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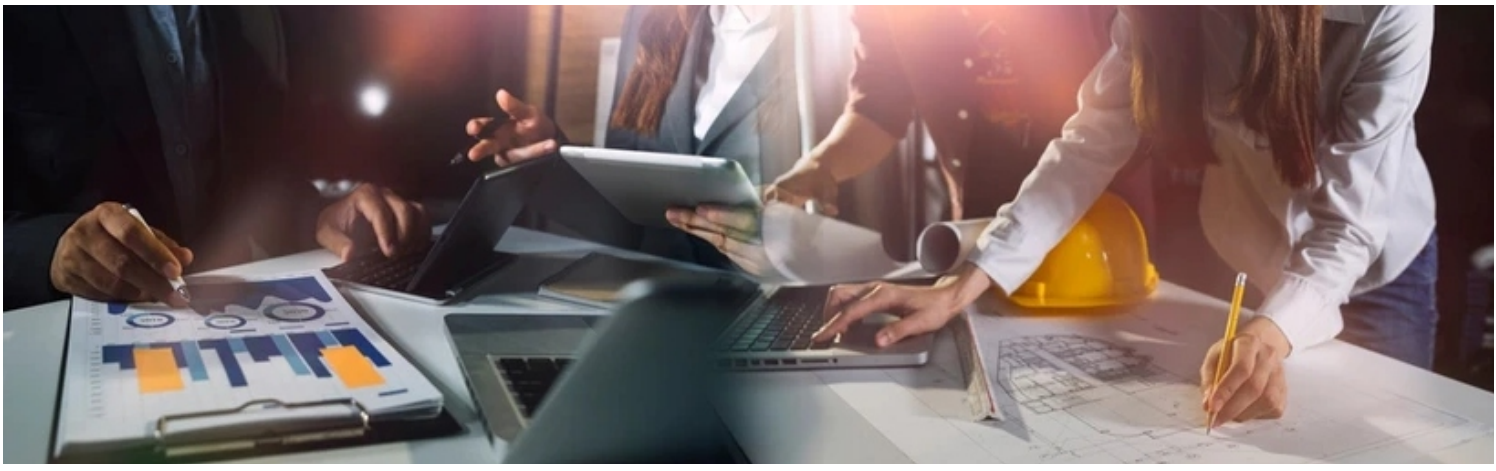

PRODUCTION PLANNING AND CONTROL

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CHAPTER 1

DETERMINATION OF PRODUCTION PLANNING AND CONTROL: STRATEGIES, TECHNIQUES AND PERFORMANCE OPTIMIZATION

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ABSTRACT:

In manufacturing organizations, production planning and control is a crucial process that tries to optimise production processes and guarantee effective resource utilization. The notion of production planning and control, its significance in accomplishing organisational goals, and the numerous techniques and procedures employed in the process are all explored in this essay. The study also emphasises how technology may improve systems for production planning and control.This research study focuses on the determination of production planning and control, examining the strategies, techniques, and performance optimization methods employed in managing the production process. It investigates the key elements of production planning and control, including demand forecasting, capacity planning, scheduling, inventory management, and quality control. The study analyzes the challenges faced in aligning production activities with customer demand, optimizing resource utilization, minimizing costs, and ensuring timely delivery of products. It explores the various strategies and techniques used in production planning and control, such as lean manufacturing, just-in-time (JIT) systems, enterprise resource planning (ERP), and advanced analytics. Additionally, the study evaluates the performance implications of effective production planning and control, including improved productivity, reduced lead times, enhanced customer satisfaction, and cost savings. The findings contribute to a comprehensive understanding of production planning and control, informing evidence-based decision-making and providing insights for optimizing production processes and performance.

KEYWORDS:

Production Planning, Production Control, Resource Optimization, Manufacturing, Technology.

INTRODUCTION

The management may use production planning and control to accomplish the specified goals.The four components thus cover a manufacturing system. i.e., amount, standard, expense, and duration.Production planning begins with an examination of the available data, such as product demand and deliverytimeline, etc., and based on the facts at hand, a plan of utilization of the firm's resourcessuch as equipment, materials, and peoples developed to reach the aim in the most cost-effective manner.

After the plan has been created, it is then carried out in accordance with the information specified in the plan. If there is any difference between what happened and what was intended, production control kicks in. By using control approaches, the corrective action is conducted in order to hit the targets established as intended.Therefore, the "direction and coordination of firms' resources towards attaining the prefixed goals" may be described as production planning and control. By making the necessary materials accessible at the

appropriate time and in the requisite amount, production planning and control aid in maintaining an unbroken flow of materials through the production line[1]–[3].

Need For Production Planning and Control

India's current techno-economic environment places a strong emphasis on industrial competitiveness.In order to increase productivity, Indian enterprises must simplify production processes and maximise resource utilisation. Planning and managing production is aimportant tool for coordinating production system operations via effective planning and management. With PPC acting as the brain, the production system may be equated to the nerve system.

1. Effective resource utilisation of businesses is achieved via production planning and management.
2. To meet the production goals in terms of quality, quantity, cost, and delivery deadlines.
3. To maintain a continuous production flow in order to satisfy the various quality and delivery deadline demands of the client base.
4. Assist the business in consistently offering customers high-quality goods at affordable prices.

A pre-production activity is production planning. It is the early identification of manufacturing needs, including labour, supplies, equipment, and production methods.Production planning, according to Ray Wild, is the selection, purchase, and organisation of all facilities required for product production in the future. It stands for the production system's design. It will organise the output in addition to organising the resources.The production strategy will be established based on the anticipated demand for the company's goods in order to reach the goals specified while using a variety of resources.

Production Management

Even with meticulous planning, it is often impossible to accomplish output that is 100% in accordance with the plan. There might be a myriad of reasons that have an impact on the manufacturing system and create a divergence from the original design. One is the lack of materials (due to scarcity, etc.); another is the breakdown of plants, machines, and equipment; a third is changes in demand and rush orders; a fourth is employee absenteeism; and a fifth is the lack of coordination and communication between different functional divisions of the organisation.

Therefore, the control mechanism kicks in whenever there is a discrepancy between actual and planned output. The goal of production control via control mechanisms is to match planned and actual output. To guarantee that production proceeds as planned, production control evaluates the state of the work and implements corrective measures. Starting the production, moving forward, and taking corrective action based on input before reporting back to the production planning are the three crucial processes in control activity.

Objectives Of Production Planning and Control

The goals of production planning and control are as follows:

1. Systematic planning of manufacturing operations to maximise product/service output efficiency.

2. To arrange the production resources, such as labourers and equipment, in order to meet the set production goals in terms of time, cost, and quantity.

3. Resource scheduling that is ideal.

4. Work in tandem with other production-related divisions to provide a consistent, ongoing flow of output.

5. To uphold delivery promises.

6. Control and planning for materials.

7. The capacity to modify in response to shifts in demand and urgent requests.

DISCUSSION

Phases of Production Planning and Control

There are three stages to production planning and control, namely:

1. Phases of planning,
2. action
3. control

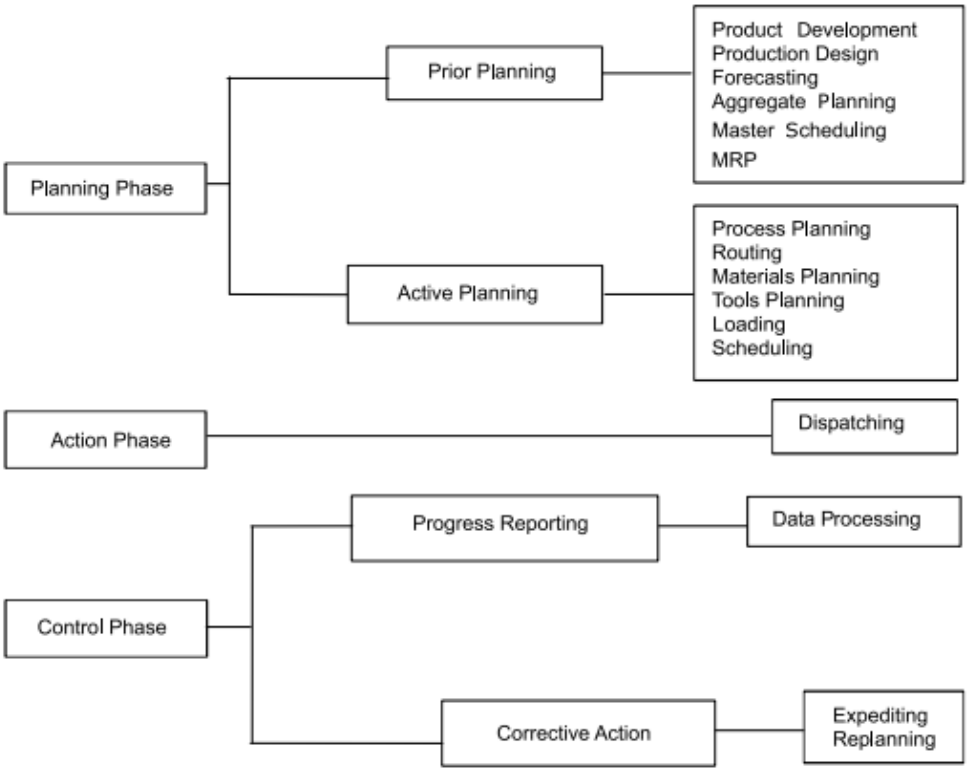

Figure 1: Represents the Phases of Phases of production planning and control.

Planning Phase

under order to determine how a target may be met or a demand satisfied under always-restrictive conditions, planning is an exercise in intelligent anticipating. Production scheduling decides on the most efficient batch size, machine assignment, and dispatching priority for the order of operations.There are two types of planning:

1. Prior planning

2. Conscious planning.

Early Planning

Pre-production planning is prior planning. This encompasses all planning activities that are done before active planning.modules for preparationthe following are the modules of previous planning:

1. The process of creating a new product with all the characteristics required for practical usage in the field and designing it in accordance with those features is known as product development and design.One must consider a number of design elements throughout the design stage, including design for using, design for manufacturing, and design for selling.

2. Forecasting is the process of estimating future demand. It must be estimated carefully since it is merely an estimate based on prior demand. The management must choose what production rate torun the facility at over an interim planning horizon based on the sales projection, factory capacity, total inventory levels, and workforce size.

3. Finding a product-wise planning across the intermediate planning horizon is the goal of aggregate planning.

4. Material requirement planning is a method for figuring out how much and when to buy dependent products in order to meet the master production schedule.

Advanced Planning

The components of active planning are materials planning and process planning and routing. Planning, loading, and scheduling for tools, etc.

1. Process planning and routing refers to the comprehensive selection of the precise technical stages and their ordering in order to create goods with the required quality, quantity, and cost. It decides how to make a product, chooses the tools and equipment, and assesses how the manufacturing process will work with the facilities. The flow of work in the plant is specifically prescribed by routing, which is connected to issues with layout, temporary storage facilities for raw materials and components, and materials handling systems[4]–[6].

2. Material planning is a procedure that establishes the needs for different raw materials/subassemblies by balancing various cost factors including carrying cost, ordering cost, shortfall cost, and so on.

3. By considering process specifications (surface finish, job length, overall depth of cut, etc.), material specifications (type of material used, hardness of the material, shape and size of the material, etc.), and equipment specifications (speed range, feed range, depth of cut range, etc.), tools' planning determines the requirements of various tools.

4. Loading is the process of allocating tasks to a number of machines such that the loads on each machine are balanced. This is a rather challenging problem that may be handled with the aid of effective heuristic processes.

5. Scheduling, which dictates when and how the job will be completed, is the time phase of loading. This sets the beginning and ending times for each task.

Action Phase

The main action in the action phase is dispatching. Dispatching marks the change from the planning stage to the execution stage. The worker is given the go-ahead to begin producing the product at this stage.Job orders, store issue orders, tool orders, time tickets, inspection orders, move orders, etc. are tasks that are a part of dispatching.The crucial detail that has to

be stated in all other reports and orders is the task order number.When retailers get an order, they are instructed to provide the materials needed to manufacture the goods in accordance with the product's requirements. The tool order directs the tool room to issue the appropriate tools in accordance with the tooling requirements for producing the product. A time ticket is nothing more than a card created to record the actual amount of time spent on different procedures. This data is used to calculate the costs for comparable projects in the future and to do variance analysis, which helps in maintaining control.The job order serves as the shop floor's formal authorisation to begin the product's manufacture.The process flow will often include some testing and inspection. In order to minimise the quantity of rework, they are to be directed to the inspection wing in the form of an inspection order for prompt testing and inspection. Moving raw materials and subassemblies to the main line is a necessary step in the production of a product. This is accomplished through a competent materials handling system. Therefore, suitable instructions are provided to the material handling facilities in the form of a move order for substantial moves of materials or subassemblies. On the shop floor, movements with smaller weights and shorter distances are controlled in response to operator demands.

Control Phase

The following two primary components make up the control phase are:

1. Progress reporting

2. Corrective action**.**

Progress Reporting

Data about the state of the work is gathered during progress reporting. Making comparisons with current performance levels is also helpful. For the aim of progress reporting, numerous data relating to materials rejection, process variations, equipment failures, operator efficiency, operator absenteeism, tool life, etc. are gathered and analysed. These data are utilised for variance analysis, which will enable us to find problem areas that need to be addressed right away and get remedial action[7]–[10].

Corrective Action

The activities listed under remedial action mostly include contingency plans. The creation ofschedule flexibility, schedule alterations, capacity modifications, make-or-buy choices, accelerating the work, pre-planning, and other similar practises are some examples of corrective measures. It may not be able to carry out the schedule according to the plan owing to unanticipated factors like machine failure, worker absence, an excessive amount of rejection due to poor material quality, etc. In these circumstances, it is preferable to rearrange the whole product lineup in order to have a comprehensive understanding of the problem and move on. In this case, it must be reexamined to determine the best course of action. If the progress reporting reveals deviations from the initial objectives, expediting refers to taking action. If expediting is unable to correct the erroneous plan, pre-planning of the whole situation becomes crucial.

CONCLUSION

In manufacturing organisations, establishing operational excellence and satisfying customer The management of the production process, matching of operations with customer demand, resource optimisation, and timely and effective product delivery are all made possible by production planning and control. This research study sought to investigate how production

planning and control are established and to provide insights into the strategies, tactics, and performance optimisation approaches used in this area.Demand forecasting, capacity planning, scheduling, inventory management, and quality control are just a few of the essential components that make up production planning and control. To fulfil market demands and prevent stockouts or surplus inventory, manufacturing operations must be coordinated with consumer demand. In order to satisfy production demands, capacity planning ensures that there are enough resources, taking into account elements like space, labour, and equipment. In order to maximise productivity and cut down on lead times, effective scheduling optimises the order and timing of production processes. The goal of inventory management is to maintain sufficient stock levels to fulfil demand while reducing carrying costs. Product standards are met via quality control, increasing customer satisfaction and minimising waste or rework.

REFERENCES

[1] D. P. Indriasari And A. Sani, "Pengendalian Manajemen Pupuk Subsidi," *J. Apl. Manaj. Kewirausahaan Massaro*, 2019, Doi: 10.37476/Massaro.V1i1.642.

[2] T. Hill, "Manufacturing Strategy Text And Cases," *Macmillan Bus.*, 1995.

[3] A. I. Pratiwi, A. Hakim, And R. Y. Santosa, "Development Of Operation Process Map And Analysis Of Inventory Control Based On Material Requirement Planning In Assembly Line," *J. Ind. Eng. Halal Ind.*, 2020, Doi: 10.14421/Jiehis.1800.

[4] C. Gudnason And J. Riis, "Manufacturing Strategy," *Omega*, 1984, Doi: 10.1016/0305-0483(84)90057-4.

[5] A. Dalal, A. Darweesh, P. Misselwitz, And A. Steigemann, "Planning The Ideal Refugee Camp? A Critical Interrogation Of Recent Planning Innovations In Jordan And Germany," *Urban Plan.*, 2018, Doi: 10.17645/Up.V3i4.1726.

[6] I. M. S. Yasa And K. Mandala, "Material Requirement Planning Untuk Memenuhi Produksi Pada Cv. Bangun Cipta Artha Di Badung," *E-Jurnal Manaj. Univ. Udayana*, 2020, Doi: 10.24843/Ejmunud.2020.V09.I02.P02.

[7] J. Venkateswaran And Y. J. Son, "Hybrid System Dynamic - Discrete Event Simulation-Based Architecture For Hierarchical Production Planning," *Int. J. Prod. Res.*, 2005, Doi: 10.1080/00207540500142472.

[8] H. Rivera-Gómez, O. Montaño-Arango, J. R. Corona-Armenta, J. Garnica-González, A. O. Ortega-Reyes, And G. E. Anaya-Fuentes, "Jit Production Strategy And Maintenance For Quality Deteriorating Systems," *Appl. Sci.*, 2019, Doi: 10.3390/App9061180.

[9] T. F. Umry And M. L. Singgih, "Inventory Management And Reorder Point (Rop) Strategy Using Abc Analysis Methods In Textile Manufacture," *Iptek J. Proc. Ser.*, 2019, Doi: 10.12962/J23546026.Y2019i5.6355.

[10] H. Junker And C. Domann, "Towards Industry 4.0 In Corporate Energy Management," *Wit Trans. Ecol. Environ.*, 2017, doi: 10.2495/ECO170051.

CHAPTER 2

FUNCTIONS OF PRODUCTION PLANNING AND CONTROL: ENHANCING OPERATIONAL EFFICIENCY

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ABSTRACT:

A critical component of manufacturing operations is production planning and control, which entails the management and coordination of resources, procedures, and activities to guarantee successful and efficient output.

The functions of production planning and control are the main subject of this study, as well as how they contribute to improved operational effectiveness. The various tasks involved in production planning and control are examined, including demand forecasting, capacity planning, scheduling, materials requirement planning, inventory management, quality control, shop floor control, performance monitoring and analysis, production cost analysis, and continuous improvement.

The research investigates how these tasks help with customer satisfaction, reducing lead times for manufacturing, assuring product quality, and boosting profitability in addition to optimising resource utilisation. It examines the main approaches, methods, and tools used to carry out these tasks.

The results contribute to a thorough knowledge of the roles played by production planning and control, as well as to the development of practises and evidence-based decision-making for improving operational effectiveness and performance in manufacturing and service sectors.

KEYWORDS:

Manufacturing Operations, Resource Management, Production Planning, Production Control, And Digital Technology.

INTRODUCTION

Pre-planning is macro-level planning that involves data analysis and is a summary of the planning strategy based on anticipated demand, market study, and product design and development. Process design (new procedures and innovations, equipment policy and replacement, and work flow (Plant layout) are all part of this stage.

Pre-planning is a PPC function that deals with making decisions about work flow, machines, and procedures based on availability, scope, and capacity.Pre-planning is macro-level planning that involves data analysis and is a summary of the planning strategy based on anticipated demand, market study, and product design and development.

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Production planning and controlling duties are divided into:

1. Function of pre-planning

2. The planning process

3. Control mechanism

Production planning and controlling duties

Pre-planning is macro-level planning that involves data analysis and is a summary of the planning strategy based on anticipated demand, market study, and product design and development. Process design (new procedures and innovations, equipment policy and replacement, and work flow (Plant layout) are all part of this stage. Pre-planning is a PPC function that deals with making decisions about work flow, machines, and procedures based on availability, scope, and capacity.

Planning Performance

Once the work to be completed is determined, the planning function begins with a study of the four Ms: machines, methods, materials, and manpower. Process planning (routing) follows this. Long-term and short-term planning are both taken into account.Standardization and process simplification are taken into account[1]–[3].

Management Function

Dispatching, material control inspection and expediting, and work-in-process analysis all impact the control phase. The PPC cycle is finally completed by evaluation, after which remedial measures are implemented in response to analysis' comments. A strong feedback and communication mechanism is necessary to improve and guarantee PPC effectiveness.

Parameters for PPC

The following parameters may be used to describe how PPC works:

1. Materials: To guarantee that each activity begins and ends correctly and to maintain continuous production, raw materials, completed goods, and purchased components must be made accessible 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.

2. Machines and equipment: The complete examination of the available production facilities, equipment downtime, maintenance policy, process, and timetables is connected to this role. worried about the cost of jigs and fittings and the accessibility of equipment. As a result, the tasks include analysing the facilities to ensure their availability with the least amount of downtime due to malfunctions.

3. Methods: This task entails analysing available options and choosing the optimal approach while taking into account any limitations that may have been imposed. A key component of PPC is the creation of process specifications and the choice of the execution order.

4. Process planning (Routing): Routing is the process of choosing the direction or route that raw materials should take to become final goods. The tasks include:Fixing the route of travel while taking into account the layout.Dissecting processes into individual operations and defining them in depth.Choosing the setup and execution times for each operation.

5. Estimating: The operations times are estimated when the general technique and sequence of operations have been defined 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.

6. Loading and scheduling: Planning machine loads and setting start and end dates for each operation are also part of scheduling, 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.

7. Dispatching: The planning phase's implementation phase. By issuing orders and instructions, it is the process of starting up manufacturing activity. By providing the operator with supplies, components, tools, fixtures, and instruction manuals, it authorizes the commencement of production operations.

The tasks include: (a) Assigning specific work to specific equipment, work centres, and people.

(b) To order the necessary supplies from the retailers.

(c) To produce jigs and fittings and provide them at the proper point of usage.

(d) Authorise the release of any required work orders, time tickets, etc. to allow for a prompt start to operations.

(e) To note the beginning and ending times of each task performed by each worker or machine.

8. Expediting: This management tool closely monitors how the task is progressing. 'Follow-up' is the natural next step following shipment. It engages in comprehensive coordination to carry out the production strategy. The three components of a function that is progressing are follow up on materials, follow up on work-in-progress, and follow up on assembly. The following are some of the responsibilities:

(a) Finding any bottlenecks, delays, or disruptions that might throw off the production schedule.

(b) To create plans of action (remedies) for fixing the mistakes.

(c) Checking if the manufacturing pace is on track.

Inspection is a key control measure. Although quality control is a distinct role, PPC places a great deal of importance on it both for the implementation of existing plans as well as its potential for future planning.

Knowing the limits of methodologies, procedures, etc. on the basis of this information is crucial during the assessment phase.Although it is often skipped, this phase is essential to increasing productivity efficiency. To find the weak points and take remedial action with regard to pre-planning and planning, a detailed examination of all the aspects impacting production planning and control is helpful. The exchange, collection, and analysis of data and information are all crucial to the success of this stage.

DISCUSSION

Operations Planning And Scheduling Systems

Systems for planning and scheduling operations are concerned with the quantity and timing of outputs as well as the optimum utilisation of operational capacity for competitive effectiveness. These systems must integrate diverse levels of activity, from top to bottom, in support of one another. As we go from the top to the bottom of the hierarchy, you'll see that the time orientation changes from long to short. Additionally, the planning process's degree of complexity varies from broad at the top to detailed at the bottom.

Components of Operations Planning and Scheduling System

Plan of Business

The business plan is a forecast of the organization's overall level of business activity for the next six to eighteen months, typically expressed in terms of outputs (in sales volume) for its various product groups, a collection of unique products that share or consume similar capacity blocks during the manufacturing process. Additionally, it details the total backlog and inventory levels that will be maintained during the planning period. All functional areas—finance, manufacturing, marketing, engineering, and research and development—agree on the level of activity and the goods they are committed to support in the business plan. The particular timing of the measures required to carry out the plan's objectives is not addressed in the business plan in all of its intricacies. Instead, it chooses a workable broad strategy for competing to achieve its main objectives. The resultant strategy directs the more specific, lower-level choices.

Planning for aggregate production

the practise of forecasting weekly or monthly production levels for several product groupings for the next six to 18 months. It indicates the total magnitude of outputs supporting the company strategy. The plan takes into account the division's current fixed capacity as well as the general corporate policies for managing inventories and backlogs, employee stability, and subcontracting.

Capacity Planning

It is the process of determining if plans for total production are feasible and gauging the utilisation of all available capacity. A declaration of intended results is only helpful if it can be achieved. As a result, it deals with the firm's capacity to fulfil demand from the supply side. Each factory, facility, or division needs its own aggregate production plan, and the same is true of aggregate capacity plans.

A capacity plan converts an output plan into input terms, estimating how much of the division's capacity will be utilised. Capacity and output must be in balance, as shown by the arrow between them[4]–[6]. Despite the fact that these fundamental capabilities are set, management has the ability to control the short-term capacities by adjusting the way they deploy their workforce, hiring subcontractors, or scheduling several work shifts to change the timing of total outputs.

As a consequence, in order to fulfil demand and use capacity at desired levels over the next several months, the overall planning process balances production levels, capacity restrictions, and temporary capacity modifications. The resultant timetable for the master production is constrained by the plan.

MPS, Or Master Production Scheduling

According to client orders and demand projections, the MPS is a timetable that indicates how many of each product must be produced each week. Its goal is to satisfy consumer demand for certain items within the product category. At this more in-depth level of planning, the product groupings are broken down into specific goods and production dates are provided. An essential connection between marketing and manufacturing is the MPS. It displays the time that each shipment may be planned for delivery as well as the time that incoming sales orders can be put into production. In order to ensure that the production and delivery timetables are realistic, it also takes into consideration the present backlogs.

Testing the viability of the master production schedule in terms of capacity is the process of resource requirement planning, also known as rough-cut capacity planning. This process makes sure that a planned MPS won't accidentally overwhelm any important departments, work centres, or equipment, rendering the MPS useless.

Planning For Material Requirements

The master production schedule may be accomplished by using a system called material requirement planning (MRP), which plans and schedules the time-phased material needs for releasing materials and receiving materials. Therefore, planning for material needs is driven by the master production schedule. MRP offers data like as component due dates, which are then utilised for shop floor management. Managers may estimate the specific needs for each work centre once this data is available.

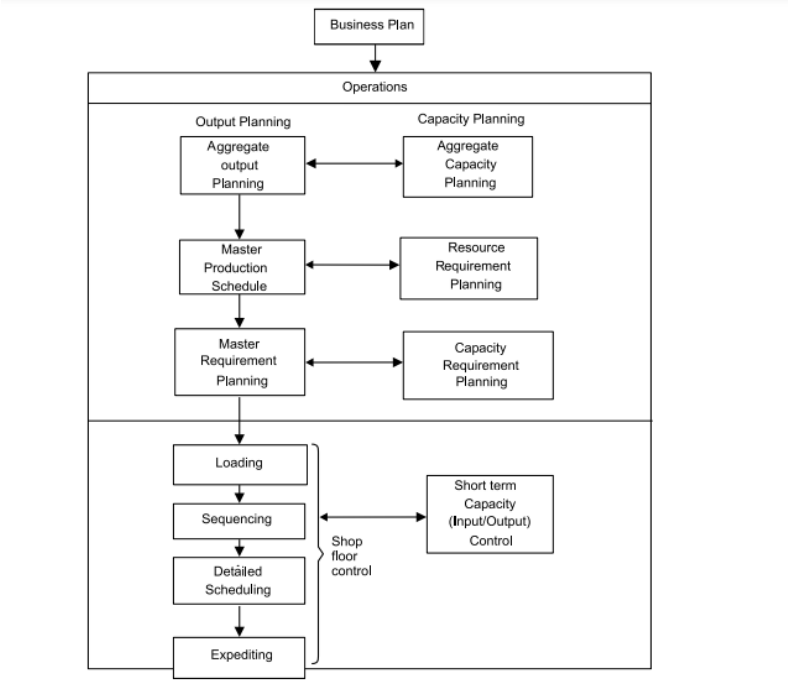

Figure 1: Represents the Operations planning and scheduling system. Planning For Resource Requirements

Planning For Capacity Requirements

Changing the MPS or projected resources iteratively to align capacity with the production schedule is known as capacity requirement planning (CRP). CRP is a supporting technique that works with MRP to precisely pinpoint the capacity needed to carry out material

requirement planning. At this level, it is feasible to compare the required and available capacity for the planned workloads more precisely.

Control Of Shop Floor

The activities that execute and manage shop operations, such as loading, sequencing, meticulous scheduling, and accelerating work in production, are referred to as shop floor control. It organises the daily and weekly tasks that complete tasks. The sequencing of processing the jobs for priority control is decided, start times and job assignments are decided for each stage of processing (detailed scheduling), and materials and work flows from station to station are monitored and adjusted (expediting). Individual jobs are assigned to machines and work centres.

Charging

Each job (client order) may have a distinct product specification, making it unique throughout the facility's multiple work centres. As fresh task orders are made available, they are distributed across the work centres, determining how much of a burden each work centre will be responsible for during the next planning period. The task of loading is sometimes referred to as machine loading or shop loading.

Sequencing

In this phase, the order of tasks in the work centres' waiting lines is determined.The adoption of a priority sequencing rule is necessary for priority sequencing, which sets the order in which the waiting tasks are handled[7]–[9].

Specific Calendaring

All occupations at each work facility have certain start and end hours, as well as work assignments. At each work centre, calendar periods are designated for the arrival of job orders, personnel, and supplies (inputs), as well as the conclusion of jobs (outputs). Schedulers may set start and completion dates and create the comprehensive schedule by predicting how long each work will take to complete and when it is due.

Accelerating

Tracking a job's progress and taking extra steps to expedite its passage through the facility is the process of expediting. To keep the work moving through the facility on schedule, extra action may be required to monitor the job's progress. Disruptions in manufacturing or service operations, such as equipment failures, a lack of supplies, and last-minute changes in priority, force managers to veer from plans and timetables and rush a crucial project under unusual handling conditions[10].

CONCLUSION

The core of effective manufacturing operations is production planning and management, which enables resource optimisation, boosts efficiency, and satisfies customer needs. Organisations may save costs, increase product quality, and minimise lead times by efficiently planning and managing production processes. Real-time monitoring, data-driven decision making, and automation are made possible by the integration of digital technology in production planning and control systems, increasing efficiency and flexibility. Utilising efficient production planning and management techniques helps businesses run more efficiently, satisfy customers, and gain a competitive edge. Strong production planning and control methods may help organisations achieve operational excellence and successfully

adjust to changing market conditions.Enhancing operational effectiveness and performance requires effective production planning and control activities. These functions and their effects on resource use, customer happiness, manufacturing lead times, product quality, and profitability were the focus of this study.To predict future consumer demand and adjust production levels appropriately, demand forecasting is crucial. Optimal resource utilisation is ensured by accurate resource allocation, inventory management, and production activity planning.The production capacity must meet the anticipated demand, and capacity planning makes sure of this. It entails evaluating the existing resources, such as machinery, labour, and space, to ascertain the capacity needed to meet production objectives.

REFERENCES

[1] S. Grundstein, S. Schukraft, B. Scholz-Reiter, and M. Freitag, "Coupling order release methods with autonomous control methods – an assessment of potentials by literature review and discrete event simulation," *Int. J. Prod. Manag. Eng.*, 2015, doi: 10.4995/ijpme.2015.3199.

[2] V. D. R. Guide, V. Jayaraman, and R. Srivastava, "Production planning and control for remanufacturing: A state-of-the-art survey," *Robot. Comput. Integr. Manuf.*, 1999, doi: 10.1016/S0736-5845(99)00020-4.

[3] A. Moeuf, R. Pellerin, S. Lamouri, S. Tamayo-Giraldo, and R. Barbaray, "The industrial management of SMEs in the era of Industry 4.0," *Int. J. Prod. Res.*, 2018, doi: 10.1080/00207543.2017.1372647.

[4] H. Jürgen Warnecke and W. Dangelmaier, "Functions and interfaces in a flexible production planning and control system," *Comput. Integr. Manuf. Syst.*, 1991, doi: 10.1016/0951-5240(91)90006-K.

[5] I. P. Tatsiopoulos, "On the unification of bills of materials and routings," *Comput. Ind.*, 1996, doi: 10.1016/S0166-3615(96)00057-7.

[6] O. Zegarra and L. F. Alarcón, "Coordination of teams, meetings, and managerial processes in construction projects: using a lean and complex adaptive mechanism," *Prod. Plan. Control*, 2019, doi: 10.1080/09537287.2019.1578905.

[7] G. R. Kontsevoy, D. N. Ermakov, N. I. Rylova, V. P. Leoshko, and M. F. Safonova, "Management accounting of agricultural production: improving planning and standardization of costs in the management information system," *Rev. Amaz. Investig.*, 2020, doi: 10.34069/ai/2020.27.03.31.

[8] D. Mourtzis, "An integrated system for managing ship repair operations," *Int. J. Comput. Integr. Manuf.*, 2005, doi: 10.1080/09511920500234044.

[9] P. Zhao *et al.*, "The Modeling and Using Strategy for the Digital Twin in Process Planning," *IEEE Access*, 2020, doi: 10.1109/ACCESS.2020.2974241.

[10] R. G. Junker *et al.*, "Characterizing the energy flexibility of buildings and districts," *Appl. Energy*, 2018, doi: 10.1016/j.apenergy.2018.05.037.

CHAPTER 3

OVERVIEW OF AGGREGATE PLANNING: CONCEPTS, APPROACHES AND DECISION-MAKING STRATEGIES

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ABSTRACT:

In operations management, aggregate planning is a strategy process that identifies the ideal levels of output, labour, and inventory over a predetermined period of time. The idea of aggregate planning, its importance in producing cost-effective manufacturing, and the numerous methods and tactics used in this process are all explored in this essay. This research study offers a summary of aggregate planning with an emphasis on the ideas, methods, and decision-making techniques involved in this significant procedure. In order to fulfil demand while maximising costs and resources, aggregate planning entails establishing production levels, labour, and resource needs over a medium-term horizon. Demand forecasting, production capacity, inventory management, labour planning, and subcontracting are some of the major elements of aggregate planning that are examined in the research. It examines a number of aggregate planning strategies and methods, including level production, pursue demand, and hybrid strategies. The study examines factors that influence decisions, including costs, customer satisfaction, risk management, and sustainability. The research also assesses the effects of efficient aggregate planning, including increased supply chain efficiency, decreased costs, and higher levels of customer satisfaction. The results add to a thorough knowledge of aggregate planning, guiding practises for attaining operational efficiency and responsiveness and evidence-based decision-making.

KEYWORDS:

Aggregate Planning, Production Levels, Workforce Planning, Inventory Management, Operations Management.

INTRODUCTION

A choice in intermediate-term planning is aggregate planning. Planning production quantity and timing across an intermediate time horizon (between three months and a year) is what this procedure entails. The physical facilities are considered to be fixed within this range for the duration of the planning period. Therefore, adjusting the manpower and inventory schedule is necessary to accommodate changes in demand. Aggregate planning looks for the most cost-effective combination[1]–[3]**.**

Aggregate Planning Strategies

Human labour, raw materials, and capital are the three main production system factors. To produce a bigger output volume, more work must be put in. Therefore, the two relevant variables are employment and the usage of overtime (OT). Materials aid in controlling production. Stocks, backorders, or item subcontracting are the company's alternate options.The following procedures may be used to handle changes in demand and uncertainty in manufacturing operations by leveraging these controllable variables:

1. Change the size of the workforce: Hiring and firing employees in response to variations in demand is one way to manage output.

2. Vary the hours worked: Keep the staff steady, but provide downtime when there is a lull and overtime (OT) when demand is at its highest.

3. Vary inventory levels: A big quantity of inventory may be used to meet demand swings.

4. Subcontract: Demand has increased from a low point. Utilising additional capacity from subcontractors will allow for consistent production rates.

Master Production Schedule

Functions of MPS

Aggregate planning is followed by master scheduling. The general plans are expressed in terms of certain end products or models that may be given a priority designation. Planning for the material and capacity needs is beneficial. a flowchart of the aggregate plan and master production schedule. The type, volume, and component lead times of the items being produced determine the time period that is employed in the master scheduling. Weekly intervals are most often utilised. The time frame that the master schedule covers also relies on the qualities of the product and the lead times. certain master schedules may span a few weeks, while others cover more than a year for certain items.

Functions of MPS

The Master Production Schedule (MPS), which turns the production plan into precise material and capacity needs, provides formal specifications of the production plan. The needs for manpower, supplies, and equipment are then evaluated.The MPS's primary duties are:

1. To group plans into distinct final products: The aggregate plan establishes the operational level that, heuristically, strikes a balance between market needs and the company's capacity for materials, labour, and equipment. This strategy is translated into a particular amount of finished goods that must be produced within a certain time frame by a master schedule.

2. Consider other timetables: The master schedule was created by trial and error. To analyse the alternative schedules, there are several computer simulation models available.

3. Generate the necessary materials: This is the fundamental input for material requirement planning (MRP).

4. Calculate capacity needs: MPS serves as a direct source of capacity needs.Thus, capacity planning requires master scheduling.

5. Make information processing easier by managing the plant's load. When the delivery should occur is determined by the master timetable. Other management information systems, including those for marketing, finances, and people, are coordinated with it.

6. Effective capacity utilisation: By defining end item requirements, the schedule determines the load and use specifications for machines and equipment.

DISCUSSION

Material Requirement Planning (MRP)

MRP is a name for the fundamental mathematics used to calculate the components needed based on end item requirements. It also refers to a bigger information system that organises

and manages industrial activities using the dependent connection.Materials Requirement Planning (MRP) is a method for figuring out how much and when to buy dependent demand items to meet demands from the master production plan.

1. Inventory reduction: MRP establishes the quantity and timing of components needed to achieve the master schedule. It is beneficial to purchase the materials and components as and when they are required, preventing an excessive accumulation of inventory.
2. Shorter production and delivery lead times: MRP determines the quantity, timing, and availability of materials and components as well as the purchases and activities necessary to achieve delivery dates. By assigning due dates to client task orders, MRP prioritises production processes and helps prevent production delays.
3. Realistic delivery commitments: Production may use MRP to provide marketing with timely information about anticipated delivery timelines to potential clients.
4. Greater efficiency: MRP enables tight coordination between several work centres, enabling materials to flow continuously through the manufacturing line. This makes the manufacturing system more effective.Figure 1represents the flowchart of aggregate plan and master schedule.

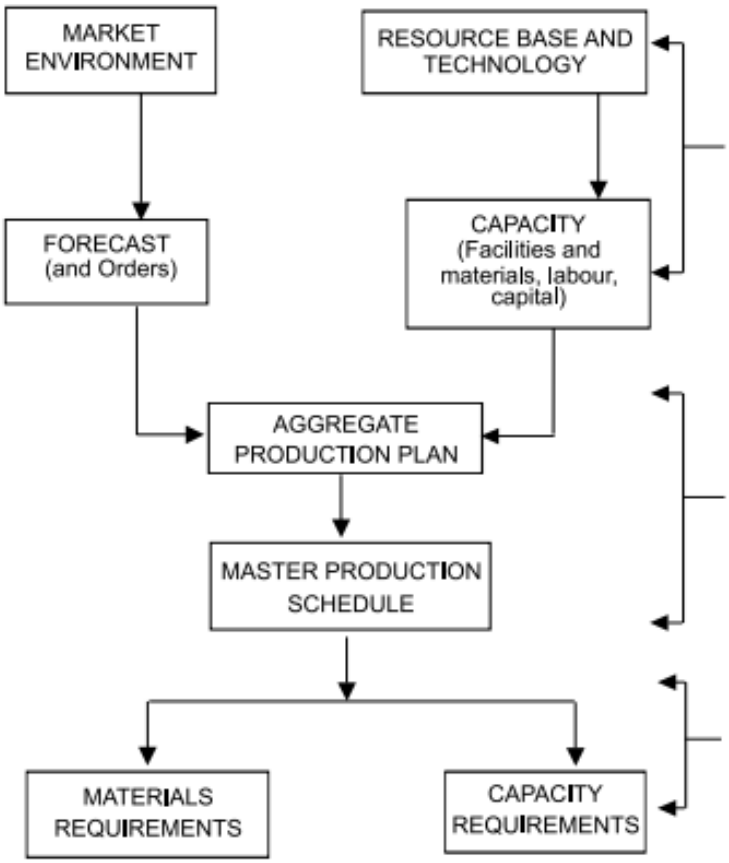

Figure 1: Represents the Flowchart of aggregate plan and master schedule.

MRP System

The master production schedule, the inventory status file, and the bill of materials (BOM) are the three inputs to the MRP system.The MRP processing logic (computer programme) generates three different types of information (outputs) for each product component based on these three information sources: order release requirements, order rescheduling, and scheduled orders.

The MPS, or master production schedule

For each item a firm produces, MPS is a list of time-phased quantities showing how many are to be produced and when. Prior to the MRP system being into operation, MPS is first built from solid client orders or from demand estimates. The MRP system turns MPS end items into precise component needs based on what the master schedule dictates. Many systems replicate a trial run to see whether they can satisfy the planned master.Figure 2represents the MRP system.

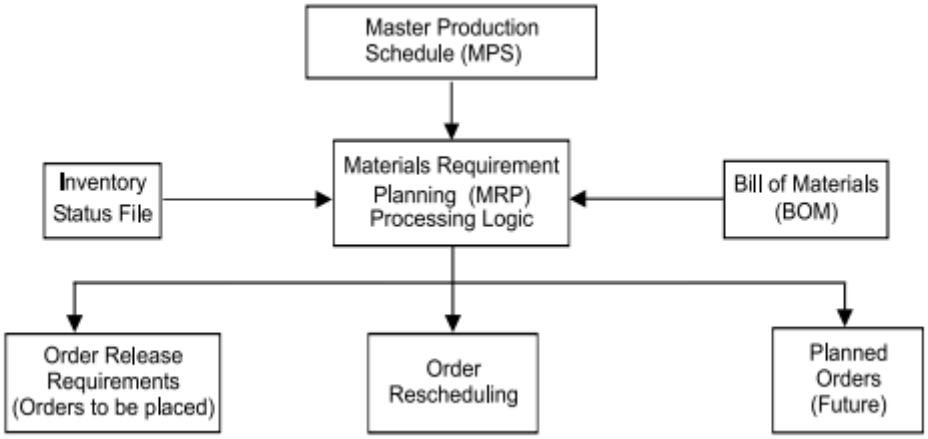

Figure 2: Represents the MRP system.

INFRASTRUCTURE STATUS FILE

An inventory status file, which provides comprehensive and current information on the on-hand quantities, gross needs, scheduled receipts, and planned order releases for an item, must be included for every inventory item that is being planned. Additionally, it contains planning details including lead times, safety stock levels, and scrap allowances.

BOM (Bill of Materials)

Each final product's BOM details how it is produced, including all subcomponents, their order of assembly, how many there are in each completed unit, and the work centres that carry out the build-up process. This data was gathered via workflow analyses, product design papers, and other common production data.

Capacity Planning

Planning for the inputs, conversion steps, and outputs of the manufacturing activity are all part of the design of the production system. The most significant duty of production management is the efficient control of capacity. Matching the level of operations to the level of demand is the goal of capacity management, which includes planning for and controlling capacity.Planning for capacity must take into account anticipated future development and expansion, market trends, sales projections, and other factors. Planning the capacity is easy when the demand is steady. But in reality, demand is seldom predictable. The variation in demand makes it difficult to find the resources needed to satisfy client demand. Decisions on capacity are tactical in nature. The rate of a facility's production capabilities is its capacity. Typically, capacity is defined as the amount of production per unit of time.For the following reasons, production managers are increasingly worried about capacity:

1. To satisfy client demand on schedule, there must be enough capacity.
2. The cost-effectiveness of operations is influenced by capacity.

3. The scheduling process is impacted by capacity.
4. Investment is required to create capacity.
5. The first step when a company chooses to create additional or new items is capacity planning.

Measurement of Capacity Planning

When they make a variety of items, gauging capacity might become more challenging in particular circumstances. In these circumstances, the capacity is specified in terms of man- or machine-hours. depicts the connection between capacity and production.

1. Design capacity: Under typical or full-scale operating circumstances, a facility's designed capacity is the intended or engineered rate of production of products or services.

For instance, the cement plant's intended capacity is 100 TPD (tonnes per day).

The sugar plant can crush 150 tonnes of sugarcane each day.

2. System capacity: The maximum production of the particular product or product mix that a system of employees and equipment is capable of generating as a cohesive whole is known as the system capacity.

Due to limitations in product mix, quality requirements, and breakdowns, system capacity is lower than design capacity, or at most equal. Due to several variables that effect production, such as real demand, downtime from equipment breakdown, and unapproved absence, the actual is significantly lower[4]–[6].Figure 3represents the capacity and output relationship.

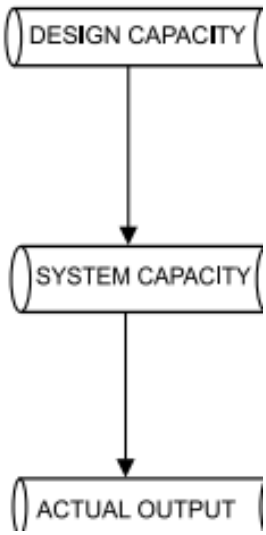

Figure 3: Represents the Capacity and output relationship.

Due to long-range uncontrolled circumstances, the system's capacity is lower than its design capacity. Due to immediate repercussions like equipment failure and workforce inefficiency, the real production is still lower. The ratio of the system's actual measured output to its capacity is used to indicate the system efficiency.

$$\text{System Efficiency (SE)} = \frac{\text{Actual output}}{\text{System capacity}}$$

3. Licenced capacity: Capacity that has been granted a licence by the different government or regulatory bodies. This is the production restriction that the government imposes.

4. established capacity: Installed capacity refers to the capacity offered at the time the unit was established.

5. Rated capacity: Rated capacity is defined as the capacity calculated using the greatest production rate determined by real testing[7]–[10].

CONCLUSION

In order for organisations to achieve cost-effective production while satisfying consumer demands, aggregate planning is essential in matching production capacity with projected demand. Organisations may establish the ideal production levels, labour needs, and inventory levels for a certain planning horizon by taking into account variables including demand projections, production restrictions, and resource availability. A good aggregate plan minimises production costs, maximises resource use, and lessens the effects of demand changes. It makes it possible for businesses to avoid under- or overusing their resources, which boosts productivity and profitability. Organisations may manage production capacity proactively, adapt quickly to changes in demand, and keep a competitive advantage in the market by using the right tactics and procedures in aggregate planning.Aggregate planning is a critical procedure that enables companies to match labour, resource, and production levels with projected demand over a medium-term horizon. An overview of aggregate planning, including its principles, methods, and decision-making techniques, was the goal of this research project.Demand forecasting, production capacity, inventory management, manpower planning, and subcontracting are some of the essential elements of aggregate planning. For predicting future demand trends and figuring out production needs, accurate demand forecasting is crucial.

Organisations may evaluate the resources at their disposal and adjust output levels by assessing production capacity. While reducing carrying costs, inventory management maintains adequate stock levels to satisfy demand. Workforce planning entails identifying the necessary labour resources and taking into account variables like scheduling, recruiting, and training. Subcontracting may be used to take advantage of outside knowledge or control demand variations.

REFERENCES

[1] B. Khoshnevis, P. M. Wolfe, and M. P. Terrell, “Aggregate planning models incorporating productivity—an overview,” *Int. J. Prod. Res.*, 1982, doi: 10.1080/00207548208947786.

[2] B. B. Sinaga, “Analisis Sistem Rantai Pasok Pt. Semen Gresik (Persero) Tbk,” *J. Optimasi Sist. Ind.*, 2011, doi: 10.25077/josi.v10.n1.p105-112.2011.

[3] J. B. E. Thomas, F. S. Ramos, and F. Gröndahl, “Identifying Suitable Sites for Macroalgae Cultivation on the Swedish West Coast,” *Coast. Manag.*, 2019, doi: 10.1080/08920753.2019.1540906.

[4] M. Shaygan, A. Mamdoohi, and H. E. Masoumi, “Car ownership models in Iran: a review of methods and determinants,” *Transp. Telecommun.*, 2017, doi: 10.1515/ttj-2017-0005.

[5] Y. Kristianto, A. Gunasekaran, and P. Helo, “Building the ‘Triple R’ in global manufacturing,” *Int. J. Prod. Econ.*, 2017, doi: 10.1016/j.ijpe.2015.12.011.

[6] R. B. Johnson and J. V. Degraff, “Principles of engineering geology,” *Princ. Eng. Geol.*, 1988, doi: 10.1016/0160-9327(77)90011-4.

[7] K. Brücknerová and P. Novotný, “Intergenerational learning among teachers: overt and covert forms of continuing professional development,” *Prof. Dev. Educ.*, 2017, doi: 10.1080/19415257.2016.1194876.

[8] A. Kumar, “Multiagent decision making and learning in urban environments,” in *IJCAI International Joint Conference on Artificial Intelligence*, 2019. doi: 10.24963/ijcai.2019/895.

[9] J. Badham, “A Compendium of Modelling Techniques,” *Integr. Insights*, 2010.

[10] R. Maio, C. Santos, T. M. Ferreira, and R. Vicente, “Investigation Techniques for the Seismic Response Assessment of Buildings Located in Historical Centers,” *Int. J. Archit. Herit.*, 2018, doi: 10.1080/15583058.2018.1503363.

CHAPTER 4

PROCESS OF CAPACITY PLANNING: A REVIEW STUDY

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ABSTRACT:

A crucial step in operations management is capacity planning, which entails figuring out and optimising the production capacity needed to satisfy both present and future demand. This essay examines the capacity planning procedure, In order to manage production capacity successfully, this research study examines the strategies, methodologies, and performance optimisation methods used in the capacity planning process. Demand forecasting, resource assessment, gap analysis, capacity requirement determination, capacity expansion strategies, financial analysis, decision-making and implementation, monitoring and evaluation, and adjustment and optimisation are some of the key steps in capacity planning that are covered in the study. It examines the factors and difficulties involved in capacity planning, including market dynamics, resource limitations, and financial ramifications. The study explores how capacity planning may lead to increased operational effectiveness, more customer satisfaction, better resource utilisation, and cost savings. The research results add to a thorough knowledge of the capacity planning process, guiding practises for maximising production capacity and performance.

KEYWORDS:

Capacity Planning, Production Capacity, Demand Forecasting, Resource Allocation, Operations Management.

INTRODUCTION

The goal of capacity planning is to identify an organization's long- and short-term capacity requirements and to determine how to meet them. Decisions on capacity planning are made based on customer demand, which is combined with the organization's human, material, and financial resources.Long-term capacity plans and short-term capacity strategies may both be used to analyse capacity needs.

Long-Term Capacity Strategies

Long-term capacity needs are more challenging to predict because of the unpredictability of future demand and technological advancements. Forecasting five or 10 years out is riskier and more challenging. Even sometimes, a company's current items could not be around in the future. Long-term capacity needs rely on marketing strategies, product development, and product lifecycles.

The goal of long-term capacity planning is to account for significant changes that have a long-term impact on production levels overall. The main duties of management include marketing environmental assessments and methodically carrying out long-term capacity planning. Decisions on long-range capacity will depend on the following factors.

many items: In order to boost profits, businesses make many products at the same time in the same facilities. The likelihood of failure will decrease with the production of more than one

product. The capacity planners perform better when they have access to a variety of products. Products may be scheduled to utilise their capacity to the fullest extent since they are at various phases of their life cycles[1]–[3].

Phasing in capacity: The rate of obsolescence is significant in high technology businesses and in industries where technological changes happen quickly. The items should enter the market as soon as possible. The facilities will take a long time to build, and there isn't much time since the items need to hit the market swiftly. In this situation, a modular approach to capacity expansion is used. Over the course of three to five years, a commitment is made to provide construction materials and labour for facilities. This is a successful strategy for leveraging technology advancements.

phasing out capacity: The obsolete industrial facilities result in a lot of plant closures and downtime. Closures have an influence beyond only the fixed expenses of equipment and plant. In this approach, the phase-out is carried out in a humane manner without having an impact on the neighbourhood.The choices for phase-out provide men with alternatives, such as moving them to other positions or places, compensating the staff, etc.

Short-Term Capacity Strategies

Forecasts of product demand are often used by managers to determine the facility's expected short-term workload. Managers plan their production needs for various goods and services up to a year in advance. Managers determine whether capacity modifications are necessary by comparing needs to available capacity.

Fundamental capacity is set for brief durations up to one year. Significant facilities won't change. There are several short-term tweaks that may be made to increase or decrease capacity.The modifications that will be necessary depend on the conversion process, such as whether it requires a lot of manpower or capital, or whether the product may be kept on hand as inventory.Physical infrastructure, plant, and equipment are required for capital-intensive operations.

Operating these facilities more or less vigorously than usual might change the short-term capacity. In labor-intensive processes, short-term capacity may be altered by firing, recruiting, or compensating employees for overtime. The methods for adjusting capacity are also influenced by how long a product may be kept in stock.

These are the short-term capacity strategies:

1. Inventories: Stocks of completed items kept on hand during slow times to fulfil demand during busy times.

2. Backlog: Customers who are prepared to wait during peak times are asked to do so, and their orders are completed after the peak period of demand.

3. Employment level (hiring or firing): Hire more workers during periods of high demand and fire workers when demand declines.

4. Employee training: Create multi-skilled workers via training so they can switch between various tasks. Having many skills is advantageous as an alternative to recruiting staff.

5. Subcontracting: Use other companies' ability to create the items or component components on a temporary basis during times of high demand.

6. Process design: Redesign the task to change the job's contents.

Routing

Routing is the choice of the route that each component of the product will take as it develops from raw materials to final goods. The product's path will also include the manufacturing process's preferred order of steps.Routing, which incorporates the following processes, is the process of determining the most beneficial route to be followed from department to department and machine to machine until raw material takes on its ultimate form.

(a) The kind of work to be done on the product or its components.

(b) The action necessary to complete the task.

(c) The necessary order of operations.

DISCUSSION

Techniques of Routing

Different operations must be carried out in order to transform raw materials into the desired products, and choosing a specific line of activities for each item is known as "routing." For the finished product to be produced at the lowest cost, a certain route, or series of processes, must be chosen. The different routing strategies include.

Route card: Throughout all operations, this card always travels with the task. This shows the materials utilized throughout production and how they moved from one operation to the next. Additionally, information on the excellent work and scrap that was created is documented.The work sheet includes(a) the manufacturing specifications that must be adhered to.(b) Routing instructions for each component, including with machine identification numbers and operational locations.

This sheet is designed for both production and maintenanceRoute sheet: It addresses a particular manufacturing order. often constructed using operation papers. Each portion or component of the order needs its own sheet. Although this document is necessary for production control, the routing system never uses it. Each operation's move order is created in accordance with the operation sheet. On this, the amount that was moved ahead, trashed, and needing correction are noted. When the operation is finished, it is sent back to the planning office[4]–[6].

Scheduling

Scheduling is the "prescription of when and where each operation necessary to manufacture the product is to be performed," according to the dictionary definition.It may also mean "determining the times at which each event or operation constituting a procedure shall commence and terminate."

The main goal of scheduling is to organize the order of tasks so that production may be methodically geared towards finishing all goods by the required date.

Principles of Scheduling

The optimal task size principle: When task sizes are modest and all tasks are of the same order of magnitude, scheduling tends to be as effective as possible.The planning should be done in a way that places an equal burden on all plants, according to principle number two of an optimal production planThe principle of optimal sequence states that scheduling tends to be most effective when tasks are organized such that work hours are typically employed in the same order.

Inputs to Scheduling

1. Performance standards: To determine capacity and allocate necessary machine hours to the facility, knowledge on performance standards (standard times for operations) is helpful.

2. The units that should be used to represent loading and scheduling.

3. The labour center's actual capacity.

4. The pattern of demand and the degree of flexibility to be offered for rush orders.

5. Operations that cross across.

6. Personalised work schedules

Scheduling Strategies

Scheduling tactics vary greatly across businesses and might be as simple as "no scheduling" or quite complex.

Four classifications have been created to categories these tactics:

1. Exact scheduling: In the real world of production, precise scheduling for individual works that are received from clients is impossible. Plans change due to changes in orders, equipment failure, and unanticipated circumstances.

2. Cumulative scheduling: Cumulative scheduling of the overall workload is helpful, particularly when long-term capacity planning is involved. This might overload the current period and underload subsequent periods. It provides several tools for managing the work.

3. Cumulative detailed: Combining cumulative and detailed information is a possible and useful strategy. if the overall timetable includes both fixed and flexible elements.

4. Priority decision rules: First come, first served is one of the aforementioned tactics that is utilised both alone and in combination with priority decision rules, which are scheduling guidelines.They help lower the Work-In-Process (WIP) inventory.

Types of Scheduling

Forward scheduling and reverse scheduling are two categories for scheduling types.

1. In job shops where clients submit their orders on a "needed as soon as possible" basis, forward scheduling is often employed. By allocating the earliest available time slot to the next priority task, forward scheduling establishes the start and end times of that task and, from there, establishes the time at which it will be completed in that work centre. The task and its components will generally be finished before they are due at the next work centres in the route since they start as early as feasible. The forward technique results in greater inventory costs and process inventory that is required at later work centres. Comparing forward scheduling to backward scheduling, the former is easier to utilise and produces results faster.

2. In assembly-type businesses, backward scheduling is often utilised to commit in advance to precise delivery dates. The start and end times of waiting tasks are determined by allocating them to the earliest available time slot, which enables each work to be finished exactly when it is due but earlier. Backward scheduling reduces inventory by allocating works as late as feasible since a job is not finished until it must proceed immediately to the next work centre on its route.

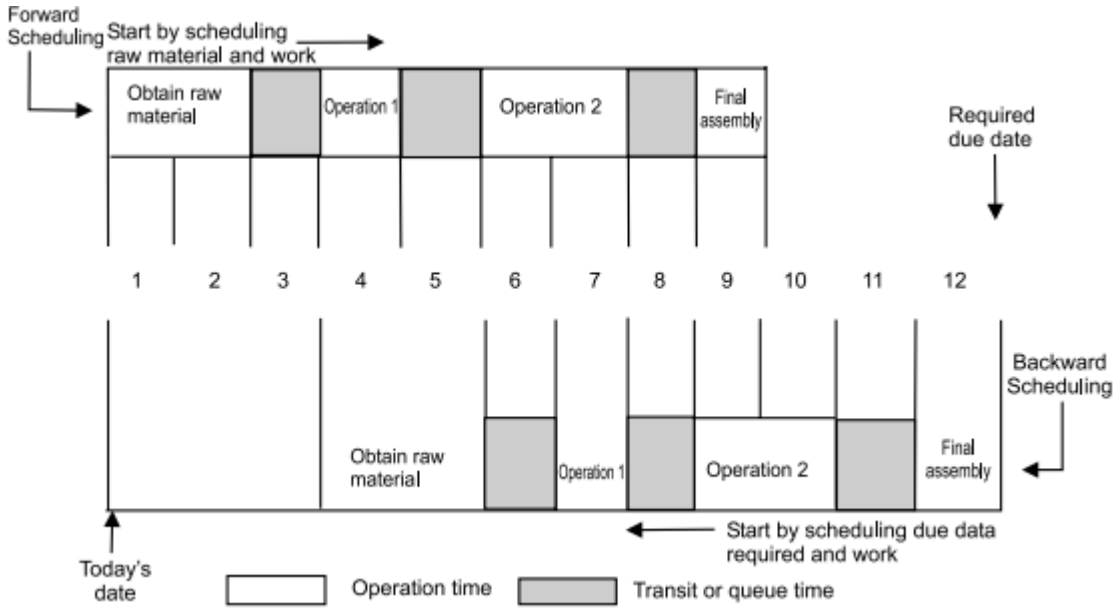

Figure 1: Represents the Forward and backward scheduling.

The production function is the area of an organization responsible for converting a variety of inputs into the necessary outputs (products) with the necessary degree of quality. Production may be defined as the "step-by-step chemical or mechanical conversion of one form of material into another to create or enhance the utility of the product to the user." Production is thus a process that adds value.The primary goal of the production department in every manufacturing company is to manufacture the goods at the appropriate time and quantity so that they may be delivered to customers when they need them. Being a highly complicated process, production is particularly challenging for individuals to manage. This entails a sizable number of processes and activities that must be properly planned and then regulated to produce the output in an efficient manner.Establishing routes and schedules for the work that will guarantee the best use of materials, labourers, and equipment is the major goal of production planning and control (PPC), which also provides the tools for verifying that the plant operates in line with these plans[7]–[10].Different manufacturing methods come in many forms. The kind, quantity, and diversity of goods all influence the manufacturing method that is chosen. This chapter has a thorough discussion of these manufacturing methods. Entrepreneurs must proceed with production planning and control (PPC), which mostly relies on the kind of production system, after deciding on the production system to be employed.

Production planning and control must be concerned with carrying out the plans, including the precise scheduling of tasks, allocating workloads to machines (and people), and ensuring that work moves through the system as intended. Production is the systematic process of turning raw resources into usable goods.

The most efficient use of natural resources, including people, money, machines, materials, and time, is necessary for a production system. Depending on the kind of organisation, production planning and control collaborate with many departments, including production, marketing, logistics, warehousing, and other departments. Data about orders is provided to production planning and control by marketing divisions. In production planning and control, a production plan is created using marketing and production data. This production plan offers a clear picture of how manufacturing resources will be used for production. The production department receives the prepared production plan. Products are made in accordance with that

plan by the production department.Like all other industrial controls, the ultimate goal of production planning and control is to increase the company's revenues. This is done through keeping consumers happy by adhering to delivery timetables, much like inventory management and control.The following list may serve as a summary of PPC's primary goals:-

a) It is used to set goals and compare them to certain performance metrics to check for discrepancies.

b) Chooses the kind and quantity of several input components to generate the result.

c) Coordinates various production system resources in the most efficient and cost-effective way possible, as well as across various departments.

d) The removal of bottlenecks

d) The best possible use of inventory

f) Material flows smoothly g) production in the proper amount and quality at the right time h) manufacturing operations are scheduled to fulfil delivery deadlines

i) Expediting the production system

j) Ensuring production system flexibility to accommodate changes and uncertainty

k) Optimizing resource use for lowest overall production cost l) Ensuring production of the right product at the right time in the right quantity with specifications properly suited to customers

m) Stable production system, with the least amount of chaos, confusion, and undue hurry.

CONCLUSION

For businesses to have the production capacity they need to satisfy consumer demands while preserving operational effectiveness, capacity planning is a critical procedure. Organisations may predict future demand and establish the needed production capacity by analysing historical data and using demand forecasting methodologiesFor businesses to successfully manage their production capacity, satisfy consumer demand, and maximise resource utilisation, capacity planning is essential. The purpose of this research study was to investigate the strategies, tactics, and performance improvement methodologies used in the capacity planning process.Several crucial phases are involved in capacity planning. Demand forecasting is the first step in the process since it helps predict capacity needs by estimating future demand patterns.

In order to understand the organization's current capacity levels and possible restrictions, resource assessments review all of the resources that are already available, including personnel, buildings, and equipment.The goal of gap analysis is to find any gaps or mismatches between the anticipated demand and the available capacity. This research aids in identifying the necessary capacity increase to close the gap between expected demand and current capacity levels. Calculating the extra capacity required to satisfy the anticipated demand is a step in determining capacity requirements.

REFERENCES

[1] L. T. Miller and C. S. Park, “A learning real options framework with application to process design and capacity planning,” *Prod. Oper. Manag.*, 2005, doi: 10.1111/j.1937-5956.2005.tb00006.x.

[2] Y. C. Lai, M. C. Shih, and J. C. Jong, "Railway capacity model and decision support process for strategic capacity planning," *Transp. Res. Rec.*, 2010, doi: 10.3141/2197-03.

[3] E. Fernando, Meyliana, H. L. H. S. Warnars, and E. Abdurachman, "Key strategic issues pharmaceutical industry of SCM: A systematic literature review," *Bulletin of Electrical Engineering and Informatics*. 2020. doi: 10.11591/eei.v9i2.1264.

[4] R. G. Askin and M. G. Mitwasi, "Integrating facility layout with process selection and capacity planning," *Eur. J. Oper. Res.*, 1992, doi: 10.1016/0377-2217(92)90040-G.

[5] A. Tenhiälä, "Contingency theory of capacity planning: The link between process types and planning methods," *J. Oper. Manag.*, 2011, doi: 10.1016/j.jom.2010.05.003.

[6] M. D. G. Guará-Tavares, "Learners' processes during pre-task planning and working memory capacity," *Ilha do Desterro*, 2016, doi: 10.5007/2175-8026.2016v69n1p79.

[7] E. Liu, X. Ma, A. Sauré, L. Weber, M. L. Puterman, and S. Tyldesley, "Improving access to chemotherapy through enhanced capacity planning and patient scheduling," *IISE Trans. Healthc. Syst. Eng.*, 2019, doi: 10.1080/24725579.2018.1442376.

[8] J. H. Ryu, "Developing an integrated capacity planning framework for production processes and demand supply chains," *Korean J. Chem. Eng.*, 2013, doi: 10.1007/s11814-012-0122-0.

[9] V. Sriram, D. Lingelbach, T. Mersha, and F. Manu, "Operations and supply chain management," in *Entrepreneurship in Africa*, 2020. doi: 10.4324/9780429402319-6.

[10] A. Larsson and A. Fredriksson, "Tactical capacity planning in hospital departments," *International Journal of Health Care Quality Assurance*. 2019. doi: 10.1108/IJHCQA-11-2017-0218.

CHAPTER 5

BLUEPRINT OF PRODUCTION SYSTEM: DESIGN, COMPONENTS AND OPTIMIZATION

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ABSTRACT:

A detailed and organized picture of the complete production process, including the movement of materials, information, and activities, is provided by a production system plan. The idea of a production system blueprint, its significance in comprehending and optimizing production processes, and the essential elements and factors involved in its formation are all covered in this essay. The study also emphasizesthe design, elements, and optimization techniques used to create an effective and efficient production system are examined in this research study, which focuses on the blueprint of a production system. The research examines the crucial components and factors to be taken into account when developing a production system, such as the structure of the facility, the choice of equipment, the production processes, workflow, and resource allocation.

It examines how these elements are interdependent and how their effects on system performance as a whole. The study looks at methods for improving production system design, including automation, advanced technology integration, and lean manufacturing concepts. It also looks at ways to increase system flexibility, quality, productivity, and efficiency. The research results contribute to a thorough knowledge of the design of a production system, influencing practices for optimizing production processes and gaining competitive advantage.

KEYWORDS:

Manufacturing Process, Material Flow, Information Flow, Production System, Plan.

INTRODUCTION

An organization's production system, which is regarded as the framework within which all production-related activities and operations take place, must be defined from the outset.The process of transforming inputs into outputs is known as the manufacturing process. The synchronization of diverse production processes and activities is ensured by proper production system design.

There isn't a single production system pattern that can be used in all types of businesses. This varies from business to business based on a variety of factors.

Types of Production systems

Three primary categories of manufacturing systems are described below:

(1) Constant/mass manufacturing

(2) Production of jobs or units

(3) Periodic or batch production

Continuous/Mass production

It is used when we need to create standardized goods using a set of procedures and an organised sequence of operations in order to meet demand. This guarantees consistent output generation. It is also known as assembly line manufacturing or mass flow production. Although this approach produces high-quality products with less work-in-process (wip) inventory, it requires a significant initial outlay for machines and equipment. This guarantees a very high rate of production since we don't need to become involved once the process has started. The technique is suitable for plants that generate a lot of yield in a limited variety. For instance, sugar factories, cement plants, and oil refineries[1]–[3].

Job or Unit production

Production is done in accordance with client requirements. This guarantees the concurrent manufacturing of several batches and orders. Each batch or order is distinct from the others and consists of a small amount of the same goods. In comparison, less money must be spent on machinery and equipment. It is adaptable and may easily adjust to accommodate changes in order size and product design. Wherever diverse items are created in response to orders, this approach works well. Products are created under this method to fulfil a particular request.

Characteristics of Job or Unit Production

A general-purpose machine or procedure should be used since product modifications happen often.

b) Human resources should be qualified to handle shifting work environments.

c) Schedules are really nonexistent in this system since no concrete information about the product is accessible. Since there are no precise plans or timelines, in-process inventory will often be large.

d) High labour and material expenses often result in high product costs.

e) Machines are organised into functional groups (such as a lathe section, a milling section, etc.). This system is particularly adaptable since management must produce a variety of product kinds. Systems for material handling are adaptable to changing product needs.

Intermittent/Batch Production

This relates to the creation of many product kinds in little batches, as the name suggests. A batch includes a limited number of comparable items. This is done to fulfil a single request or a recurring requirement. A batch may be produced once, repeatedly at erratic intervals as needed, repeatedly at regular intervals to meet ongoing demand, or repeatedly at both. This method allows for the production of items for both inventories and client orders. For instance, although components are created for inventory, they are integrated in various ways for various clients. This form of manufacturing includes, for instance, car plants, printing presses, and electrical products factories.

Characteristics of Intermittent/ Batch Production

In addition to the aforementioned, a significant portion of manufacturing facilities are categorised as composite or combination operations because they use both intermittent and continuous processes. Such a facility may include sub assembly departments that produce components continuously, but the final assembly department only works sometimes.The production systems that were just discussed need various kinds of manufacturing processes, as well as various working environments. The choice of the production method is a strategic

one since it is expensive and time-consuming to modify.So, when a company endeavour is being planned, the production method is chosen.This must be chosen with two key considerations in mind:

(1) conforming to the final product's specification;

(2) being economical.

There are four different categories for the manufacturing process.The manufacturing processes of jobs, batches, masses or flows, and process types are all examples of manufacturing processes.

Jobbing manufacturing process

Depending on the needs and specifications of the client, this is utilized to make one or a few pieces of the product. Production must adhere to the delivery schedule, and expenses are set before the client contract is signed.Batch manufacturing process: This is used to create discrete batches of each sort of product in small amounts. The same set of machinery are used to produce these batches of various items. After one another, many batches/products are independently manufactured.A huge number of the same product may be produced using the mass or flow production technique and then stored for sale. According to the order of activities, all machines and necessary equipment are set up in a line arrangement or flow. Thus, a very high rate of output is guaranteed. A distinct line layout is required for each different product since one line arrangement can only manufacture one sort of product[4]–[6].This is utilized to create items that need a certain procedure or set of steps to be followed. such as petroleum. In this, manufacturing runs are carried out indefinitely.

Factors affecting the Choice of Manufacturing Process

Before choosing a manufacturing method, take into account the following variables.Effect of volume/variety is one of the main factors to be taken into account when choosing a manufacturing method.

Intermittent processes work best when volume is low and variety is high, whereas continuous processes work best when volume is large and variety is low. The selection of the production method in relation to volume and diversity is shown in the following graph.Figure 1represents the classification of production system.

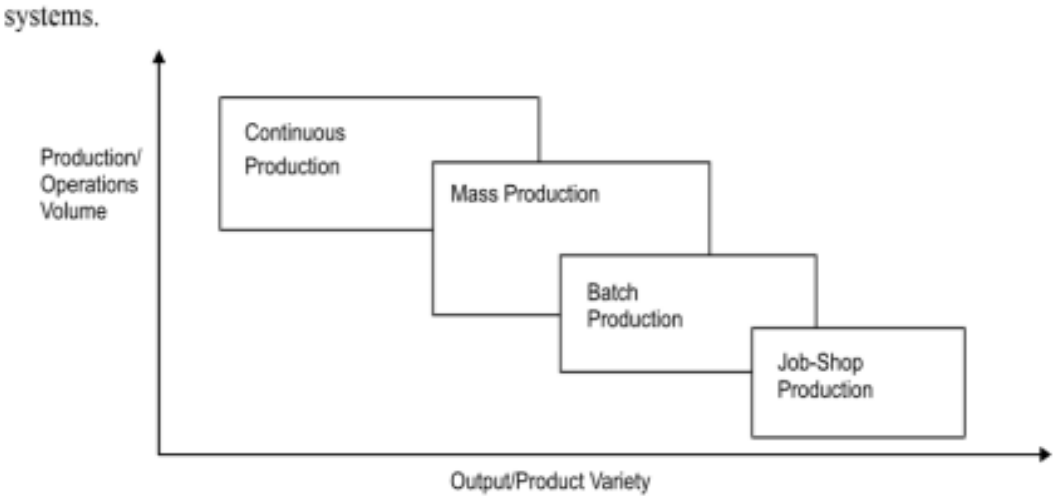

Figure 1: Represents the Classification of Production system.

Plant capacity

The main deciding element in choosing between batch and line processes is the anticipated sales volume. Fixed costs in the case of a line process are much larger than variable costs. The same is true for batch processes, therefore at low volume, a batch process would be less expensive to build and operate, while a line process would become cost-effective at greater numbers.When compared to batch processing, continuous processing often yields speedier delivery. As a result, the choice of manufacturing technique is undoubtedly influenced by lead time and degree of competition.Flexibility and Efficiency: The manufacturing process must be adaptable enough to accommodate anticipated changes, and output volume must be sufficient to reduce costs.Therefore, it is crucial for business owners to take into account all of the aforementioned criteria before making a choice about the kind of manufacturing method to be used. As far as Small-Scale Enterprises are concerned, they often use batch operations since they produce less and need less capital.The entrepreneur's next crucial option is the production and planning control (PPC) decision, which must be taken once a final decision has been reached about the product design, manufacturing system, and process.

DISCUSSION

Meaning of Production Planning and Control

PPC is a crucial choice that must be made in order to guarantee an effective and cost-effective output. Production planning is a crucial component of every industrial sector. A production system's full manufacturing operations may be coordinated and integrated using a technology called production planning and control (PPC). To put it simply, this entails planning production before the actual production activities get underway and then exerting control over those activities to make sure the planned output is realised in terms of quantity, quality, delivery schedule, and cost of production.

PPC often involves the organisation and planning of the production process, according to Gorden and Carson. It mostly refers to the overall organisation. Designing the product, figuring out equipment and capacity needs, planning the layout of physical facilities, designing the material and material handling system, figuring out the sequence and nature of the operations to be performed along with time requirements, and specifying specific production, quantity, and quality levels are all part of production planning.Routing, scheduling, dispatching, inspection, coordination, management of materials, processes, equipment, tools, and operating periods are all included in production planning. In order to achieve the desired production outcomes in terms of quality, quantity, time, and location, it is ultimately intended to plan and regulate the supply and movement of materials and labour, machine use, and associated operations. This gives you a physical system and a set of instructions on how to turn raw materials, labour, and other inputs into completed goods effectively.

Procedure of Production Planning and Control

The pre-design format serves as the foundation for the PPC. It makes an effort to carry out and accomplish all tasks in accordance with the predetermined plan. All operations must be carried out correctly, carefully monitoring all relevant information to ensure that the time frame and budget are within reason, and they must adhere to the accepted/agreed rules. These expenses include staff, capital expenditures for the facility, and costs associated with the assets. These are the stages that make up the PPC.The manufacturing rate and scale are established. Which must be divided into reasonable timeframes and schedules. To advance to the next stage of production, the defined task must be completed within the allotted time.

Essentially, PPC has three Stages

Planning, action, and monitoring are the first three stages.All three of these phases are crucial from a production standpoint since nothing can be produced without planning. A thorough planning process is the most important item that is needed for any production[7]–[10].

Elements of Production Planning and Control

It's critical to remember that the production plan is the primary component of PPC. Making decisions on future actions in advance is referred to as planning. The organisation has formed a separate planning department that is in charge of creating policies and plans for the production that will be done in due course. Based on data from management, the planning department creates a variety of charts, manuals, production budgets, etc. By placing diverse components under production control, these plans, charts, and production budgets take on a more concrete form.

Production control will inevitably suffer if production planning is flawed. Production planning offers a reliable foundation for production control in order to meet the production objectives.It's important to keep in mind that production plans are created at the highest level, while production control is carried out on the machine shop floor, where the real production is happening.

CONCLUSION

A useful tool for comprehending and improving production activities inside a company is the production system blueprint. It aids in identifying inefficiencies, bottlenecks, and possibilities for improvement by giving a visual picture of the flow of materials, information, and operations. In order to create a production system blueprint, the production process must be mapped out, the material and information flows must be examined, and issues like equipment placement, resource allocation, and production scheduling must be taken into account. Organizations may restructure their processes to increase productivity, save costs, and simplify operations by having a clear design for their production system. It supports the identification of opportunities for process optimization and automation by giving a comprehensive picture of the production process and facilitating effective decision-making. A production system blueprint is a useful tool for increasing operational effectiveness, allowing continuous improvement, and guaranteeing the efficient and effective running of production systems.

REFERENCES

[1] Y. Geum and Y. Park, “Designing the sustainable product-service integration: A product-service blueprint approach,” *J. Clean. Prod.*, 2011, doi: 10.1016/j.jclepro.2011.05.017.

[2] W. F. Visser, “A Blueprint for Performance-Driven Operations Management,” *Mining, Metall. Explor.*, 2020, doi: 10.1007/s42461-020-00199-5.

[3] R. J. Zahrl, D. A. Peña, D. Mattanovich, and B. Gasser, “Systems biotechnology for protein production in Pichia pastoris,” *FEMS Yeast Research*. 2017. doi: 10.1093/femsyr/fox068.

[4] G. S. Dell, A. C. Kelley, Y. Bian, and E. W. Holmes, “Tuning the blueprint: how studies of implicit learning during speaking reveal the information processing components of the production system,” *Language, Cognition and Neuroscience*. 2019. doi: 10.1080/23273798.2019.1613553.

[5] İ. Ergal *et al.*, "Biohydrogen production beyond the Thauer limit by precision design of artificial microbial consortia," *Commun. Biol.*, 2020, doi: 10.1038/s42003-020-01159-.

[6] G. Fan and A. L. Furst, "How Far Can Electromicrobial Production Go?," *Joule*. 2020. doi: 10.1016/j.joule.2020.09.012.

[7] Y. H. Wang, C. H. Lee, and A. J. C. Trappey, "Service design blueprint approach incorporating TRIZ and service QFD for a meal ordering system: A case study," *Comput. Ind. Eng.*, 2017, doi: 10.1016/j.cie.2017.01.013.

[8] F. Mus *et al.*, "Symbiotic nitrogen fixation and the challenges to its extension to nonlegumes," *Applied and Environmental Microbiology*. 2016. doi: 10.1128/AEM.01055-16.

[9] G. Branca and C. Perelli, "'Clearing the air': common drivers of climate-smart smallholder food production in Eastern and Southern Africa," *J. Clean. Prod.*, 2020, doi: 10.1016/j.jclepro.2020.121900.

[10] A. F. Rodrigues *et al.*, "A blueprint for the synthesis and characterisation of thin graphene oxide with controlled lateral dimensions for biomedicine," *2D Mater.*, 2018, doi: 10.1088/2053-1583/aac05c.

CHAPTER 6

ANALYSIS OF MATERIAL REQUIREMENTS PLANNING: STRATEGIES, CHALLENGES AND PERFORMANCE OPTIMIZATION

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ABSTRACT:

In order to manage material needs in a production system successfully, this research study focuses on the examination of Material needs Planning (MRP), looking at the strategies, issues, and performance optimisation techniques involved. Demand forecasting, bill of materials (BOM), inventory control, and production scheduling are some of the main MRP processes and components that are examined in the research. It examines issues with data accuracy, lead time unpredictability, capacity limitations, and system integration that arise while deploying MRP systems. The study looks at methods for improving MRP, including using lean concepts, using cutting-edge software, and setting up efficient communication channels. The research also assesses how well MRP performs in terms of increased material availability, lower inventory holding costs, higher production efficiency, and customer satisfaction. The research results add to a thorough knowledge of MRP and guide practises for improving material management and production efficiency.

KEYWORDS:

Technology, Material Requirements Planning, Inventory Control, And Production Scheduling.

INTRODUCTION

Component Requirements Planning mostly has to do with the stock of components and raw materials needed to make goods at a facility. Their demand is often referred to as secondary demand since it is entirely reliant on the market for the completed product. Primary demand is the demand for the completed goods. This primary demand is mostly determined by adding the demand from sales orders and the demand projection. The demand for the different parts and raw materials is then determined while keeping in mind the product structure. The order lot size for components and raw materials may be determined using a variety of ways. Using a time-phased priority-planning method called MRP, all goods and components in one or more factories' supply is scheduled to fulfil demand while material needs are estimated. Information technology now plays a significant role in the design and implementation of Material Requirements Planning systems and procedures since it offers data on inventory levels as well as data on production requirements (connected to customer demand). MRP methods put an emphasis on inventory optimization [1]–[3].

Concept of Material Requirement Planning

Component Requirements Planning mostly focuses on the inventory of components and raw materials needed to make goods in a plant. The demand for components and raw materials is referred to as secondary demand since it mostly depends on the market for completed goods. The contemporary market environment is one that is characterised by instability and intense rivalry in the corporate environment due to the globalisation of the economy and the

liberalisation of trade markets. With regard to pricing, quality and variety, service, and delivery speed, competition is increasing daily. The elimination of obstacles, international collaboration, and technical advancements all inevitably increase competitiveness. In terms of production, the focus is on increasing quality while lowering cost. In addition, other elements such as prompt product delivery become crucial (this is emphasised in just-in-time, or JIT, procedures. A time-phased priority-planning method, it arranges supply to fulfil demand for all products and components in one or more facilities by estimating material needs. Bills of material are exploded, net material needs are calculated, and future production is planned using MRP processes.

Information technology is crucial in the design and implementation of Material Requirements Planning systems and procedures because it offers data on both inventory levels and production requirements, which are related to consumer demand. MRP methods put an emphasis on inventory optimisation.Thefollowing data is mostly used by MRP systems to decide what material should be ordered and when:- Production cycle times and material requirements at each stage of the production cycle time; Supplier lead times. The master production schedule specifies when each product is scheduled to be manufactured. The bill of materials lists precisely the parts or materials required to make each product.well as the numerous reports that the system produces, all of which are very important to production managers.The master schedule, production cycle timings, and supplier lead times work together to establish when orders must be made after the bill of materials and master schedule specify which materials to be purchased.Figure 1represents the MRP system.

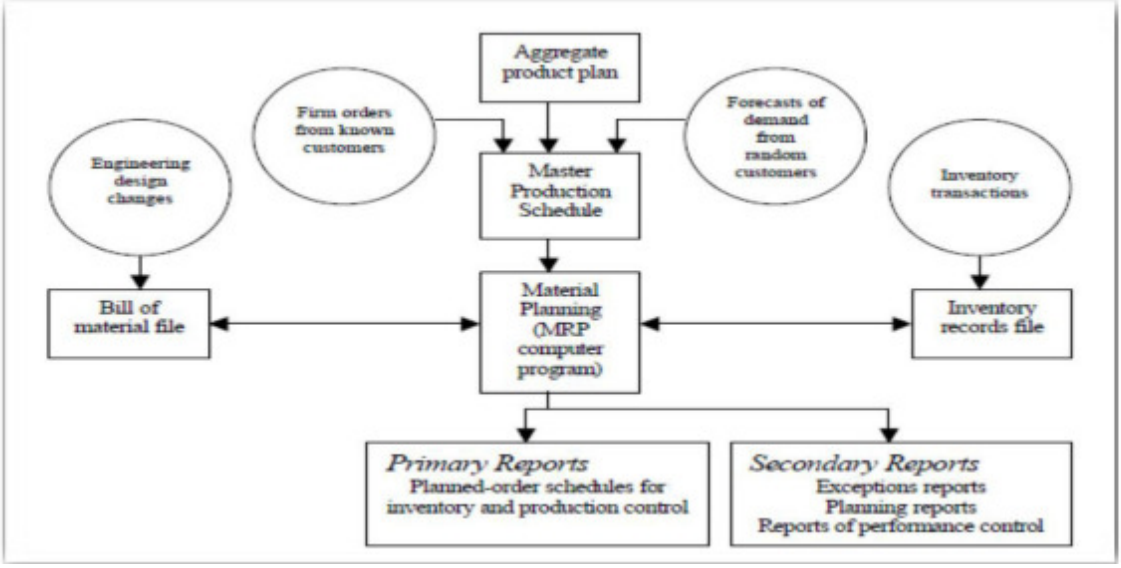

Figure 1: Represents the MRP System.

The Master Production Schedule lists the product quantities that will be produced within a certain time frame. At both the aggregate and detailed levels, quantities are provided. The terms "aggregate" and "detailed" may be used to describe weekly or daily output, respectively. The master production schedule is presented in tabular style, with columns denoting time components and rows denoting goods.

A bill of materials describes the components and raw material units required to make one unit of the product of interest (addressed in the next chapter section). Orlicky's work in the 1970s served as a pioneer for MRP. Later developed into or was included in MRPII systems, which are manufacturing resource planning systems. A computer-based planning and scheduling

system called MRPII was created to help management exercise better control over manufacturing and related support activities.

DISCUSSION

Conditions for the successful implementation of MRP

businesses engaged in assembly activities benefit most from MRP, whereas fabrication businesses benefit least. The following requirements must be met for MRP to be successful in an organisation: Access to a computer-based manufacturing system is a must. The highly dynamic nature of manufacturing environments makes it impossible to maintain a manual material requirements plan. A workable master production schedule must be created; otherwise, the accumulated planned orders of components may "bump" into the resource limitations and become unworkable. The bills of material should be accurate. It is crucial to update them as soon as the product undergoes any technical modifications. Inventory records must accurately reflect reality in order for the netting process and the generation of planned orders to be meaningful. Lead times for all inventory items should be known and provided to the MRP system. Shop floor discipline is required to ensure that orders are processed in accordance with the established priorities. If a component part is left off the bill of materials, the system will never order it. The lead times transmitted to MRP won't materialise if not.

Inputs and outputs in MRP System

Inputs to MRP Programme

Product Demand: There are two basic factors that drive demand for finished goods. The first is known clients who have made particular orders, such as those brought about by sales agents or by transactions between departments. Demand projections serve as the second source.Demand from known clients and demand projection are combined to form the master production schedule's input.Bill of Materials (BOM) Files. A bill of materials (BOM) file is a document that details the composition of a product as well as the order and quantity of the needed components. It also provides information on the workstations in which it is put together. The Bill of Materials provides details on the product structure, including the components and raw material units required to produce one unit of the desired product[4]–[6].Figure 2represents the product structure of sub-assembly A.

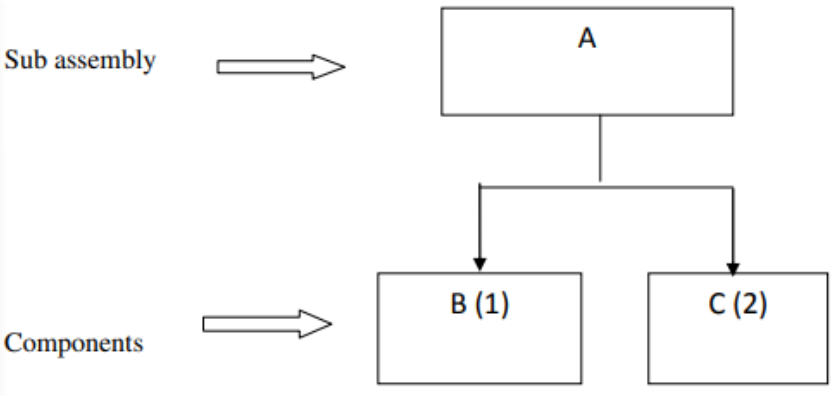

Figure 2: Represents the Product structure of sub-assembly A.

Product structure

Product build up is seen in the product structure. The diagram depicts the parts needed to construct it, their quantities, and the order in which they should be put together. One unit of component B and two units of component C, for instance, are joined to form subassembly A

(shown below). Therefore, 100 units of component B and 200 units of component C are needed to produce 100 units of subassembly A.

Master Production Schedule: The master schedule, the bill of materials, the production cycle timings, and supplier lead times all work together to establish when orders must be placed after the master schedule and bill of materials specify what supplies should be bought. The Master Production Schedule lists the product quantities that will be produced within a certain time frame.

At both the aggregate and detailed levels, quantities are provided. The terms "aggregate" and "detailed" may be used to describe weekly or daily output, respectively. The master production schedule is a table where the rows are goods and the columns are time components.

The aforementioned MPS may also include details on a model's sub models, for example, how many Model-1s with power windows and steering will be manufactured in a particular week.Inventory Records File: The inventory records file comprises the status of every item in the inventory as well as the units that are anticipated to be received within that time period as a consequence of recent orders made to suppliers. This must include information on the item's suppliers, the length of time it takes him to provide the goods, and the quantity of each order you must submit to him.

A computerised system can store extensive inventory records. The amount of information that can be carried about an object is almost endless, and each item in inventory is kept in a distinct file. The MRP programme makes particular time-based accesses to the file's status section. As required over the course of the programme, these files are accessed.

Working of MRP program

The master production schedule identifies a list of final products that are required by certain dates.The bill of materials file contains a description of the components and materials required to produce each item.

1. The inventory file contains the quantity of each item and material that is presently in stock and that is being ordered.
2. The MRP software "works" with the inventory file. Additionally, it often consults the file containing the bill of materials to determine how much of each item is required.
3. Following a correction for quantities already in stock, the net demand is "offset" to account for the lead time necessary to receive the material.

Outputs in materials requirement planning

The result of the MRP software is a variety of reports that are crucial for the production managers to use while making decisions. Following is a summary of the MRP program's many outputs.

Primary Reports

The primary or standard reports used for inventory and production management are referred to as primary reports. These reports include (a) planned orders that will be released in the future; order release notices to carry out the planned orders; (c) changes in open order due dates as a result of scheduling changes; (d) cancellations or suspensions of open orders as a result of cancellations or suspensions of orders on the master production schedule; and (e) information about inventory status.

Secondary Reports

The three primary types of secondary reports, which are optional under the MRP system, are as follows:Planned Order Report: This report informs us of the planned orders that are expected to be published at some point in the future or over a certain period of time. According to the dates and order quantities, this report assists in planning the cash needed for payments to suppliers in the future[7]–[10].For instance, the finance manager wants to know how much raw material needs to be available in May for the present month of April.This information greatly helps him in generating a report indicating how much money would be needed in May to pay suppliers.

Order Release Report

An order release report is one that provides details on anticipated orders that would be issued at the time of writing.IT enables the release of purchase orders to suppliers by the purchasing managers.

The purchasing manager may use this report to keep track of the purchase orders that need to be submitted on a certain day. In order to ensure that the products are delivered by the time the items are needed for production, the material requirement planning logic makers utilise the lead time of things to determine the release date of orders.

Order Changes Report

This lists the orders that have already been placed, and the supplier is getting ready to deliver the goods to the business. The material requirement planning may alter throughout the lead time as a result of certain customers cancelling their orders, forcing a revision of the mps due to the change in demand for open orders.In this situation, suppliers are instructed to either cancel or postpone prior orders made by the firm or to scale down those orders to meet the present demand.The order change report informs the procurement manager of any such changes that need to be made to the suppliers' open orders.

CONCLUSION

In industrial organisations, Material Requirements Planning (MRP) is essential for improving inventory control and simplifying production procedures. MRP systems help businesses identify the appropriate quantity and timing of the materials needed for manufacturing by examining production schedules, demand predictions, and inventory levels. By ensuring that resources are on hand when required, stockouts, excess inventory, and related expenses are minimised. MRP facilitates effective production planning, reduces lead times, and enhances customer satisfaction via prompt product delivery.

Although adopting MRP systems may be difficult due to issues with data quality and system integration, technological developments have significantly increased the efficacy of MRP. The accuracy and effectiveness of MRP systems have increased with the integration of sophisticated planning and scheduling software, real-time data collecting, and automated ordering procedures. MRP systems may enhance inventory management, cut costs, and boost operational efficiency for organisations, giving them a competitive edge in the market.A vital procedure for effectively managing material needs in a manufacturing system is material requirements planning (MRP).

The goal of this research study was to analyse MRP, including its tactics, difficulties, and performance improvement techniques.MRP comprises a number of crucial elements and procedures. In order to calculate future material needs based on expected production levels

and customer demand, demand forecasting is essential. The materials, components, and quantities required for each final product are listed in the Bill of Materials (BOM). The proper resources will be available when they're needed thanks to inventory management, which also helps keep carrying expenses to a minimum. A smooth production flow is ensured by production scheduling, which matches production operations with material availability.

REFERENCES

[1] C. Furqon, M. A. Sultan, and R. J. Pramudita, "Analysis of Material Requirement Planning (MRP) Implementation on The Company," 2018. doi: 10.5220/0006882001400145.

[2] R. H. Supe and M. D. Mata, "Analysis of Material Requirement Planning for Construction Project: Case Study (Residential Building)," *Int. Res. J. Eng. Technol.*, 2020.

[3] E. Rimawan, D. S. Saroso, and P. E. Rohmah, "Analysis of Inventory Control with Material Requirement Planning (MRP) Method on IT180-55gsm F4 Paper Product at PT . IKPP , TBK," *AIP Conf. Proc.*, 2018.

[4] C. C. Sum, K. K. Yang, J. S. K. Ang, and S. A. Quek, "An analysis of Material Requirements Planning (MRP) benefits using Alternating Conditional Expectation (ACE)," *J. Oper. Manag.*, 1995, doi: 10.1016/0272-6963(95)00005-D.

[5] A. S. Putri and B. I. Rosydi, "Analysis of raw material inventory for insecticide packaging bottle with material requirement planning: a case study," *J. Sist. dan Manaj. Ind.*, 2020, doi: 10.30656/jsmi.v4i2.2765.

[6] M. S. Madan and K. Gnanendran, "Course planning in educational programs: A project management approach," *Oper. Supply Chain Manag.*, 2020, doi: 10.31387/oscm0430275.

[7] R. Hencha and D. S. Verma, "Study of material requirement planning processes and its analysis and implementation a case study of automobile industry," *Int. J. Sci. Technol. Res.*, 2019.

[8] S. M. Gupta and L. Brennan, "A structured analysis of material requirements planning systems under combined demand and supply uncertainty," *Int. J. Prod. Res.*, 1993, doi: 10.1080/00207549308956817.

[9] A. I. Pratiwi, A. Hakim, and R. Y. Santosa, "Development Of Operation Process Map And Analysis Of Inventory Control Based On Material Requirement Planning In Assembly Line," *J. Ind. Eng. Halal Ind.*, 2020, doi: 10.14421/jiehis.1800.

[10] D. Mukhlis, J. Indraefrialdi, and E. Rimawan, "Inventory Management using Demand Driven Material Requirement Planning for Analysis Food Industry," *Int. J. Innov. Sci. Res. Technol.*, 2019.

CHAPTER 7

ANALYSIS OF JUST-IN-TIME MANUFACTURING SYSTEM: PRINCIPLES, IMPLEMENTATION AND PERFORMANCE EVALUATION

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ABSTRACT:

The supply of raw materials, component parts, and completed items at the precise moment they are required in the production process is the focus of the just-in-time (JIT) manufacturing production system. This research focuses on the investigation of the Just-in-Time (JIT) manufacturing system, looking at its foundational ideas, practical applications, and performance assessment techniques. The research examines the crucial JIT elements and procedures, such as inventory control, production planning, supply chain integration, and waste minimization. It examines JIT's guiding concepts, including waste reduction, ongoing innovation, and pull-based manufacturing. The study looks at the issues and factors to be taken into account while adopting JIT, such as system synchronization, supplier relationships, and cultural change. Additionally, it assesses the effects of an efficient JIT implementation on performance, including shortened lead times, higher quality, greater productivity, and cost savings. The results add to a thorough knowledge of the JIT manufacturing system, guiding practices for improving the efficiency of production processes and supply chains.

KEYWORDS:

Just-in-time Manufacturing, Lean Manufacturing, Supply Chain Management, And Inventory Control.

INTRODUCTION

"Just-in-Time (JIT) is a system to produce and deliver finished goods just in time to be sold, sub-assemblies just-in-time to be assembled into finished goods, and purchase materials just-in-time to be transformed into fabricated parts," claims Schonberger.The Toyota motor corporation in Japan was the first to come up with the concept of just in time.When Toyota wanted to quickly and precisely match consumer demand for various automobile models and colors, the concept was formalized into a management system. JIT is used in a vast array of businesses, including those that produce cars, consumer electronics, office equipment, etc.JIT may be seen as the ongoing improvement of the material flow in either factory or a network of manufacturers.The following are the four JIT approaches for enhancing material flow:

1. Redesigning the factory layout will save setup time,
2. apply the pull system, and improve supplier cooperation.

Factory Layout Revision

The design of factories may be changed to include production cells and assembly lines.These layout changes, also known as continuous flow manufacturing, are made to reduce material handling activities and the transactions that go along with them and to speed up the feedback loop for quality.Even while certain assembly lines are capable of producing many models,

they are normally focused on a single product type[1]–[3].Manufacturing cells, designed employing group technology, generate a range of finished items.Excess capacity is often included in systems in order to be able to meet certain demand spikes.

Reduced Setup Time

In order to lower lot sizes and streamline production, factories might shorten setup times.A manufacturer can profitably generate smaller lot sizes because to shorter setup periods. A firm can create a wider range of goods, components, and assemblies each day thanks to smaller batch sizes.To accomplish these smaller safety stock levels, however, preventative maintenance and a decrease in defect rates are also required.

Implementation of the Pull System

In a pull system, kanban cards are utilized to notify sub assembly and component deliveries as well as manufacturing, while final assembly lines only create genuine orders.MRP is an option, and using a pull system is made easier by smooth production.

improved supplier coordination

To minimise raw material stockpiles and address quality issues, factories might collaborate with their suppliers. For enhancing the material flow between a company and its suppliers, the first three approaches are also relevant to suppliers. To prevent the issues related to transferring inventory from customers to suppliers, the objective is to make the supplier an extension of the internal material flows.

Kanban Visual Systems

A flag or signal, referred to as a "kanban" in Japanese, serves as a visual cue that something has to be done. Toyota Motor Company first established the kanban inventory management method in Japan. Toyota Vice President Taiichi Ohno saw the method used by American supermarkets to fill vacant shelves in racks while on a trip to the USA.When a shelf was discovered to be empty of a certain item, the product was replenished to the shelf. It was so easy since an empty shelf could be seen amid the other shelves that were loaded with goods. The similar concept for refilling at his production lines crossed Ohno's mind. Using a trigger or kanban, he modified this simple but efficient technique to notify the production area that the assembly area was running short on components. Each component needs its own kanban to indicate when it need replenishment.

The following phases may be used to describe the kanban system:

When a worker needs a component, he first walks to the racks that are located across from his workstation.Bins containing the parts needed for a workstation are kept in these racks and come from the inventory of work-in-progress. Each container has a detachable requisition kanban card attached to it.

The name of the component, its identification number, the rack number and shelf on the rack at the store where more bins of the component are kept, and other information are all included on this card.In order to use the components in assembly operations, the assembly line employees pull the kanban card out of the bin, hang it on a hook on the rack and transport the bin to their workstation. Thus, the restocking of shop inventory is clearly shown by these hanging kanban cards, which are visible from any angle.A supply worker known as "Mizosomashi" in Japanese continues to move through the aisle or passageway while pushing his cart past the racks. He takes out all of the empty bins and hanging requisition kanban

cards from the racks when he gets to the ones across from the assembly line. Then he moves them with him along the aisle to the store's racks that are next to the production lines.

Mizosomashi determines the location of the rack and the shelf on the rack housing the bins full of a certain component by examining the information on each request kanbancard.The detachable production kanban card is attached to each bin in the shop. The name and identification number of the component that will be produced in the cell are listed on the production kanban card. Mizosomashi retrieves the production kanban card from the bins on the racks that match to the requisition kanban card he had brought with him. He inserts the bins in the trolley, moves it to the racks across from the assembly line, hangs the bins on the hooks on the respective racks in the shop and connects the requisition kanban cards to the bins.Consequently, the assembly line's bins have been restocked. This procedure is repeated by Mesosomas on a regular basis.

DISCUSSION

Inventory

Because inventory is essentially working capital, inventory control is crucial for effective operations management. The efficient operation of manufacturing and retailing organizations depends on their inventories. There are many different forms of inventories, including completed items, work-in-progress, consumables, and raw materials. Not every organization may need these resources, but all should adhere to theThe demands and requirements of the resources will vary based on the sort of production that is taking place, according to Vetter: Inventory Management, Different departments within the same organization treat different sorts of resources in conflicting ways. This is so because the tasks carried out by distinct departments affect their motivation. For instance, the sales department may need substantial material reserves to ensure that the manufacturing processes operate without any hiccups. On the other side, the finance division would need a minimal investment in stocks so that the money might be utilized for other, better uses to raise the organization's performance.Different inventory management methods decide how much and when to order[4]–[6].

Types of Inventories

Although different departments utilize inventories for a variety of demands and goals, every manufacturing organization should place special focus on the following five categories of inventories:

1) Inventory movements

2) Buffer stockpiles

3) Inventory of expectations

4) Disentangling inventory flows

5) Periodic inventories

Movement Inventories

Through a variety of routes of transportation, common resources are delivered to the industries and used by production organizations. Transit or pipeline inventories are other names for movement inventories. Basically, this is concerned with moving the resources from one place to another. For instance, if coal is delivered by rail from coalfields to an industrial

township, it will not be able to serve the needs of the customers for power generation, burning furnaces, etc. while it is in transit.

Buffer Inventories

Every organization maintains an average amount of inventories in stock in order to be able to use those resources quickly and effectively. These inventories are essentially kept on hand for future needs for the organization because there may be a situation where more inventories would be required. This primarily calls for demand uncertainty since every organization would need the necessary supply, everything would halt, especially manufacturing, hence it is crucial to have extra supplies of materials on hand. Similar to that, the Leadtime, which is the period of time between making an order for resources, receiving those supplies, and having them available for usage in stock, is the typical delivery time.Keeping buffer supplies is intended to improve customer service while progressively lowering the incidence of stock outs and backorders. Back ordering is a possibility in certain circumstances, meaning that the order for the items being desired will be completed as soon as the next shipment of stock comes. Stock out occurs when the stock runs out and the demands of the customers cannot be satisfied. While in other cases, things may not be as they seem since the demand might disappear permanently, resulting in a temporary or permanent loss of client goodwill.

Anticipation Inventories

Anticipation stocks are closely examined for potential demand so that, when the time comes, the product supply will flow quickly. similar to making raincoats ahead of the rainy season, making fireworks ahead of Diwali, etc. The aim behind this is to smooth out the production process' flow over a longer period of time on an iterative basis rather than running with excessive overtime in one period and then leaving the system idle for an extended length of time or even shutting it down due to superfluous demand in another.

Decoupling Inventories

Because different equipment and people often operate at varying ratessome slower and others fasterthis sort of inventory deals with the work rates of various machines and individuals. For instance, a machine may be generating just half of the output of the unit that will process the item being handled later. The holding of inventories amongst the different machines is done to stop the processing on that equipment. Different equipment and humans cannot operate continuously without such inventories. Decoupling inventories undoubtedly serve as shock absorbers and provide protection in the face of fluctuating work rates, equipment failures, and other unforeseen events.

Cycle Inventories

Cycle inventories are when purchases are made in lots rather than the precise quantity of goods required at a particular moment. However, if every purchase had been performed in accordance with the precise amount of stock needed, there wouldn't have been any cycle inventories. However, depending on the demands and requirements of the client, the cost of obtaining these supplies would be much greater. They are also known as lot-size inventories, and the higher the lot-size inventory, the higher the amount of cycle inventory would be.

Inventory Decisions

In a manufacturing organization, choosing on inventories is of utmost importance since it will determine both the company's current and future success. Determining inventories in accordance with demands and requirements is crucial in every industrial organization. This

may improve performance or decrease efficiency.Therefore, there are certain considerations that every production manager should make. As follows:

1. How much should be ordered? The management makes this decision in order to ensure optimum performance and efficient resource use.
2. When should I place my order? The management should place the most emphasis on this factor since it will determine when to order the items.
3. What amount should be taken into account so that the stock may be utilized securely and without hesitation in the future is indicated by the question, "How much stock should be kept in safety?"

Purchase Cost

Essentially, this represents an inventory's nominal cost. It is the price paid for purchasing goods from outside vendors; if the goods were created inside, they would be referred to as production costs. A unit's cost is fixed, although the price may change when the number bought rises or falls. For instance, the unit cost is Rs. 20 for the first 100 units and Rs. 19.50 for the next 100 units. The control choices would not matter if a unit cost was constant since the overall cost would be the same whether all needs were produced all at once or in installments.

Ordering Cost/Set-up Cost

When the supply is replenished, something happens. It relates to transportation, quality inspection, and processing and pursuing bought orders. It is also known as the cost of procurement. When the units are manufactured internally, setup costs are the equivalent of ordering costs. It speaks about expenses related to creating production schedules. It is assumed that the ordering fee and setup fee are unrelated to the order size. Therefore, when the buy order size grows, the cost of unit ordering and setup lowers[7]–[10].

Carrying Cost

The expense connected with keeping an item in inventory is referred to as carrying cost, sometimes known as holding cost. It varies in direct proportion to the volume of inventory and the holding period for that inventory. Opportunity cost, obsolescence cost, and degradation cost are components of carrying cost. The rate per unit or a percentage of the inventory value are two ways to describe the carrying cost.

CONCLUSION

By putting an emphasis on decreasing waste, cutting inventory, and boosting efficiency, just-in-time (JIT) manufacturing has completely changed how production systems operate. JIT allows businesses to manufacture things just when required, minimizing lead times and lowering inventory carrying costs.

It does this by synchronizing the flow of resources, information, and manufacturing operations. JIT concepts, such as continuous improvement, standardized procedures, and tight supplier engagement, assist organization’s in achieving operational excellence and customer demand responsiveness.

While adopting a JIT system might be difficult due to supply chain interruptions and the requirement for tight collaboration, these difficulties can be reduced with good supply chain management and lean manufacturing techniques.

When JIT manufacturing is properly implemented, businesses may enjoy lower inventory costs, better product quality, quicker throughput times, and more customer satisfaction. For businesses seeking to improve operational effectiveness, save costs, and gain a competitive edge in today's fast-paced business climate, JIT manufacturing has emerged as a critical approach.

REFERENCES

[1] A. Gunasekaran, S. K. Goyal, T. Martikainen, and P. Yli-Olli, "Modelling and analysis of just-in-time manufacturing systems," *Int. J. Prod. Econ.*, 1993, doi: 10.1016/0925-5273(93)90005-6.

[2] N. Singh and J. K. Brar, "Modelling and Analysis of Just□in□Time Manufacturing Systems: A Review," *Int. J. Oper. Prod. Manag.*, 1992, doi: 10.1108/01443579210009005.

[3] T. Ohno and N. Bodek, *Toyota Production System: Beyond Large-Scale Production*. 2019. doi: 10.4324/9780429273018.

[4] N. I. Kumala and S. Rosyidi, "Effects of JIT, TQM competences and product design on financial performance of the firm: Does supply chain moderates?," *Int. J. Supply Chain Manag.*, 2020.

[5] Y. E. Al Haraisa, "Just-In-Time System and Its Impact on Operational Excellence: An Empirical Study on Jordanian Industrial Companies," *Int. J. Bus. Manag.*, 2017, doi: 10.5539/ijbm.v12n12p158.

[6] E. Oztemel and S. Gursev, "Literature review of Industry 4.0 and related technologies," *Journal of Intelligent Manufacturing*. 2020. doi: 10.1007/s10845-018-1433-8.

[7] A. Gunasekaran, S. K. Goyal, T. Martikainen, and P. Yli-Olli, "A critical assessment of the modelling and analysis of just-in-time manufacturing systems," in *Manufacturing Research and Technology*, 1993. doi: 10.1016/B978-0-444-89856-2.50008-9.

[8] H. D. Rupasinghe and C. Wijethilake, "The impact of leanness on supply chain sustainability: examining the role of sustainability control systems," *Corp. Gov.*, 2020, doi: 10.1108/CG-06-2020-0217.

[9] Y. S. Kang, H. Kim, and Y. H. Lee, "Implementation of an RFID-based sequencing-error-proofing system for automotive manufacturing logistics," *Appl. Sci.*, 2018, doi: 10.3390/app8010109.

[10] G. Chauhan and T. P. Singh, "Measuring parameters of lean manufacturing realization," *Meas. Bus. Excell.*, 2012, doi: 10.1108/13683041211257411.

CHAPTER 8

FORECASTING FOR INVENTORY AND PRODUCTION CONTROL: TECHNIQUES, APPLICATIONS AND PERFORMANCE OPTIMIZATION

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ABSTRACT:

In order to manage inventory levels and production operations efficiently, this research study focuses on forecasting for inventory and production management, looking at the methodology, applications, and performance optimizations approaches involved. The essential elements of forecasting are examined in the paper, including data analysis, demand trends, and statistical models. It examines the many forecasting strategies used to inventory and production management, including causal forecasting, regression analysis, and time series analysis. The study looks at how forecasting is used to optimize resource allocation, production scheduling, and inventory levels. Additionally, it assesses the effects of precise forecasting on performance, such as less stockouts, higher levels of customer satisfaction, lower expenses associated with keeping inventory on hand, and increased operational effectiveness. The results contribute to a thorough knowledge of forecasting for inventory and production control, guiding practices for optimizing inventory management and production performance and decision-making based on evidence.To ensure efficient inventory management and production planning, forecasting for inventory and production control is a crucial procedure that includes estimating future demand for goods or resources.

KEYWORDS:

Resource Allocation, Demand Forecasting, Production Control, Inventory Management, Forecasting.

INTRODUCTION

Stoke is inventory. It is crucial for an organization's manufacturing processes, equipment and plant maintenance, as well as other operational needs. In order to ensure that the majority of the products are accessible when needed, greater inventories are often kept on hand.Production control refers to managing output using different demand forecasting techniques. Production control is the process of anticipating, planning, and scheduling work in order to achieve the proper quality and quantity at the time it is needed. It also involves monitoring the schedule to ensure that the plan is carried out using whatever systems have proven effective for the job.Demand forecasting is the art and science of predicting consumer demand to guide a company's supply chain and business management in executing that demand holistically.Both informal approaches, such informed estimates, and quantitative ones, like the utilisation of historical sales data and statistical tools, or current data from test markets, are used in demand forecasting. Demand forecasting may be utilised in inventory management, production planning, capacity planning, and sometimes in determining whether to join a new market[1]–[3].Demand forecasting projects what the product's future demand will be. In other terms, it relates to the estimation of future demand for a product or a service based on historical occurrences and current trends.

Need of Inventory

An adequate supply of completed items and ongoing manufacturing are guaranteed. The fact that all of an inventory should be understood and measured is its most important feature. For instance, we have working stock since we are unable to produce or acquire only one for each sale or usage. Due to lead times, inaccurate forecasts, servicing needs, etc., we have safety stock, but our clients don't want to wait. We may hold excess inventory to protect against supply fluctuations, such as those caused by subpar vendor performance, production issues, or seasonal product availability. Finally, as we could be aware of a price rise in the future, we might need hedge stock. Finished items, work in progress, or raw materialsany level of the bill of materials, of coursecould experience the aforementioned situation. We will only focus on the working stock and safety stock factors for sustaining inventories at the completed products level for this discussion. When we originally began out in company, all of our attention was on the final products. But eventually, we conducted the essential study and creation to broaden the science to deal with inventory at all levels.

Demand Forecasting

1. In a world where the most enduring institutions passed down through human civilization are being swept away by the tidal tides of change, forecasts are increasingly becoming the lifeblood of business.
2. It so happens that one of the first victims is commerce. In this era of financial predators, survival calls for cunning, ability, and forecasting skills.
3. Forecasting is becoming into the corporate language and a sign of survival. Every necessity of the business sector requires the skill of precise and useful future reading.
4. As a result, forecasts are a crucial component of corporate survival. Making a variety of choices in management involves anticipating data.
5. Demand forecasting projects what the product's future demand will be. In other terms, it relates to the estimation of future demand for a product or a service based on historical occurrences and current trends.

Meaning of demand forecast

A demand forecast is a projection of the future sales of your company's current products. The demand prediction should be created utilizing a multi-functional strategy. It is important to take into account the manufacturing, financial, and sales and marketing factors. The collective opinion of all involved managers constitutes the final demand prediction. You may also create a Sales and Operations Planning committee with members from the various departments who will be responsible for creating the demand prediction.The sales forecast is especially crucial since it serves as the cornerstone for all business strategies regarding markets and income. If company were not always undergoing change, which is happening at a faster rate now than it ever has before, management would be a straightforward process.

Predicting future sales, expenses, and profits for a corporation is becoming more and more crucial and required. The estimation of future sales is the obvious starting point of any business planning since the value of future sales is vital because it influences expenses and earnings.Forecasts are estimates or predictions about future events. It is a neutral evaluation of the best course of action moving forward.

No prognosis can be 100 percent accurate since the future is unpredictable.Forecasts might be of a financial or physical character. Decisions for tomorrow can be made more effectively when the predictions are more accurate.Demand forecasting, to use the words of Cundiff and Still, "is an estimate of sales during a specified future period that is tied to a proposed

marketing plan and that assumes a particular set of uncontrollable and competitive forces." Therefore, depending on a selected marketing strategy and external factors, demand forecasting is an estimate of the company's anticipated level of sales.

DISCUSSION

Procedure to Prepare Sales Forecast:

A three-stage process is often used by businesses to create sales forecasts. They first make an environmental forecast, which includes projecting inflation, unemployment, interest rates, consumer spending and saving, business investment, government expenditure, net exports, and other environmental magnitudes and events of significance to the company. This is followed by an industry forecast, which is then followed by a company's sales forecast.The industry prediction is based on consumer intention surveys, and trade groups or chambers of commerce provide analysis of statistical trends. It might provide a corporation with clues about the direction the sector will be headed in. The business bases its sales projection on the assumption that it would capture a certain market share.The external forecast, often known as the national forecast, examines trends in general business. Usually, a company's research department or outside consultants will create it.Internal forecast, also known as corporate group forecast, refers to all forecasts pertaining to the operation of a certain firm, such as sales group, manufacturing group, and finance group. Internal predictions are structured to incorporate yearly sales estimates, product cost forecasts, operational profit forecasts, taxable income forecasts, cash resource forecasts, personnel forecasts, etc.

Forecasting may be classified as below at different levels

1. Macro-level forecasting
2. Industry- level forecasting
3. Firm- level forecasting
4. Product-line forecasting

Macro-level forecasting is concerned with the state of the economy as a whole.A suitable indicator of industrial productivity, national revenue, or expenditures is used to measure it. Various trade organisations provide industry-level forecasts. This is based on an examination of data trends and a poll of consumer intentions. Forecasting at the company level is specific to one particular firm. From a management standpoint, it is quite significant. The corporation may pick which product or products should get priority when allocating its limited resources thanks to product-line forecasting.A forecast might be either vague or particular. The company may typically benefit from the broad projection. Since this broad prediction is further divided into individual projections, many businesses demand distinct forecasts for certain goods and geographical regions[4]–[6].There are different forecasts for different types of products like:

1. Forecasting demand for nondurable consumer goods.
2. Forecasting demand for durable consumer goods.
3. Forecasting demand for capital goods.
4. Forecasting demand for new-products.

Non-Durable Consumer Goods

'Single-use consumer products' or 'perishable consumer goods' are other names for them.After a single act of ingestion, they disappear. Products like food, milk, medicines, fruits, and other items are among them. The demand for these products is influenced by factors including population and features, price of the commodity and associated commodities, and family

disposable income.population, price of the item, and the cost of its connected commodities.Other things being equal, the demand for a commodity relies on the household's disposable income, as stated by the formula Dc = f (y). After taking personal taxes out of personal income, the household's disposable income is calculated. The amount of disposable income indicates the household's buying power.Price is defined as Dc = f (p, pr), which means that, under normal circumstances, the demand for a commodity relies on both its own price and the prices of related items. While the price of a commodity's complements has an inverse relationship with its own demand. It has a favourable relationship with its alternatives. Forecasting demand for non-durable consumer items is aided by their price elasticity and cross-elasticity.

Population, or Dc=f (5), states that, all factors being equal, the demand for a given good or service relies on the population's size and makeup. Additionally, the population may be divided based on sex, income, literacy, and social standing. All of these variables affect customer demand for non-durable items. The population as a whole is taken into account when predicting demand in general, but segmenting the population based on distinct traits is shown to be more beneficial when anticipating particular demand.The following are the many phases involved in predicting customer demand for non-durable goods:In order to represent the variables that affect the demand for the product, one must (i) first identify the variables that affect that demand and express them in the appropriate ways, (ii) collect relevant data or data that is approximatively relevant, and (iii) use statistical analysis techniques to determine the most likely relationship between the dependent and independent variables.

Durable Consumer Goods

These products can be used again or ingested many times without significantly losing their usefulness. Products like cars, televisions, air conditioners, furniture, etc. are among them. Consumers have the option to either repurpose things after extensive usage or dispose of them.

The following elements determine the choice:Depending on a consumer's social standing, degree of wealth, personal preferences, and sense of style, among other factors, they may choose to replace a durable product or continue using it when it needs repairs. Replacement demand tends to increase as consumer stock of the product rises. The life expectancy chart may be used by the company to assess the average replacement cost.The majority of consumer durables are used by family members together. For instance, homes use appliances like televisions and refrigerators often.

Forecasts of demand for widely consumed commodities should use the number of homes rather than the entire population. The income of the home, the number of children, the sex composition, etc. should all be taken into consideration when determining the number of households.

Consumer durable demand is influenced by the presence of supporting infrastructure. For instance, using a TV or refrigerator requires a consistent supply of electricity, using a vehicle requires gasoline availability, etc.

The availability of linked services and their pricing should also be considered when predicting demand for consumer durables.The cost of consumer durables and the availability of financing have a significant impact on consumer demand. Consumer durables are very sensitive to changes in price. A little decrease in their price might result in a significant rise in demand.

Forecasting Demand for Capital Goods

Capital items are used in subsequent manufacturing. A derived demand exists for capital goods. It will depend on how profitable certain sectors are. One example of a derived demand is the demand for capital goods. Demand for certain capital goods will be influenced by the markets they cater to and the purposes for which they are purchased.For instance, the growth of the textile sector in terms of new units and replacement of current equipment would affect the demand for textile machinery. Therefore, it is vital to estimate both replacement and new demand.In order to estimate the demand for capital goods, three different kinds of data must be known:

a) the development prospects of the user industries;

b) the norm of capital goods consumption per unit of each end-use product; and

c) the velocity of their usage.

Forecasting Demand for New Products

The techniques used to predict demand for new items vary significantly from those used for existing products. An in-depth analysis of the product and its anticipated effects on other items in the same group might help to predict demand as the product is new to customers[7]–[10].

Joel Dean has classified a number of possible approaches as follows

1. The evolutionary approach involves assuming that the demand for a new product will develop out of and evolve from an already-existing old product.
2. The new product is seen as a replacement for the current good or service under the substitution method.
3. Growth Curve Approach: This method uses a growth pattern of an existing product to predict the rate of growth and potential demand for a new product.
4. Opinion-Poll Approach: In this method, the final customers themselves are contacted directly to evaluate demand.
5. Sales Experience Approach: Using this strategy, a sample market is used to sell the new product in order to determine how much demand there is for it.
6. Vicarious Approach: Using this technique, specialized dealers who are able to assess customers' requirements, tastes, and preferences learn indirectly how consumers will respond to a new product.

CONCLUSION

Organisations must forecast for inventory and production control to guarantee optimal resource allocation, reduce inventory carrying costs, and satisfy customer expectations. Accurate demand projections may be created by examining historical data, market trends, and other pertinent aspects, allowing businesses to decide on inventory levels, production capacity, and procurement with confidence. Effective forecasting aids in production planning optimisation, lowering the possibility of stockouts or overstocking, and enhancing customer satisfaction via on-time delivery.

Due to demand unpredictability and data constraints, forecasting may be difficult, but using statistical models, doing market research, and working with stakeholders may improve prediction accuracy.

A key aspect of inventory and production control is forecasting. Organisations may decide on inventory management, production scheduling, and resource allocation by using procedures, examining demand trends, and putting statistical models to use. Accurate forecasting reduces stockouts, boosts customer satisfaction, lowers the cost of keeping goods on hand, and improves operational effectiveness. To achieve competitive advantage in a changing corporate environment, optimisation of inventory and production management, adoption of modern forecasting approaches, and data-driven decision-making are crucial.

REFERENCES

[1] R. Fildes and C. Beard, "Forecasting Systems for Production and Inventory Control," *Int. J. Oper. Prod. Manag.*, 1992, doi: 10.1108/01443579210011381.

[2] T. E. Goltsos, B. Ponte, S. Wang, Y. Liu, M. M. Naim, and A. A. Syntetos, "The boomerang returns? Accounting for the impact of uncertainties on the dynamics of remanufacturing systems," *Int. J. Prod. Res.*, 2019, doi: 10.1080/00207543.2018.1510191.

[3] P. Doganis, E. Aggelogiannaki, and H. Sarimveis, "A combined model predictive control and time series forecasting framework for production-inventory systems," *Int. J. Prod. Res.*, 2008, doi: 10.1080/00207540701523058.

[4] A. Pooya, M. Pakdaman, and L. Tadj, "Exact and approximate solution for optimal inventory control of two-stock with reworking and forecasting of demand," *Oper. Res.*, 2019, doi: 10.1007/s12351-017-0297-6.

[5] I. K. Juliantara and K. Mandala, "Perencanaan Dan Pengendalian Produksi Agregat Pada Usaha Tedung Ud Dwi Putri Di Klungkung," *E-Jurnal Manaj. Univ. Udayana*, 2020, doi: 10.24843/ejmunud.2020.v09.i01.p06.

[6] V. Polotski, J. P. Kenne, and A. Gharbi, "Kalman filter based production control of a failure-prone single-machine single-product manufacturing system with imprecise demand and inventory information," *J. Manuf. Syst.*, 2020, doi: 10.1016/j.jmsy.2020.07.010.

[7] E. Budiningsih and W. A. Jauhari, "Analisis Pengendalian Persediaan Spare Part Mesin Produksi di PT. Prima Sejati Sejahtera dengan Metode Continuous Review," *PERFORMA Media Ilm. Tek. Ind.*, 2017, doi: 10.20961/performa.16.2.16994.

[8] A. Syakura, O. Hendaryani, and R. Ramadhan, "Analisis Penggunaan Peramalan dalam Meminimalkan Biaya Simpan Produk Linzhi Plus pada CV. HN," *Performa Media Ilm. Tek. Ind.*, 2016, doi: 10.20961/performa.15.2.9826.

[9] R. T. Prasetio, "Inventory Control Using Statistics Forecasting On Manufacture Company," *J. Inform.*, 2014, doi: 10.31311/ji.v1i2.45.

[10] P. R. Winters, "Forecasting Sales by Exponentially Weighted Moving Averages," *Manage. Sci.*, 1960, doi: 10.1287/mnsc.6.3.324.

CHAPTER 9

TIME SERIES ANALYSIS: METHODS, APPLICATIONS AND PERFORMANCE EVALUATION

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ABSTRACT:

Time series analysis is the subject of this research project, which looks at its applications, methodologies, and performance assessment. For the analysis and forecasting of data that changes over time, time series analysis is a potent tool. The essential elements of time series analysis, such as data collection, trend analysis, seasonality, and forecasting models, are examined in this paper. Various time series analysis techniques, including moving averages, exponential smoothing, and autoregressive integrated moving average models, are examined. The study explores the uses of time series analysis in a number of disciplines, including economics, finance, and weather prediction. Additionally, it assesses the effectiveness of time series analysis methods while taking criteria for predicting inaccuracy, resilience, and accuracy into account. The results add to a thorough knowledge of time series analysis, guiding practices for the analysis and forecasting of time-dependent data and decision-making based on evidence.

KEYWORDS:

Time Series Analysis, Regression Analysis, Exponential Smoothing, Delphi Method, Forecasting Methods.

INTRODUCTION

Demand forecasting is a challenging task. It is a Herculean undertaking to make projections for the future under changing circumstances. The conduct of consumers is the most unpredictable since it is driven and shaped by a variety of factors. The manager cannot foresee the future using an easy approach or straightforward calculation. Numerous techniques for anticipating demand have been developed by statisticians and economists.Each of these approaches has its relative benefits and drawbacks. The correct approach must be used in order for demand forecasting to be accurate. Demand forecasting requires a skillful blending of statistical knowledge and logical judgement.Although they are crucial for categorizing connections and offering analytical procedures, mathematical and statistical methods in no way replace good judgement. A successful prediction first and foremost requires sound judgement.The forecaster's personal bias should not outweigh the facts; the decision should be made on the basis of the facts. Therefore, a middle ground between mathematical procedures and good judgement or sheer guess work should be adopted[1]–[3].

Qualitative Methods/ Techniques

Opinion Polling Method

Consumer Survey Technique or Buyer Intentions Survey: With this strategy, customers are directly asked about their upcoming purchasing intentions.This is accomplished by interviewing every customer or a chosen subset of consumers from the relevant demographic.

This is the most accurate way to predict demand in the near future. Here, the buyer is given the responsibility for anticipating. The company may request a full enumeration or a sampling survey. The industries that use the commodity as an end product are surveyed if it is an intermediary product.

Complete Enumeration Survey: As part of the Complete Enumeration Survey, the company is required to call every family in the region and conduct a door-to-door survey for the projected period. This approach provides the benefit of first-hand, impartial knowledge, but it also has certain drawbacks.

This method's main drawback is that it takes a lot of materials, labour, and time. Customers could be hesitant to disclose their purchasing intentions using this strategy out of respect for their privacy or business confidentiality. Additionally, customers may fail to articulate their opinions clearly or purposefully lead investigators astray.Sample Survey and Test Marketing: In this strategy, a random sample of representative homes are chosen, and their opinions are taken to reflect the overall public's view. The foundational tenet of this approach is that the sample accurately reflects the population. There probably won't be a noticeable variation in the survey's findings if the sample is really representative.

In addition, this approach is less time-consuming and expensive. Test marketing is one of the sample survey technique's variations. In essence, product testing is exposing the product to a variety of consumers for a certain amount of time. After some time, their responses to the product are observed, and the information is used to predict the anticipated demand. These are appropriate for brand-new items or drastically altered older products for which there are no previous data. Because it encourages a nationwide launch in a well-defined geographic region, it is a more scientific technique of evaluating anticipated demand.

DISCUSSION

End Use Method or Input-Output Method

His approach is quite helpful for sectors of the economy that focus primarily on producer products. In this method, the demand for the final product is determined by the end user demand of the intermediate product used in the production of this final product, which is projected as the basis for a demand survey of the industries using this product as an intermediate product.Numerous final good sectors that utilize an intermediate product both domestically and internationally may be included in the calculation of end user demand. It aids in our comprehension of the connections between distinct businesses.

The transaction matrix and the input co-efficient matrix are two matrices used in input-output accounting. This type's primary labor-intensive tasks are not in its functioning but rather in the data collecting and display.

Sales Force Opinion Method:

Another name for this is the process of group opinion. In this approach, salesmen's opinions are solicited rather than those of customers. The "grass roots approach" is a bottom-up strategy that calls for each salesperson in the organization to provide a unique forecast for his or her own sales region.

The sales manager and I go through and agree on each person's prediction. The organization's sales prediction is then made up of the sum of all projections. This approach has the benefits of being simple and inexpensive. There are no complex statistical analyses involved. The

salesmen's cumulative experience is this method's key asset. The forecasting of sales for new items is better served by this strategy.

Experts Opinion Method

The "Delphi Technique" of research is another name for this approach. The Delphi approach calls for a group of experts who are questioned using a series of questions, each of which is created from the answers to the previous one. As a result, any information that some experts have access to but not others is shared, giving all experts access to all the data needed for predicting.The technique is used to predict probable long-term sales of new items. This approach assumes two things: First and foremost, the panellists should be highly qualified, knowledgeable, and experienced. Second, its drivers are impartial in their work. The method's unique benefits include time and resource savings.

Statistical Methods/ Techniques

The application of statistical techniques in demand forecasting has shown to be quite beneficial. The statistical approaches are employed to preserve impartiality, which is achieved by taking into account all ramifications and examining the issue from a distance.The important statistical methods are discussed as below:

Trend Projection Method

A company that has been around for a while will have its own records of prior sales. 'Time series' is the term used to describe the results of placing such data in chronological order. Time series displays previous sales together with the actual demand for a certain product under typical circumstances. Such information may be provided in a tabular or visual format for further examination This approach is the most often used by commercial enterprises, in part because it is straightforward and affordable and in part because time series data frequently show a steady growth tendency.

Secular Trend (T), Secular Variation (S), Cyclical Element (C), and an Irregular or Random Variation (I) are the four different kinds of time series components. The formula O = TSCI describes these components. The term "secular trend" describes the long-term changes that come from general tendency. Seasonal fluctuations are changes in the social norms or the short-term weather pattern. Cyclical variations describe the changes that take place in the economy during times of depression and prosperity. The term "random variation" refers to events like wars, strikes, floods, and food shortages that happen often.

Seasonal, cyclical, and random changes are subtracted from the observable data before a prediction is generated. There is now simply the secular tendency. The projection of this trend follows. A trend line is projected to match a mathematical equation.

Utility of Forecasting

Forecasting reduces the risk associated with business fluctuations, which often have negative consequences on businesses, such as job loss, speculation, a reduction in capital creation, and lower profit margins. Forecasting is essential and plays a significant role in deciding on different strategies. Forecasting has been placed on a scientific foundation in modern times, greatly reducing the dangers and increasing the likelihood of accuracy[4]–[6].

Predictions for India

There are specialised agencies in the majority of the advanced nations. Businessmen in India have little interest in making scientific predictions. They rely more on astrology, luck, and

chance. Since they have a strong superstition, their predictions are inaccurate.There aren't enough data available to make accurate predictions. However, statistics by themselves cannot predict future events. To do good analysis and interpretation and come to solid findings, judgement, experience, and understanding of the specific trade are also required.Decision, prediction, and control are the three components that make up decision support systems. Of course, marketing forecasting is concerned with prediction. Sales forecasting may be thought of as a system with inputs and an output.This oversimplified perspective is a good benchmark for evaluating the real value of sales forecasting as a management tool. Despite this, no one has a 100% accurate forecast for future economic activity. Nobody can be certain of a forecast since they are just approximations.

Forecasting Models

The numerous forecasting models may be categorized into three groups:Extrapolative models: They employ historical data to produce forecasts for the future using various techniques for extrapolating historical data. For instance, it is possible to estimate the demand for soft drinks in a city or neighborhood to be 110 percent of the average sales during the previous three months. Similar estimates might be made for the sales of brand-new clothing over the holiday season as a proportion of those made during the same period the year before.

Casual models

They assess data from a cause-and-effect perspective. For instance, in the process of evaluating the demand for new homes, the model will pinpoint the variables that may have an impact on that demand and show how they are related.

Real estate prices, house financing alternatives, family discretionary income, building costs, and tax-law benefits are a few examples of the elements. The link between these characteristics and demand may be used to estimate the demand for new homes after it has been established.

Subjective judgements

A different set of models uses qualitative data to form subjective judgements. It could sometimes be supported by both quantitative and qualitative evidence.Several of these strategies integrate particular procedures to heavily rely on the knowledge of a group of top managers utilising a collaborative decision-making framework.

Criteria of a Good Forecasting Method

Thus, there are a variety of approaches to predict future sales. They demonstrate disparity in terms of price, adaptability, and the necessary expertise and abilities. Choosing the right approach for a certain demand scenario is therefore a challenge. The following economic factors have been proposed as having wider applicability:

(i) Accuracy: The prediction that is made has to be correct. How is a precise prognosis even conceivable? Checking the accuracy of prior predictions against current performance and of existing projections against future performance is crucial for obtaining an accurate forecast. Accuracy must be evaluated by judgement rather than exact measurement.

(ii) Plausibility: The executive should have confidence in the methods they are using and a solid comprehension of the methodology they have selected. Understanding is also necessary for accurate result interpretation. Requirements for plausibility may often increase the accuracy of outcomes.

(iii) Stability: Regrettably, a demand function tailored to previous performance may incur extremely high back costs and yet fail to perform predictably over a short period of time. The logic and clarity of the functions fitted, but mostly the consistency of the understanding connections measured in the past, determine how long a demand function's predicting abilities will last. Of fact, the acceptable cost of the projection depends on how important durability is.

(iv) Flexibility: Flexibility is a possible substitute for generality. On the basis of fundamental natural forces and human motivations, a durable function may be established. Although basic, it would be difficult to assess and so not very helpful. a group of variables whose coefficients might be periodically changed to more effectively adapt to changing situations while maintaining the integrity of the predictable forecasting process.

(v) Availability: Immediate data availability is a crucial necessity, and the forecasters' patience is constantly tested as they try to find fair approximations to relevance in late data.The methods used should be capable of yielding significant results fast. The management choices will be negatively impacted by a delay in the outcome.

(vi) Economy: Cost is a key factor that should be balanced against how crucial the projections are to the company's operations. One can wonder how much cash and management time should be set aside to achieve high forecasting accuracy. The economic factor is the criteria in this case.

(vii) Simplicity: Although statistical and economic models are unavoidably valuable, their complexity is intolerably high.These techniques might seem to be Latin or Greek to those executives who are afraid of maths. Therefore, the technique should be straightforward and easy to follow so that management may appreciate and comprehend why the forecaster chose it.

(viii) Consistency: The forecaster must deal with a variety of separate components. He would attain a result that seemed consistent as a whole if he did not change one component to put it in line with a prediction of another[7], [8]. In a nutshell, the optimal forecasting approach is one that accurately calculates returns over costs, seems logical, can be formalised for a respectable amount of time, can adapt well to changing conditions, and can provide findings that are current.

Not all items can be forecasted using the same technique.There is no special way to predict how much any commodity will sell. Depending on his purpose, the availability of data, the urgency with which predictions are required, the resources he plans to dedicate to this job, and the sort of commodity whose demand he wants to anticipate, the forecaster may attempt either technique[9], [10].

CONCLUSION

The use of forecasting methods by organization’s helps them make wise choices, allocate resources, and run their business efficiently. In order to forecast future trends and patterns, quantitative approaches like time series analysis, regression analysis, and exponential smoothing use historical data and mathematical models. These techniques are appropriate for companies with substantial historical data records and huge datasets. On the other hand, qualitative procedures, such as the Delphi method, rely on the subjective assessments and views of experts to predict the future. When there is little or suspect historical data, qualitative approaches might be helpful.

The availability of data, the goals of the prediction, and the desired degree of accuracy all play a role in choosing the best forecasting approach. Organizations may predict changes in demand, optimize inventory levels, improve production planning, and ultimately increase customer happiness by using rigorous forecasting methodologies.

REFERENCES

[1] C. M. L. Rahman, M. J. Alam, and M. R. Hasan, "Determination of Demand Forecasting Techniques Applicable For Electronics Product (Cell Phone) and Comparative Analysis," in *Proceedings of the 2nd International Conference on Industrial and Mechanical Engineering and Operations Management (IMEOM)*, 2019.

[2] A. Faruq, H. P. Arsa, S. F. M. Hussein, C. M. C. Razali, A. Marto, and S. S. Abdullah, "Deep Learning-Based Forecast and Warning of Floods in Klang River, Malaysia," *Ing. des Syst. d'Information*, 2020, doi: 10.18280/isi.250311.

[3] H. R. Glahn and D. A. Lowry, "The Use of Model Output Statistics (MOS) in Objective Weather Forecasting," *J. Appl. Meteorol.*, 1972, doi: 10.1175/1520-0450(1972)011<1203:tuomos>2.0.co;2.

[4] J. Manero, J. Béjar, and U. Cortés, "'Dust in the wind...', deep learning application to wind energy time series forecasting," *Energies*, 2019, doi: 10.3390/en12122385.

[5] E. M. Priliani, A. T. Putra, and M. A. Muslim, "Forecasting Inflation Rate Using Support Vector Regression (SVR) Based Weight Attribute Particle Swarm Optimization (WAPSO)," *Sci. J. Informatics*, 2018, doi: 10.15294/sji.v5i2.14613.

[6] C. Tian and Y. Hao, "Point and interval forecasting for carbon price based on an improved analysis-forecast system," *Appl. Math. Model.*, 2020, doi: 10.1016/j.apm.2019.10.022.

[7] S. Panigrahi and H. S. Behera, "A study on leading machine learning techniques for high order fuzzy time series forecasting," *Eng. Appl. Artif. Intell.*, 2020, doi: 10.1016/j.engappai.2019.103245.

[8] M. Ghaith and Z. Li, "Propagation of parameter uncertainty in SWAT: A probabilistic forecasting method based on polynomial chaos expansion and machine learning," *J. Hydrol.*, 2020, doi: 10.1016/j.jhydrol.2020.124854.

[9] R. I. Naisoko, C. C. Foenay, and A. E. L. Nyoko, "Analisis Penentuan Luas Produksi Pada Perusahaan Roti Bangkit Jaya Di Kota Kupang," *J. Manag. Small Mediu. Enterp.*, 2020, doi: 10.35508/jom.v13i3.3312.

[10] R. Kotharkar and A. Bagade, "Evaluating urban heat island in the critical local climate zones of an Indian city," *Landsc. Urban Plan.*, 2018, doi: 10.1016/j.landurbplan.2017.08.009.

CHAPTER 10

PERPETUAL INVENTORY CONTROL SYSTEM: DESIGN, IMPLEMENTATION AND PERFORMANCE EVALUATION

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ABSTRACT:

Time series analysis is the subject of this research project, which looks at its applications, methodologies, and performance assessment. For the analysis and forecasting of data that changes over time, time series analysis is a potent tool. The essential elements of time series analysis, such as data collection, trend analysis, seasonality, and forecasting models, are examined in this paper. Various time series analysis techniques, including moving averages, exponential smoothing, and autoregressive integrated moving average (ARIMA) models, are examined. The study explores the uses of time series analysis in a number of disciplines, including economics, finance, and weather prediction. Additionally, it assesses the effectiveness of time series analysis methods while taking criteria for predicting inaccuracy, resilience, and accuracy into account. The results add to a thorough knowledge of time series analysis, guiding practices for the analysis and forecasting of time-dependent data and decision-making based on evidence.

KEYWORDS:

Technology, Perpetual Inventory Control System, Real-Time Tracking, Inventory Accuracy**.**

INTRODUCTION

It is crucial to have knowledge of the ongoing availability of the various sorts of products and shops that have been bought, issued, and tallied up. The manufacturer can keep track of the availability of these supplies and warehouses thanks to the perpetual inventory management system without having to go through the laborious process of physical stock taking.With this approach, accurate records of the receipt, issuance, and supplies on hand are maintained. The major goal of this system is to always have up-to-date knowledge on the stock level of every item.Continuous stock taking, which involves verifying the whole stock of the company 3/4 times a year by selecting 10–15 items daily (as opposed to physical stock taking, which occurs once a year), is necessary for the effectiveness of a perpetual inventory management system.Rotations of the objects are taken. The procedure of continuous stock taking is often carried out by someone other than the storekeeper in order to have more effective control. This will assess the storekeeper's performance as well. The products might be chosen at random for a pleasant surprise. The effective execution of the system of continuous stock taking is necessary for the system of perpetual inventory control to be successful[1]–[3].

ABC analysis:

The A.B.C. (Always Better Control) approach is very useful for controlling materials in an efficient manner. According to their relative values, materials are divided into three groups using this technique. Costly products in Group 'A' may only make up 10 to 20% of the whole inventory but represent roughly 50% of the retailers' overall worth.In order to protect these things, more control is used. The products that make up Group "B" account for 20 to 30

percent of all retail items and around 30 percent of the overall dollar worth of all shops.These things can be controlled with a decent amount of care. About 70 to 80 percent of the goods in the last category, group Q, are covered at a cost of about 20 percent of the whole value. This is known as the residuary category. In the event of the third group, routine care may be given.Other names for this methodology include "selective value approach," "proportional parts value approach," and "stock control according to value method."If this strategy is used carefully, it guarantees a significant savings in storage costs and is also very beneficial in maintaining expensive objects.

Key Terms

ABC Classification

Inventory is divided into three groups: A, which includes things with a low volume and a high rupee value; B, which includes items with a medium volume and a low rupee value; and C, which includes items with a high volume and a low volume. The words "inventory" and "materials" are synonymous. It is also known as an enterprise's idle resource. Inventories are products that are either kept on hand for sale, are being manufactured, or are in the form of materials that have not yet been put to use.Inventory control is a systematic method of deciding what to purchase, when to buy it, how much to buy, and how much to stock up on so that expenses associated with purchasing and storage are minimised while minimising the impact on production and sales.Forecasting Forecasting is the systematic and scientific method of analysing and comprehending past and present data in order to anticipate future trends. Demand forecasting is the technique of predicting a product's future demand in terms of a unit or monetary value.A company's inventory is managed through an inventory control system, which includes buying, shipping, receiving, tracking, warehousing and storage, turnover, and reordering.

Aggregate Planning Information

An operational activity that does an aggregate plan for the production process, in advance of 2 to 18 months 6, to give management an idea of what quantity of materials and other resources are to be procured and when, so that the total cost of operations of the organization is kept at minimum over that period," is how the term "aggregate planning" is defined.The act of creating, evaluating, and maintaining a rough timeline for an organization's entire operations is known as aggregate planning.

The overall plan often includes customer backlogs, production levels, inventory levels, and targeted sales predictions. This timetable aims to meet demand at the lowest possible price. When done correctly, aggregate planning should reduce the negative consequences of day-to-day scheduling that involves purchasing modest quantities of material one week, laying off employees, then ordering greater amounts and rehiring employees the following week. This longer-term view on resource utilisation may reduce the need for sudden changes in demand, saving money.Here is a list of the key goals of aggregate planning: Maximise customer satisfaction; Minimise inventory investment.

1. Limit adjustments to worker levels.
2. Reduce shifts in production rates to a minimum.
3. Make the most of the machinery and equipment.

Aggregate planning, put simply, is an effort to balance capacity and demand in a manner that keeps costs to a minimum. Planning at this level takes into account all resources "in the aggregate," such as as a product line or family. Hence, the word "aggregate."The entire

number of people, machine hours, or tonnes of raw materials are all examples of aggregate resources. Gallons, feet, pounds, as well as aggregate units used in the service sector such service hours, patients seen, etc., are examples of aggregate units of production.

DISCUSSION

Aggregate planning doesn't differentiate between different sizes, colours, features, and other things. For instance, aggregate planning in the automotive industry would take into account the overall quantity of automobiles anticipated rather than specific models, colours, or features. Equivalent units are often established when units of aggregate are difficult to define (for instance, when the variety in output is high). These comparable units could be determined by value, price, labour hours, or any other metric.

In contrast to long- or short-term planning, aggregate planning is said to be intermediate-term in nature. So, the majority of aggregate plans include coverage for three to 18 months.Future short-range planning, such production scheduling, sequencing, and loading, is built on top of aggregate plans. The aggregate plan is said to be "disaggregated" in the master production schedule (MPS) that is utilised in material requirements planning (MRP).Demand and existing capacity determination are the first steps in the process of creating an aggregate plan. Capacity is defined as the total number of units that may be produced within a given time period (this necessitates computing the average number of units as the total may comprise a product mix using significantly varied manufacturing timeframes).The total number of units required to meet demand is indicated. The company must choose whether to expand or reduce capacity to meet demand or whether to raise or decrease demand to meet capacity if the two are out of balance (unequal). There are many ways available to do this[4]–[7].Situations where demand must be raised to meet capacity include the following:

1. Costing. adjusting price to spur demand at times when it is below its peak. For instance, matinee ticket prices for movie theatres, off-season hotel rates, weekend phone rates, and pricing for goods with a seasonal demand.

2. Demand is shifted by advertising, direct marketing, and other types of promotion.

3. Reordering. Demand is transferred to a time when capacity is not fully used by delaying delivery on present orders. Actually, this is only a method of demand smoothing.By accepting reservations or scheduling appointments, service businesses may manage demand by attempting to reduce the number of walk-in clients. It's often referred to as a "partitioning" demand.

4. Developing new demand. For a good or service, a new but complementary demand is generated. Customers who are waiting at a restaurant are usually sent to the bar, a free (but not complimentary) service. Other instances include the proliferation of services at convenience shops and the installation of video arcades inside movie theatres.

5. There are many options available to adjust capacity to current demand, including: a) Hiring/firing. Businesses may maintain a balance between capacity and demand by employing more staff when needed or firing staff who aren't presently needed to fulfil demand.Businesses may temporarily boost capacity without incurring the additional cost of recruiting more employees by requesting or forcing employees to work a few more hours per day or an extra day per week.Temporary or part-time work. Using temporary workers or casual labour, which refers to employees who are deemed permanent but only work as required, on a call basis, and often do not get the same benefits as full-time employees.When demand is low, finished products inventory may be accumulated and utilised to meet demand

when demand is high. No more employees are required, no temporary or casual labour is required, and no overtime is spent in this manner.It is common for businesses to decide to let another manufacturer or service provider provide the product or service to the clients of the subcontracting business.An alternate source's temporary capacity is increased by subcontracting work to them.

Interval training

Employees with a variety of skills may be able to work in several processes, giving schedule flexibility.Other approaches. There are additional, more creative approaches that are used in industry in addition to the well-known possibilities of adjusting staff size and utilisation, inventory buildup/backlogging, and subcontracting. Sharing staff with counter-cyclical businesses and looking for engaging and fulfilling projects for employees to work on during slow periods are a few of these choices.

Aggregate Planning Strategies

The aggregate planner has access to two pure planning strategies: a level approach and a chase strategy. Businesses may decide to use one of the two separate pure strategies or a strategy that blends the two.

Level Strategy

A level strategy aims to create an overall plan that maintains a constant pace of output and/or constant level of employment. The company must increase or reduce inventory levels in anticipation of higher or lower levels of expected demand in order to meet changes in consumer demand. When demand is fairly low, the company maintains a constant labour and production pace. As a result, the company may set larger inventory levels than are now required. The business is able to maintain a constant pace of production and employment while enabling the excess inventory to meet the rising demand[8]–[10].

Using a backlog or backorder would be a second option. Simply put, a backorder is a commitment to supply the goods at a later time, often when capacity starts to catch up with falling demand. The backorder, in its simplest form, functions as a tool for shifting demand from one period to another, ideally one with lower demand, and therefore balancing demand needs across time.A level plan enables a company to fulfil demand while keeping production constant.From the perspective of employee relations, this is advantageous. The level strategy's drawbacks include the price of extra inventory, the cost of subcontracting or overtime, and the price of backorders, which is often the price of rushing orders and the resulting loss of consumer goodwill.

Chase Strategy

A chase strategy entails matching capacity and demand over time. As a consequence, there may be a significant number of hiring, firing, or layoffs of staff; insecure and disgruntled workers; higher carrying costs for inventories; conflicts with labour unions; and inconsistent use of plant and equipment. It also suggests a lot of flexibility on the part of the company. The main benefit of a chase strategy is that it enables inventory to be retained at the lowest level feasible, which may result in significant cost savings for certain businesses. The majority of businesses that use the just-in-time manufacturing concept approach aggregate planning with a chase strategy.Most businesses find it beneficial to combine the level and chase strategies. In comparison to using any of the pure methods alone, a combination strategyalso referred to as a hybrid or mixed strategycan better match organizational objectives and policies and result in cheaper costs.

Techniques for Aggregate Planning

Aggregate planning methods span from informal trial-and-error methods, which often make use of simple tables or graphs, to more formalised and sophisticated mathematical methods. Production/Operations Management by William Stevenson includes an unofficial but helpful outline-based trial-and-error technique for aggregate planning. The phases in this broad process are as follows:

1. Calculate demand for every time period.

2. Calculate each period's capacity. This capacity should be in line with demand, which may necessitate the use of overtime or subcontracting.

3. Identify any relevant corporate, departmental, or union policies. Backorder policies, overtime policies, inventory level policies, maintaining a certain safety stock level, maintaining a reasonably stable workforce, and other less explicit rules like the nature of employment with the specific industry, the potential for a bad reputation, and the loss of goodwill, are a few examples.

CONCLUSION

Organizations may gain a lot from a perpetual inventory control system in terms of precise inventory management, increased productivity, and enhanced customer service. Organisations are able to plan their production, estimate demand, and restock inventory by continually monitoring levels and transactions in real-time.

In a perpetual inventory control system, the utilisation of technology, such as barcode scanning, RFID, and inventory management software, improves the speed and accuracy of data gathering and analysis. Organisations can decrease stockouts, get rid of surplus inventory, and improve order fulfilment procedures by having real-time insight into stock levels and item availability. A perpetual inventory management system's deployment requires careful consideration of elements including data accuracy, system integration, and employee training. The advantages of increased customer happiness, simpler processes, and greater inventory accuracy, however, outweigh the drawbacks. Adopting a perpetual inventory control system enables organisations to improve inventory management, save costs, and boost supply chain effectiveness.

REFERENCES

[1] Nicole Pontius, “4 Types of Inventory Control Systems,” *Internet*, 2019.

[2] L. G. K. Dewi, N. L. P. S. Dewi, and P. A. K. D. Putri, “Analisis Pengendalian Intern Persediaan Barang Dagang Dan Penerapan Akuntansi Pada Pt. Indahwati Sari,” *Widya Akunt. dan Keuang.*, 2020, doi: 10.32795/widyaakuntansi.v2i1.538.

[3] K. L. Wasantha Perera and G. B. Wickremasinghe, “Working capital management practices of manufacturing sector companies in Sri Lanka: Survey evidence,” *Invest. Manag. Financ. Innov.*, 2010.

[4] E. Chołodowicz and P. Orłowski, “Comparison of a Perpetual and PD Inventory Control System with Smith Predictor and Different Shipping Delays Using Bicriterial Optimization and SPEA2,” *Pomiary Autom. Robot.*, 2016, doi: 10.14313/par_221/5.

[5] N. Manengkey, “Analisis Sistem Pengendalian Intern Persediaan Barang Dagang Dan Penerapan Akuntansi Pada Pt. Cahaya Mitra Alkes,” *J. EMBA J. Ris. Ekon. Manajemen, Bisnis Dan Akunt.*, 2014.

[6] E. Cholodowicz and P. Orlowski, “Impact of control system structure and performance of inventory goods flow system with long-variable delay,” *Elektron. ir Elektrotechnika*, 2018, doi: 10.5755/j01.eie.24.1.14244.

[7] G. S. Amanu and Y. Indrianingsih, “Pengembangan Sistem Pendukung Keputusan Pengadaan Dan Persediaan Barang Dengan Metode Perpetual Inventory Method Dan Economic Order Quantity (Studi Kasus□: Divisi Logistik Rumah Sakit Krakatau Medika Cilegon),” *Compiler*, 2015, doi: 10.28989/compiler.v4i1.84.

[8] L. P. VanDerLinde, “System to maximize inventory performance in a small hospital,” *Am. J. Hosp. Pharm.*, 1983, doi: 10.1093/ajhp/40.1.70.

[9] Zahari and N. Suriyani, “Analisis Perencanaan dan Pengawasan Persediaan Barang Dagang pada CV. Sumber Indoraya,” *J. Bisnis dan Corp.*, 2019.

[10] G. M. Sheppard and K. A. Brown, “Predicting inventory record-keeping errors with discriminant analysis: A field experiment,” *Int. J. Prod. Econ.*, 1993, doi: 10.1016/0925-5273(93)90006-7.

CHAPTER 11

EVOLUTION OF AGGREGATE PLANNING METHODS AND THEIR TECHNIQUES

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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. This essay examines a number of aggregation planning strategies and methodologies, such as the chase strategy, level strategy, mixed strategy, and subcontracting. The article explores the function of technology in assisting collective planning as well as the benefits, drawbacks, and issues related to each strategy. Planning for shifts in demand months in advance guarantees that production plan adjustments may be made quickly. A basic strategy for adjusting a company's production schedule in response to anticipated changes in demand is known as aggregate production planning.The company's principal objective is to match resources with anticipated demand. The attainment of this objective requires consideration of a wide range of variables, including choices on output rates, overtime, employee levels and changes, inventory levels and changes, backorders, and subcontracting labour.

KEYWORDS:

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

INTRODUCTION

Planners structure a firm's operations to react to the inescapable changes in the larger economy using economic models and forecasting studies. This is done in reaction to changes in demand in production planning.

A company's production schedule might become unstable and costly to change at the last minute. Aggregate planning methods span from informal trial-and-error methods, which often make use of simple tables or graphs, to more formalised and sophisticated mathematical methods. Here are a few common techniques:

1. Linear programming;
2. graphic/charting methods;
3. simulation

Resource Distribution

The allocation of resources is essentially what aggregate production planning is all about. A production plan, which is often just one year in the future, will guarantee a seamless transition of production capacity as demand changes over time, supposing that the plan is generally correct. Employees will adjust their own schedules and work habits to meet fluctuations in demand after they get used to these adjustments. As a result, the expense of modifying work schedules will be kept to a minimum, improving efficiency[1]–[3].

Risk of Overproduction

Planning like this lessens the possibility of overproduction. Overproduction during slumps in demand may squander resources, drive down prices, and oversaturate the market. It could also put a strain on a company's capacity to maintain and keep the created goods that have no place to go. When there is little demand, aggregate production planning scales down output. As a result, when output is reduced, the company will save money since it won't have to pay for labour that would go to waste due to low demand.

Bias and Data

They are only as excellent as the individuals who create them, just as with any plans. Biases, prejudices, and habits that come from experience and education are often present in planners.forecasting models, or misinterprets economic indicators. A production plan cannot account for shocks like an increase in oil costs, Federal Reserve policies, an increase in interest rates, or shifts in consumer confidence. As the name implies, these plans can only handle "aggregates" or averages, which are a mediocre tool for forecasting changes in demand.

Labor and Uncertainty

One of the biggest issues in planning aggregate output is still labour. For instance, a business intends to recruit more part-time employees and boost overtime hours at times of high demand. When demand is low, it will subsequently reduce hours and provide unpaid furloughs. This suggests that employees, particularly long-term ones, will grow less content with business policy and cynical about it, and they won't work as hard as they might. Furthermore, due of the ongoing uncertainty of such a production philosophy, highly skilled employees will choose alternative businesses.

The majority of aggregate models foresee changes in the labour market, which might be problematic for full-time employees. It brings uncertainties and fears into the workplace.In order to maintain operating expenses to a minimum, aggregate planning is a strategy for "intermediate-range capacity planning, typically covering a time frame of 2–12 months for a production process." Because seasonal changes in demand are difficult to anticipate with accuracy, businesses utilise aggregate planning to assist in making choices about their capacity.

Sales and operations planning is a more comprehensive version of aggregate planning. "Intermediate-range decisions to balance supply and demand, integrating financial and operations planning" are what sales and operations planning are. Demand projections, budgetary restrictions, and organisational capacity constraints are used to inform choices about sales and operations planning. The supply chain is affected by the information in the sales and operations strategy.

DISCUSSION

Operation Scheduling and Controlling

In three important respects, providing a service differs from producing a good: the people who are in need of the service are the raw material for its creation. Most services are also intangible, unique, and cannot be preserved. Due to these traits, service providers often concentrate on providing excellent customer service and consider customers to be an integral component of their business operations. Analysis of five important aspects is included in operations planning for both commodities and services.Calculating how much of a product a

company must be able to produce is necessary for capacity planning. The process of location planning includes selecting possible facility locations. Designing an effective, efficient facility is part of layout planning. Planning for quality makes ensuring that goods adhere to a company's quality requirements. Planning procedures involves establishing precise production processes and ways to carry them out.

Operation Scheduling

Actually, scheduling is concerned with determining the time and usage of resources inside a company. First, overall planning is done over a lengthy time horizon, often for 1-3 years, bearing in mind the anticipated future need of the final product. This long-term strategy is then divided into master production schedules for shorter time periods.A master production schedule is a document that contains all the necessary details on the amount and timing of various items that need to be produced. The material requirement planning system estimates secondary demand, or the demand for raw materials, components, etc., based on this. Finally, extremely short-term schedules that define the scheduling and utilization of resources inside a corporation are created.

Schedules are really the operational plans that are carried out on the work floor.Thus, schedules guarantee timely product production and delivery as well as the availability of the necessary number of resources at the moment they are really needed without causing production to stop.Similar to this, operations control is a tool used to verify that the anticipated level of output is maintained. Taking prompt corrective action in the event of any difference in order to deliver defect-free goods on schedule

Scheduling Decisions:

Complete system conversion is necessary if multiple goods are manufactured in the same facility. The cost of switching a manufacturing system's processing step from one task to another is known as the "changeover." This expense relates to changing machine settings, receiving task instructions, switching materials, and switching tools[4]–[6].When switching over, modifying the timetables also requires extreme caution. The following production system components need to be altered when there is any organizational change, in addition to operations schedules:

1. INPUTS: When a production system in an organization changes, inputs are modified in accordance with the production. raw materials, components, etc. are examples of inputs;
2. OUTPUT: When inputs are altered automatically, the production system's outputs are likewise altered;
3. LOGISTICS: As the industrial system transitions, logistics will also alter;

Sequencing:

Choosing the order in which tasks are processed is known as sequencing. Additionally, the sequence is necessary for tasks done at particular workstations. Things might become tricky if work centres are overworked and tasks take a while. When it comes to the cost of waiting to be processed and the cost of optimum time at work centers, the sequence of processing is crucial.

Operations Controlling

Operational managing is used to govern the internal operations required for short-term monitoring and management of the firm. It enables decision-making in relation to ongoing

company processes. Operational controlling's primary duties include: Results control; Liquidity planning; Profitability monitoring; Improving effectiveness of use of current resources.The operational controlling process enables the transformation of strategic plans into operational plans. These strategies need to be customized for the various parts of the business as a whole. The whole procedure often occurs during the so-called "budgeting process".Operational control often takes the form of budgetary control, which is carried out by contrasting organisational units' immediate performance with that predicted by the budget. Then, managers examine how actual values compare to the objectives that have been established for a particular unit and the whole firm.Figure 1represents the production cycle.

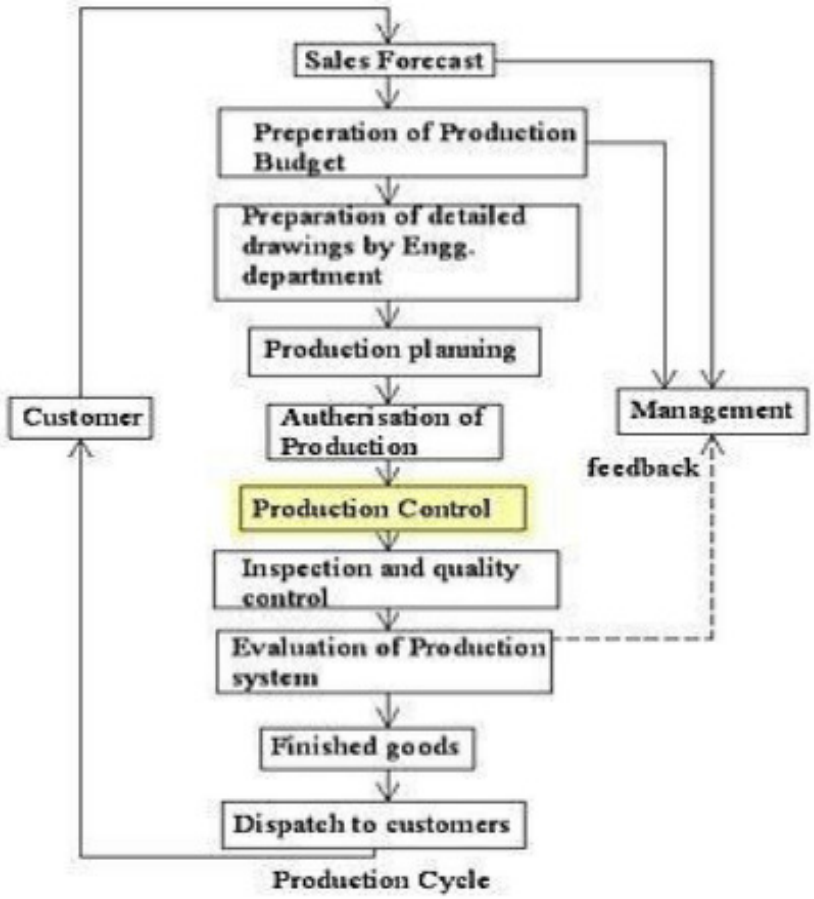

Figure 1: Represents the Production Cycle.

The production/operation control system in the aforementioned diagram is self-explanatory. The three components that make up the whole system are as follows:

1. Internal reporting framework,
2. financial management, and
3. operational planning (budgeting).

The three steps of the production control function are clear from the figure:

The planning stages

This stage deals with activities like product planning and demand forecasting based on historical patterns; This stage deals with the actual execution of the plan. The dispatching function, which is concerned with the progress of the task or job, comes first;In this stage, the scheduled activities are controlled and monitored using a variety of approaches, including

inventory control, tool control, cost control, and quality control. Reporting aids in overall process management [7]–[10].

Characteristics of Control System

The following list includes some crucial control system characteristics:

1. Control is a never-ending process.
2. Control is a function of management.
3. Each level of organisational structure incorporates control.
4. Control is a technique for completing organisational operations. Control is forward-looking. Control and planning are closely related.
5. Control is a final procedure that assesses performance against expectations.
6. Control identifies the execution process error
7. Control reduces time and effort while maximising efficiency and standardisation.

CONCLUSION

Organisations must use aggregate planning methods and strategies to match production capacity with expected demand. The choice of approach is influenced by variables such fluctuating demand, budgetary constraints, and production flexibility. The chase method includes altering output and worker levels to meet demand, which allows for more responsiveness but may result in higher labour costs.

The level plan provides stability by maintaining a constant workforce and production pace, but it may result in too much inventory. The mixed method strikes a balance between flexibility and stability by combining components of both strategies.

Another strategy that enables businesses to outsource certain production tasks to adapt to changing demand is subcontracting. Aggregate planning is more successful when using technology like advanced planning and scheduling systems and data analytics, which provide real-time data, enable scenario analysis, and speed up decision-making. Aggregate planning methods and procedures that are suited for the organisation may be chosen and put into use to optimise output, save costs, and effectively satisfy consumer expectations.

REFERENCES

[1] M. Gansterer, “Aggregate planning and forecasting in make-to-order production systems,” *Int. J. Prod. Econ.*, 2015, doi: 10.1016/j.ijpe.2015.06.001.

[2] M. R. Rosyidi and F. F. Zabadi, “Perencanaan Produksi pada Produk Hollow dengan Ukuran 15 mm X 35 mm X 0.30 mm,” *J. Rekayasa Sist. Ind.*, 2019, doi: 10.26593/jrsi.v8i1.3099.27-38.

[3] A. R. Matondang and W. Widodo, “Perencanaan Dan Pengendalian Kapasitas Produksi Produk Rakitan Radio Tipe Souness Sni 4250,” *J. Sist. Tek. Ind.*, 2018, doi: 10.32734/jsti.v20i1.383.

[4] M. Sultana, S. Shohan, and F. Sufian, “Aggregate Planning Using Transportation Method: A Case Study In Cable Industry,” *Int. J. Manag. Value Supply Chain.*, 2014, doi: 10.5121/ijmvsc.2014.5302.

[5] J. B. E. Thomas, F. S. Ramos, and F. Gröndahl, “Identifying Suitable Sites for Macroalgae Cultivation on the Swedish West Coast,” *Coast. Manag.*, 2019, doi: 10.1080/08920753.2019.1540906.

[6] N. L. Mai, E. Topal, and O. Erten, "A new open-pit mine planning optimization method using block aggregation and integer programming," *J. South. African Inst. Min. Metall.*, 2018, doi: 10.17159/2411-9717/2018/v118n7a4.

[7] K. Khalili-Damghani, A. Shahrokh, and A. Pakgohar, "Stochastic multi-period multi-product multi-objective Aggregate Production Planning model in multi-echelon supply chain," *Int. J. Prod. Manag. Eng.*, 2017, doi: 10.4995/ijpme.2017.6633.

[8] C. Boutilier, R. Dearden, and M. Goldszmidt, "Stochastic dynamic programming with factored representations," *Artif. Intell.*, 2000, doi: 10.1016/S0004-3702(00)00033-3.

[9] S. M. S. Mirzaee, S. H. Mirfakhredini, A. N. Sadrabadi, and A. M. Sharifabadi, "Compiling the strategies of alfa mining company and prioritizing them by waspas method," *Logforum*, 2020, doi: 10.17270/J.LOG.2020.473.

[10] O. Raventós and J. Bartels, "Evaluation of temporal complexity reduction techniques applied to storage expansion planning in power system models," *Energies*, 2020, doi: 10.3390/en13040988.