expectations and worries.

Risk and governance issues in ERP

When companies switch to real-time, integrated ERP systems, they are exposed to a number of new business risks. The dangers consist of: Due to the fact that the organization's data and transaction processing are contained inside a single application system, there is a single point of failure. Reengineering or revamping business processes involves considerable structural changes to organizational and people frameworks.

Shifting Job Roles

From conventional user positions with limited access to real-time company information to empowered roles with significantly higher access. Online, real-time: A continuous business environment that can make use of the additional capabilities of the ERP application and react rapidly to any issue requiring the re-entry of information is needed for an online, real-time system environment.

Change Management

After so many years of disparate business procedures across business divisions, it might be difficult to adopt a closely linked environment. The system's degree of user acceptability has a big impact on how well it works. Users need to become more devoted and effective in the execution of their daily tasks as they must realise that their actions or inactivity directly affect other users. Therefore, for what is normally a high number of users, extensive training is needed. Experience with distributed computing: Lack of knowledge on how to develop and manage distributed computing technologies may provide serious difficulties. Wide-ranging system access: Increasing remote access by users and visitors as well as strong application function integration allow for enhanced application and data access. Reliance on outside support Organisations used to internal legacy systems may discover they must depend on outside aid. Such outside help might bring a security and resource management risk factor that could put the organisations at higher risk if it is not appropriately handled. Programme interfaces and data conversions: From legacy systems and other commercial software, extensive interfaces and data conversions are often required. There are thus often substantially larger exposures to data integrity, security, and capacity needs for ERP. To properly audit and govern an ERP system, specialised competence is needed. Due to the relative complexity of ERP systems, specialisation has resulted, and each expert may only be familiar with a tiny portion of the capability of the complete ERP in a certain core module.

Enterprise Resource Planning (ERP) Systems are coherent, integrated software programmes that can support a wide range of operational processes and business functions. They also serve as the central monitoring, control, and coordination mechanism for all activities carried out both at the headquarters and in the various remote locations of contemporary businesses. ERP systems achieve data centralization, integration of business software applications, and business process redesign through cutting-edge database and communication technologies and thorough coverage of a variety of business functions, all in the pursuit of process optimisation, productivity enhancements, and gaining a competitive advantage through innovative information technology. ERP Systems are the foundational transactional information platforms for successful businesses and organisations within the Information and Knowledge Society, enabling swift responses to difficulties arising from the dynamic business environment [7]–[10].

CONCLUSION

Business Process Reengineering (BPR) is an effective strategy that helps organizations to restructure their operational procedures and achieve significant gains in productivity and effectiveness. Organizations may reduce bottlenecks, simplify workflows, and use technology to promote innovation and improve customer satisfaction by rethinking and rebuilding processes from the bottom up. BPR uses a methodical approach that includes identifying processes that may be improved, examining and mapping present processes, imagining the ideal future state, and putting the redesigned processes into practice while using effective change management. Process automation, real-time data analysis, and communication are all made possible by technology, which may increase operational effectiveness and enhance decision-making. The success of BPR projects, however, also depends on efficient change management, which includes transparent communication, employee participation, and leadership support. Businesses that adopt BPR as a strategic strategy may gain revolutionary advantages including higher productivity, lower costs, better quality, and stronger competitiveness. Organizations may adjust to changing market circumstances, foster sustainable development, and achieve success by routinely evaluating and redesigning their processes.

REFERENCES

[1] B. U. Eze, S. A. Adelekan, and E. K. Nwaba, “Business Process Reengineering and the Performance of Insurance Firms in Nigeria,” *EMAJ Emerg. Mark. J.*, 2019, doi: 10.5195/emaj.2019.163.

[2] F. De Felice and A. Petrillo, “Optimization of Automotive Glass Production through Business Process Reengineering Approach,” *Procedia - Soc. Behav. Sci.*, 2013, doi: 10.1016/j.sbspro.2013.04.031.

[3] I. P. Tatsiopoulos and N. Panayiotou, “The integration of activity based costing and enterprise modeling for reengineering purposes,” *Int. J. Prod. Econ.*, 2000, doi: 10.1016/S0925-5273(99)00080-8.

[4] J. Hoffmann, “Reengineering of business processes with Industry 4.0 puts employees in focus | Reengineering der geschäftsprozesse mit industrie 4.0 stellt mitarbeiter in den fokus,” *ZWF Zeitschrift fuer Wirtschaftlichen Fabrikbetr.*, 2016.

[5] L. Fan, M. S. U. Rajib, and M. S. Alam, “Business Process Re-engineering in the SMEs□: Critical Success Factors Perspective of an Emerging Economy,” *Int. J. Contemp. Bus. Stud.*, 2012.

[6] I. I. Ishmuradova and A. M. Ishmuradova, “Stochastic modeling of economic activity of costs on Innovation of the organization of the Republic of Tatarstan, in the formation of business processes,” *Rev. PUBLICANDO*, 2017.

[7] J. Hoffmann, “Reengineering of business processes with Industry 4.0 puts employees in focus ,” *ZWF Zeitschrift fuer Wirtschaftlichen Fabrikbetr.*, 2016.

[8] T. Boudouh, “Reengineering of the design process: An industrial case,” in *IOP Conference Series: Materials Science and Engineering*, 2019. doi: 10.1088/1757-899X/564/1/012103.

[9] K. E. Salnikov, “Foreign experience in reducing the construction time,” *Финансы и управление*, 2020, doi: 10.25136/2409-7802.2020.4.34406.

[10] J. Hoffmann, “Reengineering der geschäftsprozesse mit industrie 4.0 stellt mitarbeiter in den fokus,” *ZWF Zeitschrift fuer Wirtschaftlichen Fabrikbetr.*, 2016, doi: 10.3139/104.111497.

CHAPTER 8

A REVIEW STUDY OF PRODUCTION ENVIRONMENTAL CHOICES

Dr. Ramachandra Gopal
Associate Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India.
Email Id: ramachandracg@presidencyuniversity.in

ABSTRACT:

The impact of consumer preferences on the development and manufacturing processes, with an emphasis on environmental considerations. It looks at how consumers may influence sustainable design principles and emphasizes the need of taking into account customer preferences while developing environmentally friendly goods. The research also analyses the advantages and disadvantages of client input on design and manufacturing choices. Businesses may create plans to fulfil the rising demand for sustainable goods by studying the effect of consumer influence on purchasing decisions. This study investigates the significance of client input in the design process and how it affects the creation of new products. It looks at the advantages of actively including clients in the design process to produce goods that are more in line with their wants and preferences. Customers' input may help businesses get insightful information, improve product innovation, and boost customer happiness. This study seeks to give a thorough knowledge of consumer impact in design and provide suggestions for successfully integrating user participation into the process of product creation.

KEYWORDS:

Customer Influence, Design, Production, Environmental Choices, Sustainable Design, Customer Preferences.

INTRODUCTION

Along with the above listed considerations, other elements will also have an influence on how the planning and control system is designed. The volume and diversity of the anticipated output are two of the most important ones, and those concerns are often greatly influenced by the degree of the customer's input into the design of the good or service they get through the organization's operations. The problem of consumer design influence is sometimes a component of the company's fundamental strategy, but sometimes it's a response to market forces. For instance, a lot of cars are bought off a dealer's lot as completed items since the consumers don't want to wait for a car that is ordered with the precise features they desire. The following categories, given below in order of impact, from less to greater, seem to indicate the level of consumer influence:

MTS, or make-to-stock. These things are totally created into their ultimate shape, as the name suggests, and are then stored as completed goods. An individual consumer has basically just one choice when the product is manufactured: whether to buy it or not. The general customer base may have some effect on the overall design during the early product design phase. Once again, modifications in general product design may result from these buying patterns, although not generally in the case of a single client. Hardware, apparel, office supplies, and other items may be found in almost all retail outlets as examples of these things [1]–[3].

Make-to-Order (MTO) assembly. In this situation, the client has a little more say in the design since they may often choose from a variety of possibilities from predesigned subassemblies.

The producer will then put these choices together to create the finished item for the buyer but each buyer is limited to choose from the possibilities that are listed. These items include, for example, cars and personal computers. For instance, when a buyer gets a car from a dealer, they often have a selection of colours, body types, engines, gearboxes, and other "pure" extras, like cruise control. Because the packaging is chosen by the consumer, this strategy is frequently referred to as "Package-to-Order" in particular sectors of the economy. Breakfast cereals and baking goods (flour, baking soda, etc.) are examples of items where the product itself does not vary but may be packaged in a variety of ways depending on the needs of the consumer. In certain restaurants, the client may choose the side dishes they would want to accompany their meal, which is an example of an ATO service. They may not have much control over how those side dishes are made, but they do have some control over which ones they choose.

MTO, or make to order. Given that standard raw materials and components are used, the client is free to select the precise design of the finished product or service in this setting. A bakery or specialised furniture manufacturer are two examples. For instance, a client at a bakery may request that a particular cake be made for a birthday or anniversary. Although they could be limited to certain cake pan sizes, cake flavourings, etc., they have a wide range of design possibilities for the cake and its embellishments. ETO (engineer-to-order). In this scenario, the consumer has practically total control over how the product or service is designed. They often don't even have to stick to using common raw materials or components; they might request that the manufacturer supply something that has been "from scratch" developed.

DISCUSSION

Process Categories

The type of the customer influence problem mentioned above has a significant effect on both the design of the product or service and the procedure utilised to provide the product or service. Though there are many variations of these fundamental kinds in practise, there are basically just five categories presented to define the manufacturing process. The five standard categories are:

Project. A project-based process usually expects a unique production outcome, such constructing a new structure or creating a new software programme. Large-scale projects are often handled by teams of people that have been assembled for this one-time task based on their unique skill sets. Because they are so specialised, the planning and control methods of project management are not discussed in this book.

The reader is directed to one of the numerous excellent sources that are particularly concerned with project management, such as "5-Phase Project Management" by Weiss and Wysocki. Task Process. The majority of the time, job procedures (job shop processes) are flexible. Since the machinery is often all-purpose, it may be used to a variety of manufacturing needs. The ability to provide the output in accordance with the customer's specifications is often concentrated on the employees, who tend to be highly competent in a job process. As in an ETO or MTO design environment, this environment is often focused on the manufacture of a wide range of particular production needs. The wide range of design demands adaptable procedures and a team with better competencies. Due of the wide range of designs for each assignment, work in these locations frequently proceeds in a highly "jumbled" manner. Information links often are informal and loose due to the wide variation in design and task needs. 5 Batch or Intermittent Processing. Examples are a general-purpose machine shop, a speciality bakery, or a caterer. These "middle of the road" manufacturing facilities make up a large portion of the global industrial infrastructure today. While still versatile enough to provide some variability in design, the equipment has a tendency to be more specialised than that in workshops. The employees often do not need to be nearly as competent as the workers in the job shops since much of the "skill" required to make the product resides in the more specialised equipment. These businesses often have similar groups of equipment and human abilities, which forces the processing of the task to migrate from one region to another. Since items are often produced in small quantities, the category is sometimes referred to as batch. For instance, a batch procedure may create hundreds of the same product model over the course of several hours before switching the setup to create another batch of a slightly different product model. However, this environment is often well suited to the ATO environment. others batch operations may yield MTO and others MTS. Clothing, bicycles, furniture, and other items are just a few examples of the things that have been produced in this setting.

Process flow or repetition. As suggested by its name, this kind of process facility is often utilised for a very high volume of a relatively limited variety of designs. The labour that is engaged tends to be unskilled and the equipment is often very specialised and costly. The cost of the specialised equipment is classified as an overhead cost, which enables a broad distribution of the relatively fixed cost. Due to the decreased cost per item, it is priced competitively. For make-to-stock (MTS) designs, such as refrigerators and other appliances, repetitive processing is often used. Similar to project processing, continuous processing is at the far end of the processing spectrum, focusing on very niche applications. Since the equipment is highly specialised, minimal labour is often required. petroleum refining and large-scale chemical processes. The fact that certain items are produced in "hybrid" operations which may be conceived of as mixes of these common categories should be recognized despite the fact that these are the common forms. For instance, certain chemicals may be manufactured continuously, but they may afterwards be packaged in a batch setting. The distinctions between the middle three categories of processes job process, batch, and repetitive are outlined [4]–[6].

There are various additional consequences for planning and control that will need their being highly customised and unique for these kinds of processing settings. Depending on the sort of production environment, almost every area of planning and control will be affected. Robert Hayes and Steven Wheelwright created the Hayes-Wheelwright Product/Process Matrix some years ago as a simple method to show the variations in volume and diversity pertaining to the different process types. The horizontal axis of which is a sample of the matrix, displays the spectrum of goods from those with a lot of design diversity and low quantities (MTO) to those with limited design variety and big volumes (MTS). The spectrum of processes, from those with general-purpose machinery and variable flow to those with fixed flow, is shown on the vertical axis. The diagonal displays the ideal processing method that is often used to each kind of product.

It should be highlighted that although it is not always unwise from a commercial standpoint, manufacturing a product or service off the diagonal is not impossible. It is more important to avoid producing off the diagonal than it is to say one cannot. Perhaps using an illustration. Consider a quarter-pound hamburger made at a fast-food establishment. Given that it is often manufactured at a fast-food restaurant using a pretty strict, repetitive method, it would fall into the bottom right-hand quadrant of the matrix. Now, one would wonder whether a high-end, gourmet restaurant could likewise make such a hamburger. They would undoubtedly possess the tools and expertise necessary to make such a good, but doing so would put them in the top right-hand quadrant. The highly trained and costly labour at such a restaurant, which represents an opportunity cost (such expert labour might be better used to make a meal with higher profit margins), is what accounts for the increased cost in this scenario. In this instance, they were able to make the goods, but they were unable to successfully compete in the price-sensitive market typical of a regular, high-volume product. The possibility is there, but doing so would undoubtedly require spending money on staff training programmes and equipment. Therefore, it could be feasible, but not without significant additional expenses.

Business Environment Issues

The discussion above has a lot to say about how important it is for a producer to comprehend their market(s) and design their systems to at least meet the minimum level of criteria for the order qualifiers in their market, while also striving to be the best in those dimensions that represent order winners. While it would seem like a rather straightforward strategy at first glance, there are a few complications. They consist of: Consumer "learning." Competitors often try to approach the market similarly to one another (emphasising similar competitive aspects), but sometimes one of them may try to win market share by highlighting how they are the "best" at it. The customer's expectations may vary as a result of this. For instance, if consumers place orders based on delivery speed, manufacturers may alter their processes to increase delivery speed. As a result, customers may start to anticipate ever-shorter delivery times, so "raising the bar" for all businesses in the market. Moves made by rivals. Order winners may be disqualified by rival moves, which convert them into qualifiers and create new order winners. Take pricing as an example of an order winner in a market.

Competitors have been working hard to reduce expenses, enabling them to offer cheaper pricing. Assume that the rivals have all established cost controls to the point where consumers see very little pricing difference. In a market like this, people can start to notice other order winners like delivery time. If all competitors provide prices that are relatively comparable but one offers a much quicker delivery, then delivery speed may now determine the order winner, leaving price as a criterion. Effective marketing and advertising strategies may sometimes alter consumers' perspective of what matters most when placing a purchase. It's probable that the majority of businesses serve various markets with a variety of goods or services. In such circumstances, there may be a wide variety of order qualifiers in a wide variety of marketplaces, all of which may be vulnerable to the modifications mentioned in the previous two sections. The systems of planning and management at the organization must successfully support all markets in order for the manufacturer to be effective [7]–[10].

Changes to product design. Order winners and qualifiers often change as a result of new goods and design modifications, particularly when technology alters consumer expectations. How Internet technology has changed consumers' perceptions of how to buy numerous products and services is an excellent illustration of this. There will be multiple references to various methods for developing and managing the planning and control of an operation that will be influenced by a number of these challenges as the discussion in subsequent chapters moves forward. For instance, a firm competing on pricing may handle inventory and capacity quite differently from a company competing on delivery time. Due to the expense, businesses engaged in price competition could choose to maintain very little spare capacity or inventory, yet doing so might slow down delivery times. On the other hand, a business that competes on delivery may be prepared to incur the added expense of buffer inventory or capacity to guarantee they can satisfy the customer's expectation of delivery speed.

CONCLUSION

Particularly when it comes to environmental decisions, customer input is vital in determining how design and manufacturing processes are to be carried out. Businesses may match their designs with sustainability objectives and produce environmentally friendly goods that satisfy consumer demand by including client preferences into the early phases of product development. Customers' essential input and suggestions may help businesses make better decisions that result in better product designs and better environmental performance. The importance of client input in the design process and its beneficial effects on product development are highlighted in this study. Companies may use consumers' preferences and insights to build goods that better meet their demands by actively including them in the design process. The research emphasizes the advantages of user participation, such as enhanced innovation, more consumer happiness, and a lower chance of product failure. Additionally, it offers guidance on how to integrate user surveys, focus groups, and co-creation methods into the design process to successfully include client involvement. Businesses may gain a competitive advantage by offering goods that connect with their target market, cultivating brand loyalty, and promoting company success by adopting customer-centric design practises.

REFERENCES

[1] R. Subramanian, S. Gupta, and B. Talbot, “Product design and supply chain coordination under extended producer responsibility,” *Prod. Oper. Manag.*, 2009, doi: 10.1111/j.1937-5956.2009.01018.x.

[2] B. Melović, M. Dabić, S. Rogić, V. Đurišić, and V. Prorok, “Food for thought: Identifying the influential factors that affect consumption of organic produce in today’s youth,” *Br. Food J.*, 2020, doi: 10.1108/BFJ-10-2019-0761.

[3] I. Schäufele, D. Pashkova, and U. Hamm, “Which consumers opt for organic wine and why? An analysis of the attitude-behaviour link,” *Br. Food J.*, 2018, doi: 10.1108/BFJ-03-2018-0141.

[4] L. Chen, C. Ding, and F. Wu, “Auxiliary decision-making of enterprise green innovation under the background of environmental regulation,” *Chem. Eng. Trans.*, 2016, doi: 10.3303/CET1651138.

[5] S. Y. Huh, D. Kwak, J. Lee, and J. Shin, “Quantifying drivers’ acceptance of renewable fuel standard: Results from a choice experiment in South Korea,” *Transp. Res. Part D Transp. Environ.*, 2014, doi: 10.1016/j.trd.2014.08.006.

[6] J. Sanskrity, G. K. Deshmukh, and G. Saluja, “Go Green Initiatives of Customers: An Introspection of Myths or Reality.,” *Glob. J. Emerg. Trends e-Business, Mark. Consum. Psychol.*, 2016.

[7] P. R. D. Elivery, S. T. C. Onversion, a P. P. U. E. Ducation, and O. Utreach, “N Ational H Ydrogen,” *Energy*, 2002.

[8] L. L. Schramm, *Innovation Technology*. 2017. doi: 10.1515/9783110429176.

[9] G. Jungmeier, “The Biorefinery Fact Sheet,” *Int. J. Life Cycle Assess.*, 2017.

[10] U.S. Report, “National Hydrogen Roadmap,” 2002.

CHAPTER 9

ANALYSIS OF APPROPRIATE MATERIALS FOR PRODUCTION: ENHANCING EFFICIENCY AND QUALITY IN MANUFACTURING

Mr. A Neeraj
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India.
Email Id: neeraj@presidencyuniversity.in

ABSTRACT:

This study examines how important materials are to production and how they affect the manufacturing process. To maximise productivity and guarantee product quality, it looks at the choice, sourcing, inventory management, handling, and quality control of materials. In contemporary production systems, the research emphasises the value of sustainable practises, waste minimization, and material traceability. Metals, ceramics, and polymers are the three main groups into which most engineering materials may be divided. A compound that contains both metallic (or semimetallic) and nonmetallic components is referred to as a ceramic. These three elements are examples of nonmetallic elements. Various conventional and contemporary materials are used in ceramics. Alumina and silicon carbide are two abrasives that are used in grinding. Their various chemistry, mechanical, and physical characteristics have an impact on the manufacturing procedures that may be employed to create goods from them. Along with the three fundamental categories, there are Typically, metals used in manufacturing are alloys made up of two or more elements. This study attempts to provide perceptions and suggestions for enhancing materials management in production via a thorough investigation of best practices and case studies.

KEYWORDS:

Materials in production, Manufacturing Processes, Inventory Management, Quality Control, Sustainable Practices.

INTRODUCTION

Metals, ceramics, and polymers are the three main groups into which most engineering materials may be divided. Their various chemistry, mechanical, and physical characteristics have an impact on the manufacturing procedures that may be employed to create goods from them. Along with the three fundamental categories, there are Typically, metals used in manufacturing are alloys made up of two or more elements, with at least one of those components being a metallic element. Ferrous and nonferrous are the two primary categories into which metals and alloys may be categorised [1], [2].

Ferrous Metals

Steel and cast iron are examples of ferrous metals, which are based on iron. With more than three-fourths of the global metal tonnage falling under this category, these metals are the most significant group in terms of commerce. Iron has fewer uses in industry than any other metal, but when it is alloyed with carbon, it has additional applications and a higher market value. Steel and cast iron are made of iron and carbon alloys. An iron-carbon alloy with 0.02% to 2.11% carbon is known as steel. Within the group of ferrous metals, it is the most significant category. To improve the metal's characteristics, its composition often also contains alloying metals including manganese, chromium, nickel, and molybdenum. Steel is used in a variety of industries, including building (bridges, I-beams and nails), transportation (trucks, rails and railway rolling stock) and consumer goods (automobiles and appliances).

A casting material, typically sand casting, called cast iron is an alloy of iron and carbon (2% to 4%). In order to achieve appropriate qualities in the cast component, additional elements are often added to the alloy (in concentrations ranging from 0.5% to 3% silicon content). The most popular kind of cast iron is grey cast iron, which is available in a variety of colours and is used for internal combustion engine blocks and heads. Metallic Non-Ferrous The remaining metallic elements and their alloys are nonferrous metals. The commercial importance of alloys is often greater than that of pure metals. The pure metals and alloys of aluminium, copper, gold, magnesium, nickel, silver, tin, titanium, zinc, and other metals are considered nonferrous metals [3], [4].

Ceramics

A compound that contains both metallic (or semimetallic) and nonmetallic components is referred to as a ceramic. These three elements are examples of nonmetallic elements. Various conventional and contemporary materials are used in ceramics. Alumina and silicon carbide are two abrasives that are used in grinding. Traditional ceramics, some of which have been used for thousands of years, also include clay abundantly available, consisting of fine particles of hydrous aluminium silicates and other minerals used in making brick, tile, and pottery silica (the basis for nearly all glass products and silicon.Some of the elements mentioned above, such alumina, are used in contemporary ceramics. These materials' characteristics have been improved in different ways using current processing techniques. Nitrides metal and semimetal nitrides such as titanium nitride and boron nitride, used as cutting tools and grinding abrasives—and carbides—metal carbides such as tungsten carbide and titanium carbide, which are extensively utilised as cutting tool materials are examples of newer ceramics. Ceramics may be separated into crystalline ceramics and glasses for processing reasons. For the two varieties, different production processes are needed. Different processes are used to create crystalline ceramics from powders, which are subsequently fired (heated to a temperature below the melting point to establish bonding between the granules). The glass ceramics (specifically, glass) may be melted, cast, and then moulded using techniques like classic glass blowing.

Polymers

A polymer is a substance made of mer units repeating structural units whose atoms share electrons to create extremely big molecules. Carbon is often combined with one or more additional elements, such as chlorine, hydrogen, nitrogen, and oxygen. Thermoplastic polymers, thermosetting polymers, and elastomers are the three divisions of polymers. Multiple heating and cooling cycles may be applied to thermoplastic polymers without significantly changing their molecular structure. Polyethylene, polystyrene, polyvinyl chloride, and nylon are examples of common thermoplastics. The word "thermosetting" comes from the way that thermosetting polymers chemically change (cure) from a heated pliable state to a rigid structure when they are cooled. Epoxies, amino resins, and phenolics are examples of this kind of material. Despite having the moniker "thermosetting," several of these polymers cure by methods other than heating. The term "elastomer" refers to polymers that display noticeable elastic behaviour. They consist of silicone, polyurethane, neoprene, and natural rubber [5], [6].

Composites

Composites are really blends of the other three categories of materials and do not truly belong in their own category. A composite is a material made up of two or more phases that have undergone distinct processing steps before being fused together to provide characteristics that are better than those of the individual phases. A homogenous mass of material, such as an accumulation of grains with the same unit cell structure in a solid metal, is referred to as a phase. The matrix is the second phase that is combined with fibres or particles from the first phase to form the typical structure of a composite.

Composites may be created synthetically or found in nature (such as wood). The synthetic type is more pertinent in this case and includes ceramic in a metal matrix, such as tungsten carbide in a cobalt binder to create a cemented carbide cutting tool, polymer fibres of one type in a matrix of a second polymer, such as an epoxy-Kevlar composite, and fiber-reinforced plastic. The components of a composite, their physical forms, and the manner they are put together to create the final product all affect the properties of the composite. Some composite materials are well suited for use in tennis rackets, fishing rods, vehicle bodywork, boat hulls, and aviation parts because they combine great strength with low weight. Other composites, such as cutting tools made of cemented carbide, are robust, durable, and able to retain these qualities at high temperatures [7]–[9].

Manufacturing Processes

A manufacturing process is a planned action that alters a beginning material physically, chemically, or both, with the goal of raising the substance's value. The majority of the time, a manufacturing process is carried out as a unit operation, which is a single step in the series of actions needed to convert the raw material into the finished product. Processing activities and assembly operations are the two major categories into which manufacturing operations fall. A processing action moves a work product from one stage of completion to one that is farther along and more similar to the anticipated end result. By altering the geometry, characteristics, or appearance of the initial material, it adds value. Most processing activities are carried out on discrete workparts, however certain processing processes (such painting a spot-welded automobile body) are also relevant to assembled objects. To produce a new entity known as an assembly, subassembly, or another name that relates to the joining technique (for example, a welded assembly is known as a weldment), two or more components are joined during an assembly operation. On the DVD that comes with this book, you may see a lot of the production procedures that are discussed in this text. Throughout the text, alerts are given for these video snippets. Some of the fundamental procedures utilised in contemporary production have roots in antiquity.

Processing Operations

An energy-based processing procedure modifies the form, physical characteristics, or appearance of a workpart to increase the material's value. Mechanical, thermal, electrical, and chemical energy are among the available forms. Machinery and tools are used to apply the energy in a regulated manner. Although human labour may sometimes be necessary, it is more common for people to be hired to operate machinery, supervise activities, and load and unload materials before and after each cycle of operation. a general representation of a processing procedure.Material is introduced into the process, energy is used by the equipment and tooling to change the material, and the finished workpart leaves the process. The majority of industrial processes result in trash or scrap, either as an inevitable byproduct (such as the removal of material during machining) or sometimes faulty parts. The goal of manufacturing is to decrease waste in any of these forms.

Usually, more than one processing step is needed to convert the raw material into the finished product. The procedures are carried out in the precise order necessary to accomplish the geometry and condition specified by the design specification. Shape-changing operations, property-improving activities, and surface-processing operations are the three distinct kinds of processing operations.Various techniques are used during shaping operations to change the initial work material's geometry. Casting, forging, and machining are typical shaping techniques. By strengthening the material's physical characteristics without altering its form, property-enhancing activities give value to the material. The most prevalent example is heat treatment. To clean, treat, coat, or deposit material onto the outside surface of the work, surface processing procedures are carried out. Painting and plating are typical coating examples [10], [11].

The majority of shape processing processes alter the geometry of the work material by using heat, mechanical force, or a combination of these. The shaping processes may be categorised in a number of different ways. This book's categorization is based on the condition of the raw materials, and there are four categories as a result: There are four types of processing: (1) solidification processes, where the starting material is a heated liquid or semifluid that cools and solidifies to form the part geometry; (2) particulate processing, where the starting material is a powder and the powders are formed and heated into the desired geometry; (3) deformation processes, where the starting material is a ductile solid (typically metal) that is deformed to shape the part; and (4) material removal processes, where the starting material is a heated liquid or semi. In the first category, the initial substance is heated long enough to for it to become liquid or extremely plastic (semifluid). In this manner, almost any material may be treated. Plastics, ceramic glasses, and metals can all be heated to temperatures high enough to melt them into liquid form.The material may be pushed to flow into a mould cavity while still in a liquid or semifluid state and then allowed to solidify, taking on a solid shape that matches the cavity. The majority of these procedures are referred to as moulding or casting. Metals are referred to as "casting," while polymers are referred to as "moulding" of shaping processes.

Metal or ceramic powders serve as the starting materials in particle processing. Although these two materials vary greatly from one another, particle processing techniques used to form them are quite similar. In the typical method, powders are first crushed into a die cavity under high pressure and then heated to fuse the individual particles together. Deformation techniques include applying pressures to the beginning workpiece that are greater than the material's yield strength. To promote ductility (and for other reasons), the work material is often heated before forming to a temperature below the melting point. For the material to be formed in this method, it must be sufficiently ductile to prevent fracture during deformation.

Surface Processing

Cleaning, surface treatment, thin film deposition, and surface processing techniques are all included. Cleaning is the process of removing pollutants from a surface using mechanical and chemical methods. Mechanical operations like shot peening and sandblasting as well as physical procedures like diffusion and ion implantation are examples of surface treatments. The outside surface of the work part is covered with a coating of material using coating and thin film deposition methods. Common coating techniques include porcelain nameling, anodizing aluminum, organic coating (also known as painting), and electroplating. Physical vapour deposition and chemical vapor deposition are examples of thin film deposition methods used to create very thin coatings of different materials. In order to manufacture semiconductor materials into integrated circuits for microelectronics, a number of surface-processing processes have been modified. These procedures include oxidation, chemical vapour deposition, and physical vapour deposition. To build the minuscule circuit, they are applied to extremely specific regions on the surface of a thin silicon or other semiconductor material wafer.

Assembly Operations

Assembly is the second fundamental kind of manufacturing activity, in which two or more independent pieces are combined to create a new thing. The new entity's parts are joined either permanently or semi permanently. Welding, brazing, soldering, and adhesive bonding are permanent connecting procedures. They create a junction between parts that is difficult to separate. There are a few mechanical assembly techniques that may be used to link two (or more) pieces in a junction that is easily detachable. The employment of bolts, screws, and other threaded fasteners is a crucial conventional technique in this group. Other methods of mechanical assembly, such as rivets, press fitting, and expansion fits, provide a more durable connection. When assembling electrical goods, unique joining and fastening techniques are utilised. Some of the techniques, such soldering, are similar to or modifications of the preceding procedures. Electronics assembly largely focuses on the joining of parts, including integrated circuit packages and printed circuit boards, to create the intricate circuits seen in so many modern goods.

Production Machines and Tooling

Equipment used in production might be common or specialized. Equipment designed for general use is more adaptive and versatile. Any manufacturing business may invest in it since it is commercially accessible. Special purpose machinery is often designed to manufacture a certain component or commodity in enormous numbers. The economics of mass production allow for significant expenditures in specialized equipment that produces goods at high efficiency and with short cycle times. Special purpose equipment is used for a variety of reasons, although this is the main one. The procedure being unique and the lack of commercially accessible equipment might be another factor. Some businesses with particular processing needs create their own specialized machinery.

Typically, production machinery needs tooling to be tailored to the specific component or product. The tooling often has to be created particularly for the component or product configuration. It is designed to be swapped when used with general purpose equipment. The tooling is attached to the machine and the production run is completed for each kind of work part. The tooling is switched for the next work part type when the run is finished. The tooling is often made to function as an integrated element of the machine when utilized with special purpose machines. The tooling may never need to be changed since the special purpose machine is likely to be utilized in production, with the exception of replacing worn components or repairing worn surfaces. The kind of manufacturing process determines the kind of tooling used. Examples of specialized equipment used in different processes.

Production Systems

A manufacturing company needs systems that enable it to carry out its sort of production successfully if it is to function well. Production systems are made up of personnel, tools, and protocols created for the many materials and processes that make up a company's production activities. how production systems may be separated into two categories: (1) production facilities, and (2) manufacturing support systems. Production facilities relate to the actual machinery and how it is set up in a plant. Systems for managing production and resolving logistical and technical issues with buying supplies, moving work through the plant, and ensuring that goods meet quality requirements are known as manufacturing support systems. There are persons in both groups. These systems are operated by people. The operation of manufacturing machinery is often the responsibility of direct laborer’s, whereas manufacturing support is typically the responsibility of professional staffers.

Production Facilities

Production facilities are made up of the factory as well as its production, material handling, and other machinery. While being manufactured, the machinery comes into direct physical touch with the components and/or assemblies. The equipment "touches" the product. The layout of the plant, or the arrangement of the equipment in the factory, is another component of facilities. Typically, the equipment is grouped logically into manufacturing systems, such as an automated production line or a machine cell made up of two machine tools and an industrial robot. A manufacturing business makes an effort to organise its factories and build its production systems in a manner that best serves the unique goal of each facility.

several kinds of production facilities have come to be recognized as the best method to organize for a particular combination of product diversity and production volume. For each of the three ranges of yearly production numbers, different facilities are needed. Low Volume Production The term "job shop" is often used to designate the kind of manufacturing facility in the low-quantity range (1-100 units/year). A work shop produces specialized, one-of-a-kind goods in small numbers. Complex items like prototype aero planes, space capsules, and specialised equipment are often produced. In a work shop, the labour force is highly skilled and the equipment is all-purpose. For optimal adaptability to handle the many product variants encountered (hard product variety), a work shop must be created. The product usually stays in one place throughout its manufacturing or assembly if it is huge and heavy and hence difficult to transport.

Instead of transporting the product to the equipment, workers and processing machinery are transported to the product. A fixed-position layout is the kind of arrangement. In a pure scenario, the product stays in one place throughout the course of manufacture. Ships, aeroplanes, locomotives, and heavy equipment are a few examples of these items. Theseitems are often constructed in big modules at a single place and then hauled together for final assembly utilising high-capacity cranes. These enormous goods' constituent parts are often produced in factories with equipment set up according to kind or purpose. This configuration is known as a process layout. the lathes are in one department, the milling machines in another, and so on. distinct components, each needing a distinct order of operations, are sent through the departments in the precise order required for their processing, often in batches. The process plan is praised for being adaptable; it can take into account a wide range of operation sequences for various component combinations.

Mass manufacturing refers to the large quantity range (10,000 to millions of units per year). The manufacturing system is devoted to producing that one item, and the scenario is characterised by a high rate of demand for the product. Quantity production and flow line production are the two main types of mass manufacturing. Mass manufacture of individual components for unique pieces of machinery is referred to as quantity production. It often entails common machines (like stamping presses) outfitted with specialised tooling (like dies and material handling equipment), thereby committing the machinery to the manufacture of a single component type. The process layout and cellular layout are typical layouts used in mass manufacturing. Multiple pieces of machinery or workstations are organised in a flow-line pattern during flow line manufacturing, and the work units are physically moved through the pattern to finish the product. In order to maximise productivity, the workstations and equipment have been specially created for the product. Workstations are placed into a single continuous line, or into a succession of linked line segments in this configuration, which is known as a product layout. Typically, a mechanised conveyor is used to carry the work between stations. A little portion of the overall work on each unit of the product is completed at each station.

The assembly line, which is connected to goods like automobiles and home appliances, is the most well-known illustration of flow line manufacturing. When there is no variance in the items produced on the line, flow line production is said to be pure. The line is referred to as a single model manufacturing line since each product is identical. It is often advantageous to create feature and model variants for a particular product in order to effectively sell it. This allows different buyers to choose the precise goods that appeal to them. The feature variations are an instance of soft product diversity from a manufacturing standpoint. When there is a mild variation in the items produced on the line, the phrase "mixed-model production line" is used.An example is the assembling of modern automobiles. When a vehicle leaves the production line, it may have varied trim and choices that indicate multiple models or, often, different nameplates of the same fundamental automobile design.

DISCUSSION

Manufacturing Support Systems

A corporation must organize itself to design the processes and equipment, plan and manage the production orders, and fulfil product quality criteria in order to run its facilities effectively. Manufacturing support systems the people and processes a firm uses to manage its production operations perform these tasks. Most of these support systems plan and regulate how the product moves around the production without coming into direct touch with it. People assigned to departments like the following often perform manufacturing support responsibilities in the company: engineering for manufacturing. The planning of the manufacturing processes choosing which procedures should be employed to create the components and put the products together resides with the manufacturing engineering department. Additionally, this division is responsible for developing and procuring the machinery and other equipment that the operational divisions employ for processing and assembly. Planning and managing the production process. Ordering supplies and bought components, scheduling production, and ensuring that the operational departments have the required capacity to fulfil the production schedules are all tasks that fall within this department's purview. quality assurance. Any manufacturing company should place a high premium on producing high-quality goods in the current market. It entails creating goods that adhere to requirements and meet or surpass client expectations. The QC department is in charge of most of this work.

Lean Production and Six Sigma

These two initiatives are meant to increase manufacturing's effectiveness and standard of living. They respond to consumer desires for items to be both inexpensive and of excellent quality. Lean and Six Sigma have become popular due to how many businesses, particularly in the US, are implementing them. The Toyota Production System, created by Toyota Motors in Japan, is the foundation of lean manufacturing. Its beginnings may be traced back to the 1950s, when Toyota started using novel techniques to improve quality, lower inventory, and enhance operational flexibility. Doing more work with less resources' is a simple definition of lean production. It entails using fewer employees and less equipment to produce more in less time while maintaining a greater level of quality in the finished product. The reduction of waste is the core goal of lean manufacturing. The seven types of waste in production identified by the Toyota Production System are: (1) producing defective parts, (2) producing more parts than needed, (3) maintaining excessive inventories, (4) performing unnecessary processing steps, (5) moving workers needlessly, (6) moving materials needlessly, and (7) keeping workers waiting. Toyota employs tactics for mistake prevention, pausing a process when anything goes wrong, enhanced equipment maintenance, integrating employees in process improvements (so-called continuous improvement), and standardizing work practices among other strategies to decrease waste. The just-in-time delivery system, of n production and inventory management, was perhaps the most significant advancement. At Motorola Corporation in the United States, Six Sigma was first used in the 1980s. The goal was to boost customer satisfaction by reducing unpredictability in the business's procedures and products. Six Sigma is now understood to be "a quality-focused programme that uses worker teams to complete projects aimed at improving an organization's operational performance.

Globalization And Outsourcing

As the globe becomes increasingly linked, barriers that were once imposed by national borders have been diminished or abolished. As a result, there is now a freer movement of people, money, technology, and products across different areas and nations. This tendency, which was identified in the late 1980s and is now a dominating economic reality, is referred to as globalisation. It's interesting to note that once undeveloped countries like China, India, and Mexico have advanced their manufacturing technology and infrastructure to the point that they are now significant producers in the world economy. These three nations in particular benefit from having huge populations (and a correspondingly large labour pool) and cheap labour costs.Hourly wages in the United States are now an order of magnitude or more higher than in these nations, making it challenging for domestic U.S. enterprises to compete in many goods with a high labour content. Examples include clothing, furniture, many toys, and electrical equipment. As a consequence, the United States has lost manufacturing jobs, while these other nations have gained employment in related fields. Outsourcing and globalisation are strongly connected. Outsourcing in the manufacturing industry refers to the employment of outside contractors to carry out tasks that were previously completed internally. Using local vendors is one of the many methods of outsourcing. In this instance, the employment are still located in the US.

As an alternative, American businesses may outsource their work to other nations, which would result in the manufacture of components and goods that were formerly produced domestically. In this situation, American jobs are lost. There are two options: (1) offshore outsourcing, which describes the production of goods in China or other foreign countries and their shipment to the United States by cargo ship, and (2) near-shore outsourcing, which describes the production of goods in Canada, Mexico, or Central America and their shipment to the United States by rail or truck.

Due to its rapidly expanding economy, the significance of manufacturing therein, and the volume of work that American businesses have outsourced to China, China is a nation of special relevance in this topic of globalisation. American businesses have outsourced a large portion of their manufacturing to China (and other east Asian nations) in order to benefit from the cheap labour costs. It has led to cheaper expenses and larger profits for the outsourcing corporations as well as lower prices and a broader choice of items for American customers, despite the logistical issues and costs of getting the goods back into the country. The loss of lucrative manufacturing employment in the United States has been a drawback. The percentage contribution of the manufacturing sector to GDP has decreased as a result of American outsourcing to China. About 20% of the US GDP in the 1990s was made up of the manufacturing industry. This donation is currently less than 15%. At the same time, China's manufacturing industry has expanded along with the rest of the economy and now makes up almost 35% of the country's GDP. China's manufacturing sector is still smaller than the United States since its GDP is nearly three times greater. However, China leads the globe in a number of sectors. The combined outputs of the following six countries that produce the most steel, namely Japan, the United States, Russia, India, South Korea, and Germany, are less than its total steel production in tonnes.4 Aside from that, China is also the biggest manufacturer of metal castings, producing more tonnes than the next three biggest producers (the United States, Japan, and India, in that order.

Environmentally Conscious Manufacturing

Waste is an integral part of almost all production processes The most apparent instances are chip removal operations, in which a beginning workpiece is chipped away to produce the required component shape. Almost all manufacturing processes produce waste in some shape or fashion. Power is a further inevitable component of production that is necessary to complete any given process.That energy must be produced using fossil fuels, which when burned cause environmental damage (at least in China and the United States).

A product is produced at the conclusion of the production process and is then sold to a consumer. The product eventually wears out and is discarded, maybe in a landfill, leading to environmental deterioration. The environmental effects of human activity worldwide and how modern civilization is using our natural resources at an unsustainable pace are topics that society is becoming more and more concerned about. The current state of global warming is of great concern. The manufacturing sectors are a part of these issues.

Environmentally responsible manufacturing refers to initiatives that aim to identify the best ways to utilise resources and materials during production while minimising any negative effects on the environment. Green manufacturing, cleaner production, and sustainable manufacturing are further words used to describe these programmes. They can all be boiled down to two fundamental strategies: designing goods with little environmental effect and designing processes with minimal environmental impact. The natural place to start with environmentally responsible production is with product design. When trying to take environmental effect into account during product design before manufacturing, a process is frequently referred to as "design for environment" (DFE).

In DFE, the following factors are taken into account: choose materials with low energy requirements, choose procedures with little energy and material waste, Designing items that can be easily dismantled to retrieve the components, minimising the use of dangerous and poisonous materials, and paying care to how the product will be disposed of at the end of its useful life are all examples of good product design.

The materials and methods utilised to create the product are heavily influenced by design choices. The alternatives accessible to the manufacturing divisions to achieve sustainability are constrained by these choices. To improve the environmental friendliness of plant operations, many strategies may be used. These are a few of them: Adopt good housekeeping practices to keep the factory clean, stop pollutants from entering the environment rivers and atmosphere reduce material waste in unit operations, recycle waste materials instead of throwing them away, use net shape processes, use renewable energy sources when possible, maintain production equipment to ensure maximum efficiency, and purchase equipment that uses the least amount of power.

CONCLUSION

This study's findings emphasise the need of good materials management in manufacturing for raising productivity and preserving product quality. The research emphasises the significance of choosing proper materials, creating trustworthy sourcing channels, and putting effective inventory management strategies into practise. It emphasises the need of adequate handling, storage, and quality control procedures to safeguard against material damage and guarantee specification compliance. The study also emphasises the significance of waste reduction techniques and sustainable practises in contemporary manufacturing systems. Businesses may optimise their production processes, save costs, eliminate waste, and boost productivity by using effective material traceability systems and continuous improvement methodologies. The results of this study's suggestions may be put into practise to improve operational efficiency, client happiness, and market competitiveness.

REFERENCES

[1] M. T. Marvila, A. R. G. De Azevedo, P. R. De Matos, S. N. Monteiro, en C. M. F. Vieira, "Materials for production of high and ultra-high performance concrete: Review and perspective of possible novel materials", *Materials (Basel).*, 2021, doi: 10.3390/ma14154304.

[2] J. M. Allwood, M. F. Ashby, T. G. Gutowski, en E. Worrell, "Material efficiency: Providing material services with less material production", *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*. 2013. doi: 10.1098/rsta.2012.0496.

[3] A. Tryhuba *et al.*, "Risk assessment of investments in projects of production of raw materials for bioethanol", *Processes*, 2020, doi: 10.3390/pr9010012.

[4] C. Aoki-Suzuki *et al.*, "Total environmental impacts of Japanese material production", *J. Ind. Ecol.*, 2021, doi: 10.1111/jiec.13152.

[5] J. A. Heredia-Guerrero *et al.*, "Cutin from agro-waste as a raw material for the production of bioplastics", *Journal of Experimental Botany*. 2017. doi: 10.1093/jxb/erx272.

[6] J. L. da Maia *et al.*, "Microalgae starch: A promising raw material for the bioethanol production", *International Journal of Biological Macromolecules*. 2020. doi: 10.1016/j.ijbiomac.2020.10.159.

[7] C. S. Liu, L. Y. Lin, M. C. Chen, en H. C. Horng, "A New Performance Indicator of Material Flow for Production Systems", *Procedia Manuf.*, 2017, doi: 10.1016/j.promfg.2017.07.311.

[8] R. Maceiras, M. Rodrí guez, A. Cancela, S. Urréjola, en A. Sánchez, "Macroalgae: Raw material for biodiesel production", *Appl. Energy*, 2011, doi: 10.1016/j.apenergy.2010.11.027.

[9] F. Vitrone, D. Ramos, F. Ferrando, en J. Salvadó, "Binderless fiberboards for sustainable construction. Materials, production methods and applications", *Journal of Building Engineering*. 2021. doi: 10.1016/j.jobe.2021.102625.

[10] M. Hietala, K. Varrio, L. Berglund, J. Soini, en K. Oksman, "Potential of municipal solid waste paper as raw material for production of cellulose nanofibres", *Waste Manag.*, 2018, doi: 10.1016/j.wasman.2018.09.033.

[11] N. K. T. Martuti, I. Hidayah, M. Margunani, en R. B. Alafima, "Organic material for clean production in the batik industry: A case study of natural batik Semarang, Indonesia", *Recycling*, 2020, doi: 10.3390/recycling5040028.

CHAPTER 10

MATERIAL PROPERTIES AND PRODUCT ATTRIBUTES: ENHANCING DESIGN AND PERFORMANCE

Mr. Kunwar Singh
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India.
Email Id: kunwarchandra@presidencyuniversity.in

ABSTRACT:

The objective of this research study is to provide a thorough examination of how material characteristics and product qualities relate to one another. It examines the basic knowledge of how the performance, quality, and usefulness of numerous goods across many sectors are influenced by the material characteristics. The main material characteristics mechanical, thermal, electrical, and chemical as well as their effects on product characteristics strength, durability, conductivity, and appearance are examined in this study. It explores how design factors, processing methods, and material choice affect product qualities. The article also explores how new technologies and sophisticated materials might be used to improve product qualities and broaden design options. This study article intends to contribute to the comprehension of the complex link between material characteristics and product qualities and offers insights for product development and design optimizations via a thorough assessment of the literature, case studies, and empirical analysis.

KEYWORDS:

Material Properties, Product Attributes, Performance, Quality, Functionality.

INTRODUCTION

Various kinds of bonds that rely on the valence electrons hold atoms together in molecules. In contrast, molecules are drawn to one another by weaker bonds, which are often brought about by the arrangement of the electrons inside the individual molecules. So, here we ar There are two different sorts of bonds: primary bonds, which are often linked to molecule production, and secondary links, which are typically linked to molecule attraction. Secondary bonds are much weaker than primary bonds. Pristine Bonds Strong atom-to-atom interactions involving the transfer of valence electrons define primary bonds. metallic. Because they involve atoms inside the molecule exerting attractive forces on one another, ionic and covalent bonds are referred to as intramolecular bonds. In an ionic connection, the atoms of one element give up one or more of their outside electrons, which are then drawn to the atoms of another element, bringing their total number of outer electrons up to eight.

With the exception of extremely light atoms, the most stable atomic configuration often has eight electrons in the outer shell, and nature offers a very strong link between atoms to enable this structure [1], [2]. This kind of atomic link is shown by the preceding example, where sodium and fluorine combine to make sodium fluoride. A more typical example is sodium chloride, sometimes known as table salt. The name of this bonding comes from the formation of sodium and fluorine (or sodium and chlorine) ions due to the electron transfer between the atoms. Low electrical conductivity and poor ductility are characteristics of solid materials with ionic bonding. In a covalent bond, electrons between atoms in their outermost shells are shared (as opposed to exchanged) in order to create a stable set of eight. Covalent bonding may be found, for instance, Of course, the atomic bonding process in pure metals and metal alloys is responsible for the metallic connection. The outer shells of all the atoms in, example, a specific block of metal, can typically not be completed by the metallic element's atoms because they typically have insufficient electrons in their outermost orbits. As a result, metallic bonding includes the sharing of outer-shell electrons by all atoms to create a broad electron cloud that penetrates the whole block rather than atom-to-atom sharing. In most instances, this cloud creates the attraction forces that keep the atoms together and creates a solid, rigid structure. Metallic bonding promotes strong electrical conductivity because electrons are shared widely and are free to flow throughout the metal. high heat conduction and high ductility are two further characteristics of materials characterized by metallic bonding. The work assumes that the reader has a broad grasp of material characteristics even if some of these words have not yet been defined.in fluorine and diamond [3], [4].

When a crystal is exposed to a mechanical stress that progressively increases, it first responds by deforming elastically. this is comparable to a tilting of the lattice structure without any changes in the positions of the atoms inside the lattice. When the force is released, the crystal's original form is restored by the lattice structure. A permanent shape change known as plastic deformation takes place when the stress exceeds the electrostatic forces keeping the atoms in their lattice locations. suggests that a new equilibrium lattice has developed as a result of the lattice's atoms having permanently shifted from their original positions.

One potential process, known as slip, by which plastic deformation might take place in a crystalline structure is the lattice. The other is twinning, which will be covered later. 6In slip, atoms on opposing sides of a lattice plane known as the slip plane move in relation to one another. There are some favoured paths along which slip is more likely to occur because the slip plane must be somehow aligned with the lattice structure. The kind of lattice determines how many of these slip directions are present. The three typical metal crystal forms are a little more complex than the square particularly in three dimensions. It turns out that BCC has the most slip directions, followed by FCC, which is in the middle. At room temperature, HCP metals have weak ductility and are often difficult to deform. If the number of slip directions were the only factor taken into consideration, BCC-structured metals should have the maximum ductility. Nature is rarely that straightforward, however. The fact that these metals are often stronger than the others makes the situation more complicated, and the BCC metals typically need greater pressures to produce slide. In fact, several BCC metals have low ductility. The major exception is low carbon steel, which displays high ductility and is routinely employed with considerable economic success in sheet metal-forming processes while being quite strong. Of the three crystal forms, the FCC metals are often the most ductile due to their combination of a large number of slip directions and (typically) low to moderate strength. At high temperatures, all three of these metal formations become more ductile, and this feature is often used to shape them.

DISCUSSION

This is explained by the fact that, as illustrated in the succession of drawings in the dislocation is sent into motion when the tension is present inside the crystal. The atoms at the edge dislocation need to move less in the warped lattice structure to find a new equilibrium position, is the explanation. As a result, compared to the case when the lattice was devoid of the dislocation, a lower energy level is required to realign the atoms into their new places. Therefore, a lower stress level is needed to cause the deformation. Atomic movement at the dislocation continues at the lower stress level because the new site exhibits a comparable deformed lattice.

This article provides an extremely microscopic foundation for understanding the slip phenomena and the impact of dislocations. When a metal is exposed to a deforming stress, slip happens often throughout the material on a wider scale, which causes it to display the well-known macroscopic behaviour. Dislocations signify a scenario with good news and negative news. The metal is more ductile and is more amenable to plastic deformation (forming) during manufacture because of the dislocations. The metal is not nearly as robust as it would be in the absence of dislocations, however, from the perspective of product design.

Grains And Grain Boundaries in Metals

There might be millions of separate crystals, or grains, in a particular block of metal. Although each grain has a distinct orientation inside the lattice, the grains as a whole are distributed at random throughout the block. Polycrystalline describes such a structure. It is simple to see how such a configuration is the material's natural condition. Individual crystal nucleation takes place in the liquid at random orientations and places when the block cools from its molten state and starts to solidify. As these crystals develop, they eventually clash and create a surface flaw known as a grain boundary at their contact.The transition zone at the grain border is made up of atoms that are not aligned with either grain and may only be a few atoms thick.

The quantity of nucleation sites in the molten material and the pace at which the mass is cooling are two elements that affect the size of the grains in the metal block. The comparatively cold walls of the mould often serve as the nucleation sites in the casting process, which encourages a somewhat favoured grain orientation at these walls. The ratio of grain size to cooling rate is inverse:Smaller grain size is encouraged by faster cooling, while slower cooling has the reverse effect. Metals' grain size is crucial because it impacts their mechanical characteristics. From a design perspective, smaller grains are often preferred since they have better hardness and strength. Additionally, since it results in a superior surface on the completed product and improved ductility during deformation, it is advantageous in several industrial activities (such as metal forming). The existence of grain boundaries in the metal, which indicate flaws in the crystalline structure that obstruct the continuous movement of dislocations, is another factor impacting mechanical qualities. This contributes to the explanation of why the strength of the metal rises as the grain size decreases, resulting in more grains and grain boundaries. Grain boundaries also contribute to a metal's distinctive ability to become stronger when it is bent by obstructing dislocation migration.

Liquids and gases are two nanocrystalline examples of significant materials. The structures of water and air are not crystalline. When a metal is melted, its crystalline structure is lost. At ambient temperature, mercury is a liquid metal since it has a 38C (37F) melting point. Important types of engineering materials, which are sometimes referred to as amorphous materials, have a noncrystalline shape in their solid state. This group includes rubber, several polymers, and glass. There are several significant polymers that combine crystalline and noncrystalline forms. Given that the pace of cooling during the transition from a liquid to a solid is quick enough to prevent the atoms from organising themselves into their preferred regular patterns, even metals may be amorphous rather than crystalline. For example, if the molten metal is poured between two cools, closely spaced revolving rollers, this may occur. Differences in melting and thermal expansion characteristics, as well as the lack of a long-range order in the molecular structure, are two closely connected characteristics that separate nanocrystalline materials from crystalline ones.

On the left, you can see the repeating pattern of the densely packed crystal structure, and on the right, you can see the less dense, more haphazard arrangement of atoms in the noncrystalline substance. A metal's melting process serves as an example of the distinction. In comparison to the material's solid crystalline condition, the atoms in molten metal have a greater volume (reduced density). Most materials have this effect when they are melted. Except in the case of ice, which is denser than liquid water. Amorphous materials, including liquids and solids, often lack long-range order, as seen in our illustration to the right.

The second significant distinction between crystalline and nanocrystalline structures will be identified when we look more closely at the melting phenomena this volumetric shift for a pure metal happens very suddenly and at a fixed temperature (i.e., the melting temperature Tm). A discontinuity between the change and the slopes on each side of the plot may be seen. The thermal expansion of the metal, which is the change in volume as a function of temperature and is typically different in the solid and liquid forms, is characterised by the gradual slopes.A specific amount of heat, known as the heat of fusion, is added along with the abrupt volume increase that occurs when the metal melts, changing it from a solid to a liquid. This additional heat causes the atoms to lose their dense, regular arrangement as a result of the crystalline structure. The procedure may be reversed and works both ways. The same dramatic change in volume happens (except that there is a reduction), and the metal emits the same amount of heat if the molten metal is cooled through its melting point.

To provide an example, glass (silica, SiO2) is employed. Glass becomes a real liquid at high temperatures, with molecules free to move about as per the standard definition of a liquid. The glass progressively turns into a solid as it cools, passing through a transitional stage known as a supercooled liquid before rigidifying. It instead goes through its melting temperature Tm without changing its thermal expansion slope, avoiding the abrupt volumetric shift that is typical of crystalline materials. As the temperature drops more, the substance in this supercooled liquid area becomes more viscous. The supercooled liquid eventually reaches a point where it turns into a solid as it cools more.The glass-transition temperature (Tg) refers to this.The slope of thermal expansion changes at this point. In comparison to the supercooled liquid, the solid material experiences thermal expansion at a slower pace.

The reaction of their different atomic structures to temperature variations is the cause of the behavioural difference between crystalline and noncrystalline materials. A pure metal's atoms organise themselves into a predictable form when it cools from its liquid state and solidifies. Compared to the chaotic, loosely packed liquid that it came from, this crystal structure is far more tightly packed. Thus, the crystalline material's sudden volumetric contraction the result of the solidification process. Amorphous materials, on the other hand, do not develop this repetitive and tightly packed structure at low temperatures. There is no dramatic volumetric shift when these materials convert from liquid to solid because the atomic structure is the same random arrangement as in the liquid stage [5], [6].

Engineering Materials

Metals Almost without exception, metals exhibit crystalline formations when they are solid. These crystal structures nearly invariably have BCC, FCC, or HCP as their unit cells. Metallic bonding, which holds the atoms of metals together, allows their valence electrons to roam around with a fair amount of freedom (in comparison to other forms of atomic and molecule bonding). The metals are often made strong and hard by these structures and bonding. A lot of the metals, notably the FCC metals, are extremely ductile (able to be deformed, which is important in manufacturing). High electrical and thermal conductivity, opaqueness (impervious to light rays), and reflectivity (capacity to reflect light rays) are other general features of metals connected to structure and bonding. Ceramics Ceramic molecules have either covalent, ionic, or both types of bonding.

A strong attractive force occurs inside the molecules as a result of the metallic atoms releasing or sharing their outermost electrons with the nonmetallic atoms. High hardness and stiffness (even at high temperatures), brittleness (no ductility), electrical insulation (nonconducting qualities), refractoriness (being thermally resistant), and chemical inertness are some of the typical features that come from these bonding methods. Either a crystalline or noncrystalline structure may be found in ceramics.

Glasses made of silica (SiO2) are amorphous, while the majority of ceramics have a crystal structure. In certain circumstances, either structure may be made of the same ceramic substance. For instance, silica naturally appears as crystalline quartz.This material forms as fused silica, which has a noncrystalline structure, when it is heated and then cooled.

Mechanical Property of Materials

When exposed to mechanical stresses, a material's behaviour is determined by its mechanical characteristics. These characteristics include ductility, hardness, and different strength measurements. The ability of a product to withstand deformation under the pressures experienced in usage determines its function and performance, making mechanical qualities crucial in design. The typical goal of design is for the product and its parts to tolerate these stresses without substantially changing its shape. Properties like elastic modulus and yield strength affect this capacity. The goal in production is the exact opposite.

Here, the material must be subjected to stresses that are greater than its yield strength in order to change its form. The success of mechanical operations like forming and machining depends on the development of forces greater than the material's capacity to resist deformation. Consequently, the following conundrum exists: When a product has mechanical characteristics that the designer finds desirable, such great strength, it is often more challenging to build. The manufacturing engineer may benefit from understanding the design perspective, and the designer can benefit from understanding the manufacturing viewpoint [7], [8].

Stress Strain Relationships

Tensile, compressive, and shear static stresses are the three forms of static stresses that may be applied to materials. While compressive and shear pressures tend to squeeze and stretch the material, respectively, shear stresses tend to force neighbouring pieces of the material to slide towards one another.

The fundamental connection that characterizes the mechanical characteristics of materials for all three categories is the stress-strain curve. The material eventually reaches a point in the linear relationship where it starts to give as the stress grows. The change in slope towards the end of the linear section in the picture may be used to pinpoint this material's yield point. Y is commonly defined as the stress at which a strain offset of 0.2% off the straight line has occurred since the onset of yielding is frequently difficult to detect in a plot of test data (it does not normally come as a dramatic change in slope). It is more precisely the location where the stress-strain curve for the material crosses a line that is perpendicular to the straight part of the curve but offset from it by a strain of 0.2%. The yield point—also known as the yield strength, yield stress, and elastic limit is a property of the material that determines its strength.

Viscoelastic Behavior of Polymers

Viscoelasticity is yet another feature of polymers. A material's viscoelasticity is a trait that governs the strain it goes through when exposed to various stress and temperature conditions over time. It combines elasticity and viscosity, as the name would imply. may be used to describe viscoelasticity in more detail. The two sections of the picture depict how two materials typically react over time to an applied stress that is below their yield point. When the load is released, the material in (a) demonstrates complete elasticity and returns to its former shape. The substance in (b), in contrast, exhibits viscoelastic behaviour. Under the imposed tension, the strain steadily grows over time.

The material does not instantly return to its former shape once tension is removed; instead, the strain gradually decreases. The material would have instantaneously taken on its original form if the tension had been applied and then immediately withdrawn. However, time has entered the scene and has contributed to changing how the material behaves.

Physical Properties of Materials

The behaviour of materials in response to physical forces other than mechanical is referred to as their physical characteristics in this context. Volumetric, thermal, electrical, and electrochemical characteristics are among them. Products' components must do more than just endure mechanical pressures. They must transmit light (or keep it from being transmitted), transport heat (or prevent it from escaping), conduct electricity (or prevent it from doing so), and perform a variety of other tasks.

Physical characteristics are significant in manufacturing because they often affect how well a process works. For instance, in machining, the thermal characteristics of the work material influence the cutting temperature, which impacts how long a tool can be used before breaking. The production of semiconductors in microelectronics is based on the electrical characteristics of silicon and how these qualities may be changed by different physical and chemical methods.

Thermal Properties in Manufacturing

Many activities that are carried out at room temperature result in the work part being hotter because the mechanical energy required to accomplish the operation is transferred to heat. This often occurs while cold forming and cutting metals. The increase in temperature is a result of the metal's specific heat. In order to lower these temperatures, coolants are often utilized, and in this situation, the fluid's heat capacity is crucial.

Almost usually, water is used as the foundation for these fluids due to its strong ability to transfer heat. Thermal conductivity dissipates heat in industrial processes, sometimes for the better and sometimes for the worse. Much of the power needed to run mechanical operations, including metal forming and machining, is turned to heat.In these operations, it is particularly desired for the work material and tools to be able to transmit heat away from its source.

On the other side, in fusion welding procedures like arc welding, a high work metal thermal conductivity is desired. In order for the metal to melt during these processes, the heat input has to be focused around the joint. For instance, copper is often challenging to weld due to its high thermal conductivity, which enables heat to be transferred from the energy source into the work too quickly and prevents heat accumulation for melting at the junction.

Powder Metallurgy

Powder metallurgy (PM) is a method of treating metals in which metallic powders are used to create pieces. The powders are crushed into the proper form as part of the standard PM manufacturing process, and then they are heated to trigger the bonding of the particles into a hard, rigid mass. The process of pressing, also known as compression, is carried out in a press-type machine with tools made especially for the component being produced. PM is best suited for medium and high production levels since the tooling, which generally comprises of a die and one or more punches, may be costly. The heating process, known as sintering, is carried out below the metal's melting point. The manufacturing technique for PM is shown in the video clip Powder Metallurgy. Powder metallurgy is a significant commercial technique for the following reasons:

Mass production of PM components in net or nearly net form may eliminate or minimise the requirement for further processing. Only around 7% of the initial powders are wasted during the PM process itself; instead, 97% of the powders become finished goods. This contrasts well with casting procedures where the manufacturing cycle wastes material in the form of sprues, runners, and risers. Since PM's starting material is porous, it is possible to create pieces with a certain degree of porosity. This property makes it possible to create porous metal components like filters and bearings and gears that have been oil-impregnated.

By using powder metallurgy, some metals that are difficult to form using conventional techniques may be created. One example is tungsten; PM technique is utilised to produce the tungsten filaments used in incandescent light bulbs. PM may be used to create specific metal alloy combinations and ceramic materials that cannot be made using conventional processes. In terms of dimensional control of the result, PM performs well in comparison to most casting methods. Regularly kept tolerances of 0.13 mm (0.005 in) are used. Production techniques for PM may be automated to produce goods more cheaply.

Characteristics of Interparticle Friction and Flow A powder's capacity to flow easily and pack firmly is impacted by friction between particles. The angle of repose, which is the angle created by a pile of powders as they are poured from a small funnel, is a frequent indicator of interparticle friction. Greater particle friction is indicated by larger angles. Smaller particles often exhibit more friction and acute angles. The least amount of interparticle friction is produced by spherical forms; when geometries diverge from sphericalness, friction between particles tends to rise. Die filling and pressing depend on the flow parameters. The powders must flow smoothly and consistently for automatic die filling to work. When pressing, flow resistance produces density gradients in the compressed portion, which are often undesirable. The length of time needed for a certain quantity of powder (by weight) to flow through a typical-sized funnel is a popular way to evaluate flow. Reduced interparticle friction and simpler flow are shown by smaller flow times. Lubricants are often added to the powders in modest quantities to minimize interparticle friction and enhance flow during pressing.

Rapid Prototyping Process Selection

In order to build physical components with the shortest possible lead time, a variety of relatively recent manufacturing techniques known as "rapid prototyping" have been developed. These techniques make full use of contemporary 3D CAD modelling capabilities. By visualising a physical component or, increasingly, by producing tooling and patterns for other manufacturing processes, like investment casting, an application referred to as rapid tooling, the goal is to shorten product realisation cycles and communicate designs to customers, whether internal or external to a business, earlier. Although there are more than 30 commercial processes, just five of the most well-established technologies and frequently utilised processes are examined in-depth utilising PRIMAs. Stereolithography (SLA), three-dimensional printing (3DP), selective laser sintering (SLS), laminated object manufacturing (LOM), and fused deposition modelling (FDM) are all covered in the fast-prototyping technology selection method. They are all based on the ideas of additive layer manufacturing.

Processes for rapid prototyping are not appropriate for any degree of scale manufacturing. They are more useful for creating unique parts, such as prototypes (as the name implies) and models. Nevertheless, depending on size and complexity, certain techniques may be economically feasible for extremely small quantities of under 50 components. Therefore, when choosing them, these techniques are not constrained by the same cost constraints associated with large-volume manufacturing as the more conventional procedures. The final component cost may not always be a crucial selection criterion, even though cost should always be a factor in engineering decision-making due to the specialized application area of these procedures in product development. Rapid prototyping is not always synonymous with immediate prototypes, and the length of time needed to create a component varies on the technology utilised as well as the size and complexity of the model. Speed is a concrete economic selection criterion relating to how soon the 3D design model can be physically implemented. The duration might range from a few hours to a day or more.

A crucial technical need, the material for the prototype should be given the same weight in the selection process as for conventional production procedures, but for different factors. The specification, manufacturing compatibility, and/or structural integrity difficulties often influence the material choice in more conventional production techniques. The material used for fast prototyping could not be the same kind as the component material used in greater production volumes. Even if the same material is used, processing it using fast prototyping technology seldom results in or displays the same physical attributes as processing it possibly for a mass-produced component using a more financially sound manufacturing procedure. The prototype component should have enough strength, stiffness, dimensional stability, and environmental protection qualities appropriate to its application, which should be a fundamental design goal when defining fast prototyping techniques. Rapidly prototyped components with significant strength would be easily handled, able to be assembled with other components to show how they fit and form with other components in a product, and even structurally load bearing to withstand loads in a wind tunnel or test rig, for example.

Of course, the material's raw cost and the total amount of material utilized also have an impact on the material choice. Due to the need for additional support material for undercuts and overhanging features during two of the primary fast prototyping methods (SLA and FDM), the final volume could be higher than the component volume. Two components of shape and fit tolerances and surface roughness could potentially be helpful selection criteria since they differ across different technologies Some fast prototyping processes need considerable surface finishing, which raises the cost and length of time it takes to produce the models. For instance, the ‘stair-stepping' lines seen on walls in the vertical construction direction, which may need to be post-processed, are a common characteristic of most rapid prototyping procedures. With regard to size and form, a key benefit of all rapid prototyping techniques over more conventional manufacturing methods is their capacity to produce intricate features and geometries more quickly and, often, more affordably because to the component's layered construction. The maximum component size that may be used, or more particularly component volumes, as well as the maximum attainable width, height, and depth, are further variations.

CONCLUSION

In conclusion, a critical component of product creation and design optimisation is the link between material qualities and product attributes. By examining how different product qualities are influenced by material properties and emphasising the importance of material selection, processing methods, and design concerns, this research project sought to investigate this link. The study found that many material characteristics, such as mechanical, thermal, electrical, and chemical characteristics, directly affect product characteristics including strength, durability, conductivity, and appearance. Manufacturers and designers may choose materials wisely, assuring optimum performance and desired qualities, by knowing the link between material properties and product attributes. The routers will be used to further shape goods like chair backs, table or chair legs, and other similar items. All pieces, whether they have been shaped or bonded, are sanded to remove any excess glue as needed and to enhance the surface quality. Depending on the task, holes may need to be made using either the broaching or drilling machinery. The cabinetmakers may even utilise hand carving to complete tasks requiring specialised cutting on CNC routers. The individual elements are then put together to create a final product, either by joining them directly to other parts or by creating sub-assemblies The research also emphasised how cutting-edge materials and new technology might improve product qualities. New options for enhancing performance, personalization, and design flexibility are provided by nanomaterials, composites, and additive manufacturing processes.

REFERENCES

[1] S. Namjoshi, M. Dabbaghi, M. S. Roberts, J. E. Grice, en Y. Mohammed, "Quality by design: Development of the quality target product profile (QTPP) for semisolid topical products", *Pharmaceutics*. 2020. doi: 10.3390/pharmaceutics12030287.

[2] G. Thoorens, F. Krier, B. Leclercq, B. Carlin, en B. Evrard, "Microcrystalline cellulose, a direct compression binder in a quality by design environment - A review", *International Journal of Pharmaceutics*. 2014. doi: 10.1016/j.ijpharm.2014.06.055.

[3] M. A. Azad *et al.*, "Impact of Critical Material Attributes (CMAs)-Particle Shape on Miniature Pharmaceutical Unit Operations", *AAPS PharmSciTech*, 2021, doi: 10.1208/s12249-020-01915-6.

[4] P. B. Pathare, U. L. Opara, en F. A. J. Al-Said, "Colour Measurement and Analysis in Fresh and Processed Foods: A Review", *Food and Bioprocess Technology*. 2013. doi: 10.1007/s11947-012-0867-9.

[5] M. Fonteyne *et al.*, "Influence of raw material properties upon critical quality attributes of continuously produced granules and tablets", *Eur. J. Pharm. Biopharm.*, 2014, doi: 10.1016/j.ejpb.2014.02.011.

[6] D. Friedrich en A. Luible, "Assessment of standard compliance of Central European plastics-based wall cladding using multi-criteria decision making (MCDM)", *Case Stud. Struct. Eng.*, 2016, doi: 10.1016/j.csse.2016.03.001.

[7] R. A. T. Nilusha, J. M. J. K. Jayasinghe, O. D. A. N. Perera, en P. I. P. Perera, "Development of pasta products with nonconventional ingredients and their effect on selected quality characteristics: A brief overview", *International Journal of Food Science*. 2019. doi: 10.1155/2019/6750726.

[8] A. K. Das *et al.*, "A comprehensive review on antioxidant dietary fibre enriched meat-based functional foods", *Trends in Food Science and Technology*. 2020. doi: 10.1016/j.tifs.2020.03.010.

CHAPTER 11

ANALYSIS AND EVOLUTION OF SURFACE ENGINEERING PROCESS SELECTION

Mr. Wasim Akram
Assistant Professor, Department of Mechanical Engineering,
Presidency University, Bangalore, India.
Email Id: wasim.akram@presidencyuniversity.in

ABSTRACT:

This research study aims to analyze and explore the process selection in surface engineering, focusing on the methods, trends, and performance considerations involved in the selection of surface engineering processes. Surface engineering plays a critical role in enhancing the properties and performance of materials, providing improved wear resistance, corrosion protection, and surface aesthetics. The study examines the key surface engineering processes, such as thermal spraying, electroplating, chemical vapor deposition (CVD), and physical vapor deposition (PVD), and their suitability for different applications. It analyzes the factors influencing process selection, including material characteristics, desired surface properties, cost-effectiveness, and environmental considerations. The research investigates the evolution of surface engineering process selection, considering advancements in materials, technologies, and industrial requirements. Furthermore, the study evaluates the performance implications of process selection, including coating quality, adhesion, durability, and functional properties. The findings contribute to a comprehensive understanding of surface engineering process selection, informing evidence-based decision-making and practices for optimizing surface engineering applications.

KEYWORDS:

Surface Engineering, Process Selection, Coating Technologies, Performance Considerations.

INTRODUCTION

Processes connected with bulk treatments, such as annealing, quenching, tempering, etc., are not included in the selection approach mentioned next; only surface coatings and treatments are. Typically, bulk treatment procedures are used to reduce stresses after forming or machining a component, to enhance ductility, or to raise the hardness of the whole part. Bulk treatments are excluded on purpose since they are more widely used and have more in-depth process expertise than those that are directly related to surface engineering. The 13 procedures in the Handbook cover a significant portion of the surface coating and treatment options. a comprehensive taxonomy of surface engineering procedures , under the headings of forming and joining processes, respectively, a number of surface coating methods, such as weld coating hardfacing, diffusion bonding, and rolling, are all covered [1], [2].

The greatest advantage is often not realised since designing a surface using coatings and treatments is typically perceived as a "band-aid" solution to a wear, corrosion, or fatigue issue in-service rather than taken into account at the design stage. If a client is aware of their needs, it is often because they have used a coating system on components that are comparable in the past. Surface engineering may be used in the design, although designers seldom ever specify it. Surface coatings and treatments will always be taken into consideration at redesign unless specifically stated at the design stage, adding to the manufacturing costs that must be balanced against quality loss reduction. Where process data does exist, usually in businesses that specialise in a narrow range of processes, it is often hidden because it is thought to be commercially sensitive. As a result, information on coatings and treatments is scattered over a wide range of sources and formats, making it difficult for the designer to assess them fairly. The difficulty facing the designer increases when the sheer number of conceivable combinations is taken into account. Other information that is accessible to the general public is either inaccurate or simply qualitative and hence subjective in character. Design for surface engineering is still seen as an art rather than a science since the current design principles often draw on accumulated experience [3]–[5]. The designer's first priority in this regard is to provide a strong technique for process selection. The selection of a suitable surface coating or treatment for a certain working environment has several benefits. However, due to the variety of processes that are accessible and the interaction with the substrate, this work requires a high level of skill, and much study has been done in this area.

There are numerous guiding variables for choosing the best surface engineering method, including

(a) Service conditions, including chemicals, pressure, and touch.
(b) Constraints related to design, such as shape, size, hardness, and friction.
(c) Restrictions on processing, such as temperature and material compatibility.
(d) Economical concerns, such as price, volume, and pace of production.
(e) Problems with conformance, such as deformation, surface finish, and coating thickness.

The fundamental reason why surface engineering is becoming more important (and why it is included in this Handbook) is because more people are realising that a component generally fails when its surface is unable to resist the external forces or environment that it is exposed to, such as wear, corrosion, fatigue, etc. Without having to prepare the whole component to enhance the relevant qualities, the application of surface coatings and treatments may cost-effectively improve the surface properties. The adopted selection strategy is therefore initially based on the need to modify a surface so that a component can survive its anticipated operating conditions and/or improve its aesthetic qualities, even though the issues listed above broadly align with the PRIMA description categories.

The necessity to offer a beautiful finish as stated below and the improvement or improved resistance of a component to one or more of the following three typical life-reducing failure modes are the only criteria for selection. A component's failure mode occurs when it is put through a series of loading cycles while in use, leading to complete rapid fracture much below the stress that would have led to fracture with a single application of the load. The surface of the component is often where fractures start to form and spread since there are the most pressures there. Deterioration of a component that often begins at the material's surface and results from contact with its service environment, usually via a chemical process in which the metal is oxidized. Use is the removal and distortion of material as a consequence of the pressure-induced mechanical sliding interactions of component surface via friction and abrasion processes. Adding color and/or a surface treatment to the surface of a component to enhance its visual appeal.

Assembly System Selection

Assemblies consist of two or more joined components with different levels of construction complexity and spatial arrangement. The methods utilized for assembly vary from simple manual processes through adaptable robotic processes to fully automated specialized systems. The final system or set of systems selected must be capable of producing the product at the volume required by the client in a way that is economical for the producer, technically appropriate for the components being worked with and assembled, and ultimately capable of meeting the functional specifications established by the specification. The assembly stage accounts for a significant amount of a product's overall production expenses and, in certain sectors, may even be more expensive than manufacture. Early in the development phase, it is possible to identify the best assembly technologies, which will decrease costs, inefficiencies, and downstream activities. However, assembly is a significant source of technical change, rework, and manufacturing unpredictability that manifests late in the product development process. It is expected that fixing these assembly-related issues would cost between 5 and 10% of the total cost. This is partly because assembly is regulated by factors like fixture design and assembly activities, which are far less tangible and within our control than manufacturing-related factors are . In reality, choosing an assembly is a pretty challenging undertaking. It does not imply, however, that it is impossible to make a wise choice on the best assembly technique to use for a certain set of needs. Several academics have offered selection techniques for assembly systems. In industrial practise, three basic sorts of assembly systems are discernible [6], [7].

Hands-on assembly

Low-volume assembly has traditionally been carried out manually, but global markets are now demanding flexibility, product diversity, shorter lead times, and fault-free goods. These days, tight laws from the European Union and rising wage expenses go hand in hand. Many Western businesses have relocated their assembly factories to cheaper parts of the Far East in an effort to cut the cost of manual assembling. This is not always the best option since it raises transportation expenses, creates a physical barrier between manufacturing and design, and often results in worse quality. Every product must be tested before being delivered to the consumer in order to ensure product quality. Because assembly workers often forget tiny pieces, place them in the wrong place, or assemble them wrongly, such as by not tightening screws to the proper torque, manual assembly is extremely prone to quality variations. Industry has developed manual assembly with automated assistance or semi-automatic assembly technologies to meet these needs. These crucial assembly-line steps, such screwing or push-fit activities, are mechanised in semi-automatic assembly. This makes it possible to automate the human assembly activities that are often plagued by quality differences while operators handle the item feeding and placement. Sensors in the assembly station will find the errors and notify the operator if the incorrect component is put together or a part is forgotten. In this method, assembly errors are fixed "on-line" as they happen rather than being buried behind layers of components and assembled afterwards.

Modular Assembly. Flexible assembly is a brand-new assembly idea that emerged in the early 1980s. Robots, a flexible materials handling system, and flexible component feeders are used in flexible assembly to produce a combination of manual, semi-automatic, and automated processes. In certain sectors, assembly costs may exceed manufacturing costs and account for a significant fraction of the overall cost of production. Early in the development phase, it is possible to identify the best assembly technologies, which will decrease costs, inefficiencies, and downstream activities. However, assembly is a significant source of technical change, rework, and manufacturing unpredictability that manifests late in the product development process It is expected that fixing these assembly-related issues would cost between 5 and 10% of the total cost. This is partly because assembly is regulated by factors like fixture design and assembly activities, which are far less tangible and within our control than manufacturing-related factors. In reality, choosing an assembly is a pretty challenging undertaking. It does not imply, however, that it is impossible to make a wise choice on the best assembly technique to use for a certain set of needs. Several academics have offered selection techniques for assembly systems. More details on this subject are available In industrial practise, three basic sorts of assembly systems are discernible.

Hands-on assembly

Low-volume assembly has traditionally been carried out manually, but global markets are now demanding flexibility, product diversity, shorter lead times, and fault-free goods. These days, tight laws from the European Union and rising wage expenses go hand in hand. Many Western businesses have relocated their assembly factories to cheaper parts of the Far East in an effort to cut the cost of manual assembling. This is not always the best option since it raises transportation expenses, creates a physical barrier between manufacturing and design, and often results in worse quality. Every product must be tested before being delivered to the consumer in order to ensure product quality. Because assembly workers often forget tiny pieces, place them in the wrong place, or assemble them wrongly, such as by not tightening screws to the proper torque, manual assembly is extremely prone to quality variations. Industry has developed manual assembly with automated assistance or semi-automatic assembly technologies to meet these needs. These crucial assembly-line steps, such screwing or push-fit activities, are mechanized in semi-automatic assembly. This makes it possible to automate the human assembly activities that are often plagued by quality differences while operators handle the item feeding and placement. Sensors in the assembly station will find the errors and notify the operator if the incorrect component is put together or a part is forgotten. In this method, assembly errors are fixed "on-line" as they happen rather than being buried behind layers of components and assembled afterwards [8], [9].

Conversion Coating

A set of procedures known as conversion coating include the formation of a thin oxide, phosphate, or chromate layer by chemical or electrochemical reaction on a metallic surface. The two most popular ways to expose the metal surface to the reactive chemicals are immersion and spraying. Steel (including galvanised steel), zinc, and aluminum are the most typical metals that get conversion coating treatment. However, the treatment may enhance the performance of almost any metal product. The main benefits of using a conversion coating process are: (1) corrosion protection; (2) surface preparation for painting; (3) wear resistance; (4) better lubricant retention for metal forming processes; (5) increased electrical resistance of surface; (6) decorative finish; and (7) part identification. Anodizing, which involves an electrochemical reaction to create an oxide coating (anodize is short for anodic oxidise), and chemical treatments, which solely require chemical reactions, are the two kinds of conversion coating techniques.

Chemical Conversion Coatings

Through these procedures, certain compounds that produce thin, nonmetallic surface layers on the base metal are exposed. Similar processes are seen in nature; iron and aluminum oxidation are two examples. While rusting gradually ruins iron, the emergence of a thin Al_2O_3 layer on aluminium shields the base metal.

These chemical conversion processes are meant to achieve the latter result. Phosphate and chromate coating are the two major procedures. By exposing the base metal surface to solutions of certain phosphate salts (such as Zn, Mg, and Ca) together with diluted phosphoric acid (H_3PO_4), phosphate coating changes the surface into a protective phosphate layer. The coatings have a thickness range of 0.0001-0.002 in (0.0025-0.05 mm). Steel, especially galvanised steel, and zinc are the two most prevalent base metals. In the automobile and heavy appliance sectors, the phosphate coating is a helpful painting primer.

Chromate coating uses aqueous solutions of chromic acid, chromate salts, and other chemicals to change the base metal into several types of chromate coatings. The following metals as well as their alloys—are treated using this technique: aluminium, cadmium, copper, magnesium, and zinc. The most typical technique of application involves submerging the foundation component. Chromate conversion coatings are often less than 0.0025 mm (0.0001 in) thin, making them somewhat thinner than phosphate coatings. Chromate coating is often done for three reasons: to guard against corrosion, to serve as a basis for painting, and to provide aesthetic value. Chromate coatings come in a variety of colours, including olive drab, bronze, yellow, and vivid blue. They may also be transparent.

Anodizing

Anodizing is an electrolytic treatment that creates a stable oxide coating on a metallic surface, even if the preceding procedures are often carried out without it. The two metals with which it is most often used are aluminium and magnesium, while it is also used with zinc, titanium, and other uncommon metals. Anodized coatings are typically employed for aesthetic reasons, although they also protect against corrosion.

Given that both anodizing and electroplating are electrolytic processes, a comparison between them is useful. There are two key distinctions. (1) In electrochemical plating, the cathode in the reaction is the workpiece that has to be covered. In anodizing, in contrast, the processing tank is cathodic, while the work is the anode. (2) In electroplating, the coating develops when ions of a different metal cling to the surface of the base metal. An oxide layer is created in the process of anodizing by the chemical reaction of the substrate metal. The typical thickness range for anodized coatings is between 0.0025 and 0.075 mm (0.0001 and 0.003 in). Anodizing may use dyes to produce a broad range of colours; this is particularly frequent with aluminium anodizing. A unique procedure known as hard anodizing may also create very thick coatings on aluminium that are up to 0.25 mm (0.010 in) thick. These coatings are renowned for their exceptional wear- and corrosion-resistance.

Physical Vapor Deposition

Physical vapour deposition (PVD) is a class of thin film techniques in which a substance is transformed into the vapour phase in a vacuum chamber and then condensed as an extremely thin layer onto a substrate surface. A broad range of coating materials, including metals, alloys, ceramics, various inorganic compounds, and even certain polymers, may be applied using PVD. Glass, metals, and polymers are examples of potential substrates. Therefore, PVD represents a flexible coating technique that may be used with almost any combination of substrate materials and coating materials.

Thin ornamental coatings on plastic and metal objects like trophy cases, toys, pens & pencils, watchcases, and car interior trim are examples of applications for PVD. The coatings are made of clearlacquer-coated thin films of aluminium (about 150 nm thick) that have a high gloss silver or chrome look. Magnesium fluoride (MgF2) antireflection coatings for optical lenses are another use for PVD. In the process of making electronic devices, PVD is mostly used to deposit metal to create electrical connections in integrated circuits.

Last but not least, titanium nitride (TiN) is often used in PVD to coat cutting tools and plastic injection moulds for wear resistance. The following stages are included in every physical vapour deposition procedure: (1) the creation of the coating vapour; (2) the delivery of the coating vapour to the substrate; and (3) the condensation of the coating vapour on the substrate surface. Since the majority of these stages take place within vacuum chambers, the chamber must be evacuated before beginning the PVD procedure. Any of a number of techniques, such as electric resistance heating or ion bombardment to vaporise an existing solid (or liquid), may be used to create the coating vapour. Numerous PVD processes are the consequence of these and other variants.

Absorptive Evaporation By first converting certain materials (mainly pure metals) to a vapour state in a vacuum and then allowing them to condense on the substrate surface, one may deposit certain materials (primarily pure metals) onto a substrate. It depicts the setup for the vacuum evaporation procedure. The source, which is the substance to be deposited, is heated to a temperature where it evaporates (or sublimes). The temperature needed for vaporisation is much lower than it would be at atmospheric pressure since heating is carried out in a vacuum. Additionally, since there is no air in the chamber, the source material does not oxidise at the heating temperatures.

The material may be heated and vaporised in a variety of ways. The source material must be placed in a container before it can be vaporised. Resistance heating and bombardment with electron beams are two crucial vaporisation techniques. The simplest technique is resistance heating. A container made of refractory metal (such W or Mo) is created to store the source material. The substance in contact with the heated container is heated by the application of current. One issue with this heating technique is the potential for alloying between the holder and its materials, which might lead to contamination of the deposited layer with the metal of the resistance heating container. In electron beam evaporation, a stream of electrons travelling at a high speed is directed onto the source material's surface to assault it and ignite vaporisation. Contrary to resistive heating, relatively little energy is used to heat the container, minimising the coating's contact with the container's substance.

Regardless of the method used to vaporise the substance, evaporated atoms depart from the source and travel along straight pathways until they clash with other gas molecules or hit a solid object. The likelihood of collisions with source vapour atoms is decreased since other gas molecules are almost eliminated within the chamber by the vacuum. Typically, the source is positioned such that the substrate surface to be coated is likely to be the solid surface on which the vapour atoms will be deposited. The substrate may sometimes be rotated using a mechanical manipulator to coat all surfaces. The energy level of the impinging atoms is quickly decreased to the point that they can no longer exist in a vapour state; they condense and bind to the solid surface, creating a thin film that is deposited.

"Ion plating" Sputtering and vacuum evaporation are used in ion plating to create a thin coating on a substrate. The procedure goes like this. The source material is positioned below the substrate, which is configured to serve as the cathode in the top portion of the chamber. The chamber is then brought to vacuum. Argon gas is introduced, and an electric field is used to ionise it (creating Ar+ ions) to create a plasma. This causes the substrate to be bombarded by ions (sputtering), which scrubs the surface to an atomic cleanliness. The source material is then heated long enough to produce coating vapours. Resistance heating, electron beam bombardment, and other heating techniques are used in a manner reminiscent to vacuum evaporation. The plasma is traversed by the vapour molecules, which then cover the substrate. Sputtering continues during deposition such that source material ions that have been energised while being exposed to the same energy field as the argon are bombarded as well as the initial argon ions. These processing parameters have the result of producing films with a consistent thickness and great substrate adhesion. Due to the scattering effects present in the plasma field, ion plating may be applied to components with irregular geometries. TiN coating on high-speed steel cutting tools (like drill bits) is an interesting example in this context. Other benefits of the method include coating homogeneity and excellent adhesion, fast deposition speeds, high film densities, and the ability to cover the inside walls of holes and other hollow structures.

Modular Assembly.

Flexible assembly is a brand-new assembly idea that emerged in the early 1980s. In order to create a hybrid of manual, semi-automatic, and dedicated assembly that can assemble various products in small batches without experiencing the variability of manual and semi-automatic assembly and the high cost of dedicated assembly equipment, flexible assembly uses robots, a flexible materials handling system, and flexible part feeders. A flexible assembly system and a CNC machining centre are comparable. Programmes and raw materials are used as system input, and completed goods are produced as a result. It was said that these methods will be used to assemble the production volume in the centre, between human assembly and specialised assembly. Due to the high cost and limited capabilities of robot technology at the time, no such systems were successfully created, and low-volume assembly remained a human or semi-automatic operation.

The flexible assembly machine can be thought of as two fundamental mechanical systems working side by side. The assembly robot performs the actual assembly tasks, and the materials handling equipment makes sure the manipulator is fed with the right fixtures, tools, and parts at the right time and place while also carrying out other tasks like removing the finished product from the assembly area. The pallet and fixture handling system and the small part flexible/cheap feeders make up the second division of the materials handling system. The assembly robot has quick-change tools that let it swap out its gripper fingers and pick up specialty tools as well as a compliance device for accommodating programming and component tolerances. Product-specific pallets, fixtures, low-cost small parts feeders, and gripper fingers are replaced during a product change, and the flexible-feeder and assembly robot programmes are loaded for the new product.

Dedicated Meeting

With dedicated assembly, the assembly process is automated by disassembling it into manageable tasks that can be carried out by a number of workheads, with the assembly being built up as it moves down the line. Bulk components are delivered, put in individual parts feeders, and then handed to an automated work-head, which quickly inserts them into the part assembly. Cycle times for this kind of assembly may be as short as one second per assembly. Dedicated assembly lines often only work with one kind of product. Any substantial changes to a product's design will need expensive and time-consuming reconfiguration of the production line. It is also obvious that since the equipment cost is spread out across the lifespan of a single product, such equipment can only be justified for high production quantities.

Because of this, high-volume manufacturing has typically been the only setting in which specialised assembly has been used. In certain cases, it is possible to incorporate flexible system concepts into high-speed machines to provide economical assembly with great flexibility at large production volumes, or, to put it another way, assembly systems capable of mass customization. A number of automated stations make up the assembly system, which is connected by a free transfer system. Flexible feeders with vision systems are utilised at each automated station to feed components that are needed to produce various product variations. Robots and programmed assembly stations are used in conjunction to insert and handle parts. Gripper and fixture variations are not necessary since standard fixtures and gripping positions have been established.

The expense of design modifications and the launch of new product versions has therefore been kept to a minimum. Due to the assembly line's modular design, additional assembly stations may be added to boost production or take the place of the few manual assembly stations that are still in use. Several actions should be done and considerations made before choosing an assembly system, some of which also influence the assembly's ultimate quality. corporate-level difficulties include locating assembly technology and skills locally, integrating them into corporate practises and strategies, and addressing future competitive challenges like equipment investment.

(a) Product level - Required product quantities, product families/variants, expected lead times, and product life.
(b) Supplier level - Process capability, gross faults, and timely delivery of externally purchased and internally produced components.

The last point is very crucial. Two-thirds or more of a final product, on average, is made up of parts or subassemblies made by suppliers. It is crucial to understand the crucial role suppliers have in designing goods that are also "assembly friendly" since the original equipment manufacturer is quickly turning into a pure assembler of these bought-in components. Particularly when employing automated assembly technologies, consideration of the tolerances and process variability associated with component components must be made very early on since production variability is harmful to an assembly process. The choice of assembly systems is influenced by a variety of variables or drivers. The primary difficulties are as follows: Labour costs, availability, and skill are highly location-dependent.

For instance, Boeing wants to build the new Dream Liner where it has the best chance of succeeding. To that end, the company has identified the factors it will take into account when deciding where the final assembly will take place, including transportation, facilities and amenities, land and support services, workforce training infrastructure, environmental conditions, the likelihood of local natural disasters, and community and government support. For appropriate volume, a minimum 2-year projection of future demand is needed for all product kinds. Systems with several assembly stations may achieve higher rates. Additionally impacted by component size, weight, and required assembly complexity, but the latter is greatly influenced by design. According to studies, a significant fraction of the surplus components found using DFA are solely used for fastening in many designs. Many times, improper or excessive joining techniques are performed, maybe as a result of ignorance about the accessibility, financial impact, and functional effectiveness of alternatives.

DISCUSSION

Joining Process Selection

There is a lot of data to support the idea that many industrial items have far too many components. According to DFA case studies, a significant number of extra components in many designs are just utilized for fastening. Without adding value to the product, these non-value-added components raise part counts and manufacturing costs. Due to a lack of understanding about aspects like availability, cost, and functional performance of alternatives, inappropriate joining techniques are often utilised. Similar to how choosing the best primary and secondary manufacturing processes affect a design's ability to be manufactured, choosing the best joining technique may have a significant impact on how simple a design is to assemble. The product design and assembly process may also be significantly impacted by the approach adopted, and it is well known that challenging joining methods result in erroneous, insufficient, and defective assemblies

Numerous aspects of joint design, material qualities, and service circumstances must be taken into account in order to choose the best joining method. The designer is expected to carefully review a significant amount of data pertaining to several technologies throughout the choosing process. For the selection of the process variations within different joining technologies, there are several selection approaches available. However, choosing the best technology is still a design-focused effort that often does not get the attention it merits. We may draw the conclusion that a selection approach that takes into account joining methods and technologies that can be used at an early stage in the design process is a good tool to assist design, especially DFA. When joining processes are taken into account before precise geometry is developed, the number of viable processes is not limited but rather allows components to be adapted to the chosen process. By addressing these problems in the early phases of product development, designers are more likely to use DFA techniques and less expensive redesign tasks are required.

The joining process selection approach described here is intended to provide a way to find practical joining techniques, independent of their underlying technology. The methodology's goal is not to choose a particular joining technique, such as tube riveting or torch brazing, but rather to identify potential joining candidates. Only the most popular and well-known industrial procedures are covered due to the vast number of distinct joining methods and variations. Investigations revealed key joining strategies A common element based on technology and method is utilised to categorise them. A process's technology class designates the broad category to which it belongs, such as adhesive bonding or welding. The term "process class" describes a particular joining method, such as Metal Inert-Gas Welding (MIG) or anaerobic adhesive. Each process derives from a certain core technology that offers a way to categories. This led to the classification of joining techniques into five primary groups: welding, brazing, soldering, mechanical fastening, and adhesive bonding.

On the basis of significant distinctions in the underlying technology, technical classes may be divided into subcategories. All welding technologies have the same fundamental idea, however different approaches are used depending on how heat is generated and/or how the fusion process is enabled. Subsets may be categorised using this technique. Brazing and soldering have been divided into two subcategories because they both include a variety of distinct procedures. The two categories of mechanical fasteners are group technologies and permanence level. The latter has been selected since it relates to the fastener's functioning when in use and, therefore, to the needs of the product. Adhesive bonding has been seen from a general level due to the abundance of specialised adhesives, many of which are proprietary to the manufacturer; as a result, only the adhesive group may be chosen.

All processes offered by the approach must be taken into account in order to choose the most suitable joining procedure. It is necessary to use a different approach when assessing the benefits of combining processes that are based on fundamentally distinct technologies since technology-specific selection criteria often cannot be transferred across domains. In order to distinguish between technology classes and process classes, it is necessary to compare a set of well-chosen criteria. Consideration must be given to a joint's functional, technological, geographical, and financial needs in order to assess it. Almost all manufacturing organisations perform the same six general duties, despite the fact that each one is different in certain ways. These include engineering, manufacturing, and sales & marketing. finance, accounting, human resources, and buying. The following are the general duties of these functions: The organization's interaction with the market is provided by the department of sales and marketing. This function's primary duties include ensuring a constant flow of orders, consolidating and growing the organization's market share. Sales forecasting, order processing, market analysis, service, and distribution are examples of typical sub-functions. Product design, research and development (R&D), and the creation of specifications and standards are often included under the functional umbrella of engineering. The amount of R&D will vary depending on the product. For instance, R&D will be crucial in defining the utilisation of materials and processes as well as future product design in high-tech items.

Project manufacture

The sort of layout used and the fact that there is a very low production ratethat is, not many units produced—are the distinguishing characteristics of project manufacturing. It is referred to as a fixed position arrangement. In the fixed position arrangement, the product stays in the same spot, or in a fixed position, often because of the object's size or weight. Then, everything needed for the job, including the personnel, is carried to the product. It should be noted that assemblies, sub-assemblies, and component components may be produced elsewhere and then transported to the product site. The employees are often quite competent, and there is a lot of material handling. Additionally, it is typical for the goods produced utilising this pattern to be unique, such as ships, aeroplanes, spacecraft, bridges, buildings, etc. This method of production has the following benefits: Reduced material transportation; improved continuity of operations when employed with a collaboration approach; and flexibility in handling changes in product design, changeovers, and volume.

Cellular manufacturing

Usually, a cellular manufacturing system is made up of a number of interconnected cells. The cells themselves are often made up of many clustered processes. These are often organised into groups based on the steps and processes required to create a certain component part, sub-assembly, or product. Although more flexible, the layout inside the cell is quite similar to that of a flow system. Typically, cells are arranged in a U form to let employees to travel between machines while loading and unloading components. Within cells, there are often significant degrees of automation, including the ability for all machines to operate unattended and turn off when the machining cycle is over. Additionally, this enables the workers to wander between machines or do manual tasks like finishing and inspection.

The present system must be gradually transformed in order to adopt a cellular manufacturing system. To do this, portions of the present system must be transformed into cells. The cells should be created in a manner that enables the production of certain groups or families of parts, i.e., components that share comparable geometrical properties and call for similar manufacturing procedures. Group technology is one technique used to transition conventional manufacturing, notably the jobbing shop, to cellular manufacturing. This method aids in assembling components into harmonious families. Typically, cells are connected directly to one another or to sites of assembly.

The Kanban pull inventory system allows for indirect connections between them as well. Last but not least, the cells may be connected in a manner that enables synchronous operation with sub- and final assembly lines. Regarding the workers, it's possible that they travel between cells while using various procedures. As a result, multitasking is often needed of employees. Numerous characteristics of cellular manufacturing set it apart from conventional production methods. Instead of moving in groups, parts typically travel one at a time from machine to machine. A cell worker should have completed a circuit of the cell when they reach the end. Additionally, setup times are often faster than with conventional systems. Additionally, lead times for goods and components are often shorter. This is possible because many operations may be completed simultaneously while the equipment operate unsupervised. Cells often provide for quicker set-up and lead times, more flexibility and responsiveness, and improved output.

Continuous/process manufacture

Continuous/process manufacturing, such as the production of sugar or fertiliser, includes the continuous production of a product and often combines chemical, physical, and/or mechanical methods. Continuous manufacturing, also known as process manufacturing, is characterised by the use of machinery that is continuously operational for weeks or even months at a time. However, because to equipment failure and/or scheduled maintenance, this seldom occurs. There are no produced discrete goods. Instead, the product is produced in large quantities, and production is probably quantified in terms of physical volume or weight. The process equipment will be arranged in a way that is product-focused, highly specialised, and likely automated. As a result, it will be quite costly. However, depending on their position, such as semi-skilled plant operators, skilled maintenance technicians, etc., the workforce is likely to have a range of skill levels. The production systems that use continuous processes are often the most effective but also the least adaptable.

Manufacturing firms that emphasise their products often use an MTS approach. This strategy's viability depends on the fact that businesses with product-focused manufacturing systems generate significant quantities of a select few common items with well-defined demand patterns. Short client delivery times, which rely on the completed products inventory, and high inventory costs are further features of this method. The MTS model also relies on predictable, somewhat lengthy product life cycles. Last but not least, the consumer is often kept at a distance and unable to communicate their preferences for the product's design. All of the aforementioned are characteristic of businesses that use a mass production technique.

Assemble to order (ATO) strategy

After receiving client orders, the ATO strategy is a method for generating goods with a wide range of alternatives from a small number of key subassemblies and components. This requires producing the aforementioned sub-assemblies and components and keeping them on hand until a client order is received. Then, using the right subassemblies and components, the precise product the client demands is put together. Because there are often many alternatives available and demand cannot be reliably predicted, maintaining completed products inventory is economically impractical. Businesses that adopt an ATO approach often combine process- and product-focused process architectures. The reason for this is because although low-volume sub-assemblies and parts may be produced using process-focused layouts, high-volume sub-assemblies and parts can be produced using a product-focused layout. Customers will mainly interact with a manufacturing business using this technique in a sales capacity. Delivery time is low to medium and depends on the availability of the key components and subassemblies. Then, 20 to 30 pieces at a time will be kept in one of the presses. These pieces will be utilised for things like the tops of tables, desks, and dressers. The routers will be used to further shape goods like chair backs, table or chair legs, and other similar items. All pieces, whether they have been shaped or bonded, are sanded to remove any excess glue as needed and to enhance the surface quality. Depending on the task, holes may need to be made using either the broaching or drilling machinery.

The cabinetmakers may even utilise hand carving to complete tasks requiring specialised cutting on CNC routers. The individual elements are then put together to create a final product, either by joining them directly to other parts or by creating sub-assemblies. Each object has a stamp indicating the year of manufacture, and expansion leaves of tables, cabinet doors, and dresser drawers all have location-specific stamps top drawer, left door, etc. If a piece of furniture is ever returned for repairs, detailed instructions such as the kind of wood and finish are always provided, enabling the repair to closely resemble the original piece. The furniture pieces next typically travel to the "white" inventory area, and finally to the finishing department where linseed oil or another finish is applied, followed by a transfer to the completed products inventory where the items are ready for distribution to retailers and consumers.

Mechanical Cleaning and Surface Treatments

By using abrasives or other comparable mechanical action, mechanical cleaning entails physically removing dirt, scales, or coatings from the work surface of the workpart. The techniques used for mechanical cleaning often perform additional tasks like deburring and enhancing surface polish in addition to cleaning.

Shot peening and blast finishing In blast finishing, a surface is cleaned and finished using the high-velocity impact of particle media. Sand blasting, the most popular of these techniques, employs sand grits (SiO_2) as the blasting medium. Other materials, such as soft materials like nylon beads and broken nut shells, as well as hard abrasives like silicon carbide (SiC) and aluminium oxide (Al_2O_3), are also used in blast finishing. Pressurised air or centrifugal force is used to drive the media towards the target surface. In other applications, the procedure is carried out wet, in which case small water slurries are aimed towards the surface by hydraulic pressure. Shot peening is the process of applying a high-velocity stream of tiny cast steel pellets (known as shot) to a metallic surface in order to cold work and introduce compressive stresses into the surface layers. The main purpose of shot peening is to increase the fatigue strength of metal components. In spite of the fact that surface cleaning is a byproduct of the process, its goal is distinct from blast finishing.

Additional Mass Finishing and Tumbling The term "mass finishing methods" refers to a class of finishing procedures that includes vibratory finishing, tumbling, and related activities. Mass finishing is the process of finishing pieces in mass while combining them in a container, sometimes with abrasive media present. To produce the required finishing action, the mixing forces the components to rub against the medium and one another. Deburring, descaling, deflashing, polishing, radiusing, burnishing, and cleaning are all mass finishing techniques. Extrusions, castings, forgings, stampings, and machined components are among the parts. To obtain the appropriate finishing results, these mass finishing processes are sometimes used to objects made of plastic and ceramic. Since the pieces produced by these techniques are often tiny, finishing them separately is not cost-effective.

Tumbling, vibratory finishing, and many centrifugal force-based procedures are examples of mass finishing. In tumbling, which is also known as barrel finishing and tumbling barrel finishing, pieces are blended by spinning the barrel at rates ranging from 10 to 50 revolutions per minute. The barrel is horizontally orientated and has a hexagonal or octagonal cross section. "Landslide" motion of the media and pieces as the barrel turns produces finishing. The rotation causes the contents of the barrel to rise, and then gravity causes the top layer to fall. This continuous cycle of rising and falling subjects all of the pieces to the same desired finishing action throughout time. However, compared to other mass finishing techniques, barrel finishing is a somewhat sluggish operation since only the top layer of components is being completed at any given time. To finish the procedure, many hours of tumbling are often required.

As a substitute for tumbling, vibratory finishing was launched in the late 1950s.Instead of only the top layer as in barrel finishing, the vibrating vessel agitates all components with the abrasive material. As a result, vibratory finishing processing times are drastically decreased. This approach uses open tubs, which reduces noise while allowing viewing of the pieces during processing. However, certain media also conduct nonabrasive finishing activities including burnishing and surface hardening. Abrasive media make up the majority of the media used in these operations. The medium might be made of synthetic or natural materials. Corundum, granite, limestone, and even hardwood are examples of natural media. These materials have the disadvantages of being usually softer (and hence wearing out more quickly) and nonuniform in size (and occasionally clogging in the workparts). In terms of size and hardness, synthetic media may be produced with higher uniformity.

These materials, which are compressed into the required form and size using a bonding substance like a polyester resin, include Al2O3 and SiC. the shapes for these media include spheres, cones, angle-cut cylinders, and other regular geometric forms. In addition, steel is used as a mass finishing medium in forms similar to those in) for operations such as burnishing, surface hardening, and mild deburring. There are numerous sizes for the shapes Based on the part's size, shape, and finishing needs, the media are chosen.A chemical is often used in conjunction with the medium in mass finishing operations. A mixture of chemicals known as a mass finishing compound is used to perform a variety of tasks, including cleaning, chilling, preventing rust on steel parts and steel media, and improving the brightness and colour of components (particularly when burnishing.

When diffusion is impractical due to the high temperatures needed, ion implantation is a viable option. A high-energy stream of ionised particles is used in the ion implantation procedure to embed atoms of one (or more) foreign elements into a substrate surface. The physical and chemical characteristics of the layers close to the substrate surface change as a consequence. Additionally, the impregnated element's concentration profile differs significantly from the typical diffusion profile. Ion implantation has many benefits, including (1) low temperature processing, (2) excellent control and repeatability of impurity penetration depth, and (3) the ability to surpass solubility limits without precipitating extra atoms. Ion implantation has several uses in place of specific coating processes. Its benefits include (4) no waste disposal issues, unlike with electroplating and many coating procedures, and (5) no discontinuity between the coating and substrate. Ion implantation is mostly used to fabricate semiconductor devices and change metal surfaces to enhance their qualities.

Electroplating

The electrolytic process of electroplating, also known as electrochemical plating involves the deposition of metal ions from an electrolyte solution onto a cathode workpiece. The source of the plate metal is the anode, which is typically constructed of the metal being plated. A direct current is sent between the anode and the cathode from an external power source. The movement of plate metal ions in solution allows the electrolyte, which is an aqueous solution of acids, bases, or salts, to conduct electric current. Parts must be chemically cleaned just before electroplating in order to get the best results.

Applications and Techniques

There are many different pieces of equipment available for electroplating, and the decision will depend on the part's size, shape, throughput needs, and metal plating. The three main techniques are rack plating, strip plating, and barrel plating. In revolving barrels that are either oriented horizontally or at an oblique angle, barrel plating is carried out (35). The technique is appropriate for batch plating of many tiny pieces. Through the tumbling motion of the components, as well as a conductor that extends into the barrel from the outside, electrical contact is maintained. Barrell plating has its limits; for example, the process's intrinsic tumbling movement may harm heavy, sharp-edged, threaded, soft metal, and items that need excellent finishes.

For items that are too big, heavy, or complicated for barrel plating, rack plating is employed. The racks are constructed from heavy-gauge copper wire and are shaped in ways that will retain the components and allow electricity to flow to them. Workparts may be put into baskets, clipped to the racks, or hung from hooks as desired. Except for where component contact occurs, the racks are insulated to prevent plating of the copper itself. Moving the racks with the components through the series of electroplating tanks is necessary. A continuous strip is drawn through the plating solution by a take-up reel in the high-production process known as strip plating. A good example of a suitable use is plated wire. By using this technique, small sheet metal components held on a long strip may also be plated. The procedure may be configured such that just certain areas of the components are plated, such as the gold-plated contact points on electrical connections.

Electroplating often uses the coating metals zinc, nickel, tin, copper, and chromium. The most typical substrate metal is steel. Jewellery is plated with precious metals (such as gold, silver, and platinum). Additionally, electrical connections are made of gold. Fasteners, wire products, electric switch boxes, and different sheet-metal components are examples of items made of steel that has been zinc-plated. The zinc coating acts as a sacrificed barrier to prevent the underlying steel from corroding. Galvanising is an alternate method for applying a zinc coating to steel (Section 28.3.4). Steel, brass, zinc die castings, and other metals are decorated with nickel plating to prevent corrosion. Applications include consumer items and automobile trim. As a base coat for a much thinner chrome plate, nickel is also used. Tin plate is still often used in "tin cans" and other food containers to prevent corrosion.

To make electrical components easier to solder, tin plate is also used. Copper is a valuable plating metal with many useful uses. It is often used as a decorative finish on steel and zinc, either alone or in the form of brass plate when alloyed with zinc. In printed circuit boards, it is also crucial for plating Last but not least, steel is often nickel and/or chrome plated over copper as a basis.

Chrome plate, also known as chromium plate, is often used in kitchen appliances, office furniture, and automobile equipment because of its attractive look. It also creates one of the toughest electroplated coatings, which makes it a popular choice for parts that need to withstand wear, such as thread guides in textile machines and hydraulic pistons and cylinders, piston rings, and aviation engine parts.

Hot Dipping

A metal substrate is submerged in a molten bath of a second metal during the hot dipping process, and after withdrawal, the second metal is coated onto the first. Of course, the melting point of the first metal must be greater than that of the second. Steel and iron are the two metal substrates used most often. The most popular coating metals are lead, tin, aluminium, zinc, and aluminium. Hot dipping creates transition layers with different metal compositions. Intermetallic complexes of the two metals are typically present next to the substrate; solid solution alloys with a predominance of the coating metal are present near the exterior. The coating adheres to the transition layers really well. Corrosion prevention is the main goal of hot dipping.

This protection is often provided by two mechanisms: (1) barrier protection, where the coating just acts as a shield for the metal nderneath, and (2) sacrificial protection, where the coating slowly corrodes via an electrochemical process in order to protect the substrate. Depending on the metal being coated, hot dipping is known by many names: terneplate refers to the plating of lead-tin alloy onto steel; aluminizing is the coating of aluminium onto a substrate; tinning is the coating of tin; and galvanising is the plating of zinc (Zn) onto steel or iron. With a history of nearly 200 years, galvanising is by far the most significant hot dipping procedure. In a batch process, it is used on completed steel and iron components, and in an automated continuous process, it is used on sheet, strip, pipe, tubing, and wire.

The normal coating thickness ranges from 0.0016 to 0.0035 in (0.04 to 0.09 mm). The duration of immersion has a big impact on thickness. The average bath temperature is 450°C (850°F). Aluminizing is increasingly being used commercially, and it is steadily gaining market share over galvanising. Excellent corrosion protection is offered by hot-dipped aluminium coatings, which in certain circumstances outperform galvanising by a factor of five . In applications for food containers, dairy equipment, and soldering applications, hot dipping tin plating offers harmless corrosion protection for steel. Electroplating has progressively replaced hot dipping as the most used commercial technique for plating tin onto steel. A lead-tin alloy is heatedly dipped onto steel during terneplating. Lead makes up the majority of the alloy (only 2%–15% Sn), although tin is necessary for the coating to adhere properly. The least expensive coating process for steel is called terneplate, although it offers only little corrosion protection.

Polymers and resins, which act as binders in organic coatings, control the coating's solid-state characteristics, including its tensile strength, physical attributes, and surface adherence. During and after the coating is applied to the surface, the binder keeps the pigments and other components together.

Natural oils (used to make oil-based paints) and resins like polyesters, polyurethanes, epoxies, acrylics, and cellulosics are the most used binders in organic coatings.

The coating's colour is produced using dyes and pigments. Dyeing agents are soluble substances that provide coating liquids colour but do not cover the surface below. Determining that dye-colored coatings are often translucent or transparent. Pigments are solid, microscopic-sized particles that are scattered throughout the coating liquid yet are insoluble in it. They not only tint the coating but also cover the subsurface. Since they are particles, pigments also have the tendency to make the coating stronger.

The binder and a few other elements in the liquid coating composition are dissolved using solvents. Aliphatic and aromatic hydrocarbons, alcohols, esters, ketones, and chlorinated solvents are typical solvents used in organic coatings. Different binders need different solvents. Surfactants (which make coatings easier to spread on surfaces), biocides, fungicides, thickeners, freeze/thaw stabilisers, heat and light stabilisers, coalescing agents, plasticizers, defoamers, and catalysts that encourage cross-linking are some of the additives used in organic coatings. With the help of these materials, a broad range of coatings, including paints, lacquers, and varnishes, may be produced.

The technique used to apply an organic coating to a surface is determined by a number of variables, including the coating liquid's composition, the desired coating thickness, production rate and cost concerns, component size, and environmental constraints. It is crucial that the surface be adequately prepped before using any of the application procedures. This includes washing and potential surface treatments like phosphate coating. For the best corrosion protection, metallic surfaces may sometimes be plated before receiving an organic coating. Transfer efficiency is a key factor in every coating technique.

The percentage of paint added to the process that is actually applied to the work surface is known as transfer efficiency. Some techniques only achieve a 30% transfer efficiency, which translates to a waste of 70% of the paint that cannot be recovered. Brushing and rolling, spray coating, immersion, and flow coating are all options for putting on liquid organic coatings. To get the desired effect, the substrate surface may sometimes get multiple consecutive coats. An automobile's car body is a prime example; the process typically used to construct a sheet-metal car body for a mass-produced vehicle is as follows: (1) Phosphate coat, (2) priming coat, (3) colour paint coat, applied by spray painting, and (4) clear coat, sprayed by spraying (for high gloss and additional protection. The two most common application techniques are brushing and rolling. They transport data with a high efficiency that is almost 100%. Manual rolling and brushing techniques are more suited for small-scale manufacturing than for large production. Rolling is only appropriate for flat surfaces, but brushing is highly adaptable.

CONCLUSION

In conclusion, a critical component of product creation and design optimisation is the link between material qualities and product attributes. By examining how different product qualities are influenced by material properties and emphasising the importance of material selection, processing methods, and design concerns, this research project sought to investigate this link. The study found that many material characteristics, such as mechanical, thermal, electrical, and chemical characteristics, directly affect product characteristics including strength, durability, conductivity, and appearance. Manufacturers and designers may choose materials wisely, assuring optimum performance and desired qualities, by knowing the link between material properties and product attributes.

The routers will be used to further shape goods like chair backs, table or chair legs, and other similar items. All pieces, whether they have been shaped or bonded, are sanded to remove any excess glue as needed and to enhance the surface quality. Depending on the task, holes may need to be made using either the broaching or drilling machinery.

The cabinetmakers may even utilize hand carving to complete tasks requiring specialized cutting on CNC routers. The individual elements are then put together to create a final product, either by joining them directly to other parts or by creating sub-assemblies The research also emphasized how cutting-edge materials and new technology might improve product qualities. New options for enhancing performance, personalization, and design flexibility are provided by nanomaterials, composites, and additive manufacturing processes.

REFERENCES

[1] W. Wang *et al.*, “Surface diffusion-limited lifetime of silver and copper nanofilaments in resistive switching devices”, *Nat. Commun.*, 2019, doi: 10.1038/s41467-018-07979-0.

[2] S. Gorsse, C. Hutchinson, M. Gouné, en R. Banerjee, “Additive manufacturing of metals: a brief review of the characteristic microstructures and properties of steels, Ti-6Al-4V and high-entropy alloys”, *Science and Technology of Advanced Materials*. 2017. doi: 10.1080/14686996.2017.1361305.

[3] V. Pérez-Silos, A. Camacho-Morales, en L. Fuentes-Mera, “Mesenchymal Stem Cells Subpopulations: Application for Orthopedic Regenerative Medicine”, *Stem Cells International*. 2016. doi: 10.1155/2016/3187491.

[4] M. Shabgard, M. Seyedzavvar, en S. N. B. Oliaei, “Influence of input parameters on the characteristics of the EDM process”, *Stroj. Vestnik/Journal Mech. Eng.*, 2011, doi: 10.5545/sv-jme.2011.035.

[5] M. L. Jewell, B. Fickas, H. Jewell, en M. L. Jewell, “Implant Surface Options and Biofilm Mitigation Strategies”, *Plastic and Reconstructive Surgery*. 2019. doi: 10.1097/PRS.0000000000005946.

[6] H. A. Lee, Y. Ma, F. Zhou, S. Hong, en H. Lee, “Material-Independent Surface Chemistry beyond Polydopamine Coating”, *Acc. Chem. Res.*, 2019, doi: 10.1021/acs.accounts.8b00583.

[7] M. Acosta, F. Baiutti, A. Tarancón, en J. L. MacManus-Driscoll, “Nanostructured Materials and Interfaces for Advanced Ionic Electronic Conducting Oxides”, *Advanced Materials Interfaces*. 2019. doi: 10.1002/admi.201900462.

[8] J. Rajala, “Design of the Otjikoto Gold Mill, Namibia”, *Mining, Metall. Explor.*, 2021, doi: 10.1007/s42461-020-00336-0.

[9] T. Huovinen, L. Lindenburg, R. Minter, en F. Hollfelder, “Multiplexed Affinity Characterization of Protein Binders Directly from a Crude Cell Lysate by Covalent Capture on Suspension Bead Arrays”, *Anal. Chem.*, 2021, doi: 10.1021/acs.analchem.0c03992.