DOI: https://doi.org/10.46480/esj.4.2.68

Directions of Production Planning & Production Control System: Mathematical Evolution from the Flexibility Point of View

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Abstract

Production Planning and Production Control systems are some of the keys that determine the development of modern production systems. The article presents the importance of a flexibility factor in the process of manufacturing, planning, and control systems development during the 20th century. Finally, actual problems and trends in the production system design and control over the design were perceived in addition to possible feasible directions of the development of manufacturing systems, probably in the 21st century were specified. Production planning and production control are usually painstaking to be one of the most noteworthy issues in the planning and operation of a manufacturing structure. A better planning system has a significant bang on cost reduction, increased productivity, customer satisfaction, and overall spirited improvement for a product. Also, the current customer demand for prominent diversity products has put into an increase in product complications that further lay emphasis on necessitates for superior planning. Proficient planning leads to the amplification in capability exploitation competence and, therefore, thereby reducing the operational time required to intact jobs and accordingly escalating the profitability of an organization in the current spirited environment. There are different systems of manufacturing, planning, and control for a job-shop together with flow-shop in which the jobs are to be a progression through a series of machines for an optimizing number of required performance measures.

Keywords: Production Planning and Production Control, Flexibility Factor, Flexible Manufacturing System, Production System Design, Enterprise Resource Planning, Job Shop, Flow Shop.

Received: May 25, 2020
Accepted: August 22, 2020

Introduction

In the current commerce scenario, the competitiveness of every manufacturing industry is resolute by its aptitude to act in response rapidly to the rapidly varying market and to manufacture high-quality products at low costs. However, the product price tag is no longer the prime factor, heart-warming the manufacturer's insight. Other spirited factors such as flexibility, quality, efficient delivery, and customer satisfaction are drawing the identical consideration. Manufacturing industries are striving to attain these capabilities through automation, robotics, and other innovative concepts like Just-In-Time (JIT), Production Planning and Control (PPC), Enterprise Resource Planning (ERP), etc. We encompass well-thought-out the paper into two major segments. In the first segment, we present a framework for the awareness, issues, and tradeoffs involved in implementing and designing the manufacturing, planning, and control systems for accurate production planning. In the second segment, we present a very new and high customized production model from the flexibility point of view for producing consistently high-quality and cost-effective products. Flexibility is a facet that allows a mixed form manufacturing system to cope up with a definite level of variations in part or product style, without having several interruptions in a production due to changeovers between models. Flexibility determines the capability to adapt to a wide diversity of possible surroundings.

Manufacturing & Manufacturing Systems

The word was resultant from the Latin words <u>*manus*</u> (meaning 'hand') and <u>*facere*</u> (meaning 'to make') (Kalpakjian, 1995). In Late Latin, these were collective to form the word *manufactus* meaning 'made by hand' or 'hand-made.' Indeed, the word factory was resultant from the now-obsolete word *manufactory*. In its broadest and most general intellect, 'manufacturing' is defined as (DeGarmo *et al*., 1988): the conversion of stuff into things. In modern context: the production of products from raw materials using various processes, equipment, operations, and man command according to a thorough production plan. Therefore, manufacturing is 'adding value' to the raw material. The value added to the substance through processing must be superior to the cost of processing to permit the organization to formulate money or a profit. Therefore, added value can be defined (As per ICMA, 1974): the bump up in market value resulting from an amendment of the form, location, or availability of manufactured goods, exclusive of the cost of materials and services. This definition affixes the dimension of the processing being productive.

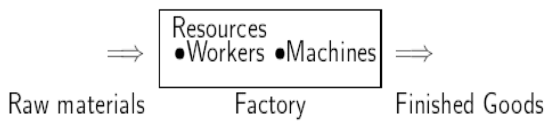

Figure 1. A Fundamental Model of a Manufacturing Process

Based on the above stated description, a 'manufacturing system' can be defined as a system in which raw materials are the progression of one form into another form, known as a product, gaining a superior, or additional value in the process and therefore creating the wealth in the figure of a return. According to Lucas Engineering, a manufacturing system is defined as (Lucas Engineering and Systems, 1992): an integrated arrangement of manufacturing processes, machine systems, people, organizational structures, information flows, control systems, and computers, whose intention is to achieve economic product manufacture and internationally spirited performance. Usually, the input/output analysis of a manufacturing system spirit is as shown in Figure 2. It can be seen from this figure that a system does not have an influence or control over all the

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How to cite: Kumar Agarwal, A., & Kumar, R. (2020). Directions of Production Planning & Production Control System: Mathematical Evolution from the Flexibility Point of View. *Ecuadorian Science Journal.* 4(2), 17-24.
DOI: https://doi.org/10.46480/esj.4.2.68

inputs, for example, social pressures. It means that the arrangement must be flexible enough to deal with using input variations (Evans, 1996).

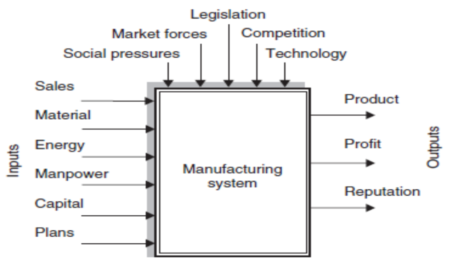

Figure 2. Inputs and outputs of a Manufacturing System

The core products of a manufacturing system are a consumer product or producer products. In some instances, the production of one manufacturing system is the input of another. Thus, there may be significant interaction between systems. Finally, it should also be illustrious that not all the outputs are tangible or assessable. For example, how is a reputation measured, although it can encompass a visible consequence on the manufacturing system?

Characteristics of a Manufacturing System

Despite the consequences of the nature of the manufacturing organization or the product life form manufactured, all manufacturing systems have several common characteristics, which are:

1. All manufacturing schemes will have specific business objectives to meet in the most cost-effective revenue.
2. All manufacture schemes consist of an integrated set of sub systems, which usually stand on functions, which comprise an association according to the material processing.
3. All manufacturing schemes must have some resources for controlling the sub-systems and the whole system.
4. To operate suitably, all manufacturing schemes need a stream of information and a decision-making process.

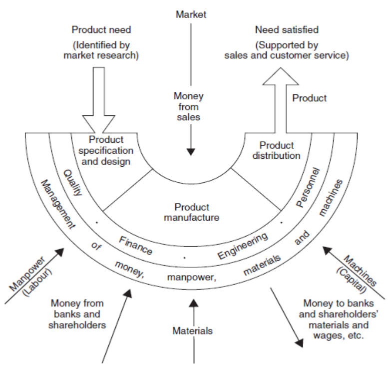

Figure 3. Sub-systems around Main Functions of a Manufacturing System

All of the exceeding must be included in the manufacturing system to permit stable operation in the rapidly changing global market in which nearly all organizations compete. Each organization has its unique manufacturing system, developed to support its specific objectives and deal with its unique individual unique troubles (Mair, G. 1993).

However, the sub-systems within each can be signifying, as shown in Figure 3. It is apparent from the figure that the sub-systems built around the main functions or departments of an organization which can be promoting busted downward.

How to Develop an Effective Manufacturing Strategy

The business strategy should be built-up to permit the organization to meet its business objectives but be flexible enough to accommodate the change. The business strategy, in turn, is used to formulate both the *marketing strategy* and the *manufacturing strategy*. Finally, the execution of these strategies will require both people and processes, like demonstrated in Figure 4. The manufacturing strategy can be explained as a long-range plan to use the resources of the manufacturing system to support the business strategy and, in turn, meet the business objectives (Cimorelli and Chandler, 1996). This strategy, in turn, has need of several decisions to be made to allow the formulation of the manufacturing strategy. Six basic decision categories that have been acknowledged and these are (Hayes and Wheelright, 1984):

i. *Capacity decision*

ii. *Process decision*

iii. *Facility decision*

iv. *Make or buy decision*

v. *Infrastructure decision*

vi. *Human resource decision*

Figure 4. Developing an Effective Manufacturing Strategy

Functions in a Manufacturing Organization

Although every manufacturing organization is unique in some respect, but there are six broad functions can be recognized in almost all manufacturing organization. The general responsibilities of these stated functions are as follows:

i. *Sales and marketing*

ii. *Engineering*

iii. *Mechanized*

-***Production planning*** with responsibility of producing manufacturing plans such as, the *Master Production Schedule* (M.P.S) and the *Materials Requirements Plan* (M.R.P).

-***Quality assurance*** whose job it is to make sure that products are being ready to the required pattern.

-***Plant maintenance*** with the responsibility of ensuring that all the equipments and the machineries are preserved at an appropriate level for its utilization.

-***Industrial engineering*** with the responsibilities includes the determination of work methods and standards, plant layouts, and expenditure estimation.

-***Manufacturing engineering*** with the responsibilities includes the development of manufacturing systems and manufacturing processes, process evaluation, and process planning.

-***Production/materials control*** who coordinates the flow of materials and job through the manufacturing plant (work-in-progress). Stores willpower generally is incorporated in this utility.

-***Production*** whose responsibility it is to actually manufacture the product.

iv. Human resource

v. Finance and account

vi. Procurement

Principle of Production, Planning & Control (PPC) System

"The highest efficiency in a production system is obtained by manufacturing the required quantity of a product, as per requirement of customer needs, at the required time by the optimum and cheapest process." PPC is a tool that coordinates all manufacturing activities in a production system. PPC fundamentally consists of planning production in manufacturing organizations before actual production activities start and exercising control activities to ensure that the designed manufacture system is recognized in terms of quantity, quality, delivery schedule, and cost of production. The variety of activities occupied in production planning are: designing the product, determining the equipment and capacity requirement, designing the layout of physical facilities, the material with material handling system, formative the sequence of manufacturing operations, and the nature of the manufacturing processes to be executed beside with the requirements and state certain production quantity and quality ranks.

Factors Determining an Effective Production Planning System

The production planning used, which varies from company to company. Production planning may commence with a product idea and a plan for the design of the product and the entire production/operating system to manufacture a desired product. It moreover includes the task of planning for the manufacturing of a modified version of an existing product using the existing facilities. The wide-ranging difference between the planning actions in one company and another is primarily due to the differences in the economic and technological conditions under which the firms operate. The three chief factors shaping production-planning procedures are:

1) The volume of Production:

The amount and an intensity of production planning are determined by the quantity and character of the operation and the nature of the manufacturing processes. Production planning is expected to reduce the manufacturing costs. The scheduling of production in the case of custom order job shop is limited to planning for the purchase of raw materials and workings and determination of work centers, which have the capacity of manufacturing the product.

2) Nature of Production Processes:

In a job shop, production planning may be informal, and the development of work methods is not there the individual worker who is highly skilled. In high volume capability production, numerous product engineers are involved, and they lay an enormous amount of their efforts into designing the product and the manufacturing processes.

3) Nature of Operation:

Detailed production planning is requisite for repetitive operation. For example, in case of continuous the manufacturing of a single standardized product. The variants in the mechanized approach are:

- Manufacturing en route for an order, this may or may not be repetitive at regular intervals.
- Manufacturing for the stock, and sale (under repetitive batch or mass production). Example: Manufacture of automobiles, watches, typewriters, etc.

4) Lead time:

The continuous process usually yields faster deliveries as compared to the batch process. Therefore, lead-time and level of competition indeed influence the choice of the production process.

5) Flexibility and Efficiency:

The manufacturing process needs to be flexible enough to adjust the contemplate changes, and the volume of production should be enormous enough to lower its production expenditures.

Objectives of a Production Planning & Control (PPC) System

The vital objective of the production plans and control, akin to that of all additional manufacturing controls, is to contribute to the earnings of an enterprise. At the same time, as with inventory management and control, this is proficient by keeping the customers satisfied throughout the meeting of delivery schedules. Explicit objectives of production planning and control are to create directions and schedules for job that will ensure the optimum utilization of materials, workers, and machines to provide the means for making sure the operation of the plant in accord with the plans. Three stages in Production Planning and Control role are:

1) **Planning:** Prefer the best course of action amongst several substitutes.
2) **Operation:** Implementation as per plan.
3) **Control:** Preserve the performance by comparing the actual results with performance standards set and taking suitable corrective action if necessary, to reduce variance.

Designed Steps of a Production Planning & Control System

Production Planning and Control is a process that comprises the performance of some critical functions on features, viz., planning as well as control. Observe the Figure 5.

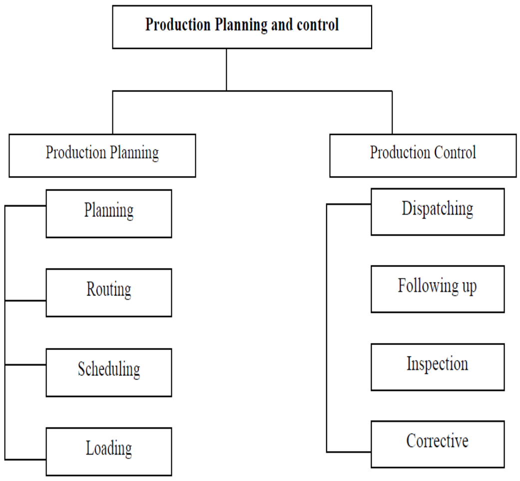

Figure 5. Designed Steps of a PPC Process

1) Production Planning:

Actual performance is then assessing with the planned performance, and, when required, a corrective action is in use. In several instances, re-planning is necessary to make sure the effective utilization of the existing manufacturing facilities, and the workforce.

(a) Planning: Production planning is defined as the technique of foreseeing every step in a prolonged series of operations, each walk to be taken at the right time. and in the right place and each process to be performed in maximum efficiency. It helps entrepreneurs to work out the quantity of material workforce, machine, and money require for producing a predetermined intensity of outputs in a specified period.

(b) Routing: Under this, the manufacturing operations, their path, and their sequence are recognized. To execute these routed operations, an appropriate class of machines and personnel required are also worked out. The central aim of routing is to determine the best and cheapest sequence of procedures and to ensure that this sequence is firmly pursued. In small enterprises, this job is frequently done by an entrepreneur himself in a rather ad-hoc manner. The routing procedure involves successive different activities.

- An analysis of the item to conclude what to make and what to purchase.
- To determine the quality and type of materials.
- They are determining the manufacturing operations and their sequence.
- A determination of lot sizes.
- Determination of scrap factors.
- An analysis of the price tag of an item.
- An organization of the production control structure.

(c) Scheduling: It means the working out of time that must be required to act upon each operation and also the time necessary to execute the entire series as routed, making allowances for all factors concerned. It mainly anxiety with the time element and priorities of customer needs. An outline of a scheduling differs from one job to another, which is enlighten as below:

Production schedule: The main intention is to schedule that amount of work, which can effortlessly be handled by plant and equipment exclusive of interference. It is not an independent decision as it takes into account the following factors.

- Physical plant facilities being designed of the class of required processing the material.
- A workforce who possesses their desired skills and experience to set in motion the equipment to execute the desired type of concerned work.
- Essential materials and acquired parts for a desired job.

Master Schedule: Scheduling usually starts with the groundwork of master schedule which is weekly or monthly break-down of the production requirements for every product for a definite period, by having this as a running record of total production requirements, an entrepreneur is in a enhanced situation to shift the production from one product to another as per the changed production requirements. Above preparation shapes a base for all subsequent scheduling activities. A master schedule is followed by a schedule operator, who fixes the total time required to do a piece of a particular job with a specified given machine or who shows the time required to do each detailed manufacturing operation of a given job with a specified given appliance or process.

Manufacturing schedule: It is prepared on the basis of type of manufacturing process involved. It is extremely valuable where single or few products are manufactured repeatedly at regular intervals. Thus, it would show the mandatory quality of each product and sequence in which the same to be activated.

Scheduling of job order manufacturing: The Scheduling attains superior significance in a job array manufacturing. This significance will enable the speedy execution of the job at each center point. As far as small scale industry is concerned, schedule is of utmost importance as it brings out efficiency in the operations and reduces cost price. The small entrepreneur should maintain four types of schedules have to close up the scrutiny of all stages namely an inquiry schedule, a production schedule, a shop schedule, and arrears schedule. Out of above four, a shop schedule is the most essential and mainly suited to the needs of small-scale industry as it enables a supervisor to see at a glance.

- The total load on a manufacturing segment.
- The operational chain.
- The stage at which any job has reached.

(d) Loading: The next step is the implementation of the schedule plan as per the route chalked out. It includes the assignment of the job work to the operators at their specified machines or workplaces. So, loading determines who will do the job as routing determines where and scheduling concludes when it shall be complete. Gantt Charts are most commonly utilized in small industries to determine the existing load on a manufacturing unit and also to foresee how quick a job can be ready. The value of their techniques lies in the fact that they compare what have been completed and what ought to have been complete. Most of a small-scale enterprise fails due to non-adherence to delivery schedules. Therefore, they can be victorious, if they can meet delivery orders in time, which no doubt depends upon the production of quality goods at the right time. It makes all the more significant for entrepreneurs to judge ahead of time what should be finished, where and when thus to leave nothing to chance once the work has begun.

2) Production Control:

Production control is the process of the production planning of manufacturing operations, launching the take out route of each spot part or assembly, setting, initial and final for each significant point, an assemblage or the final production and release the necessary orders as well as initiating the essential follow-up to have the even function of an enterprise. The production control is of a complicated environment in miniature industries. The production planning and control division can function at its best in small scale unit only when the work supervisor, the purchasing supervisor, the personnel supervisor, and the financial regulator assist in the planning of production activities. The production regulator directly reports to the works supervisor. Still, in small scale units, all the three functions, namely, material control, planning, and control, are frequently performed via an entrepreneur himself as production control starts with dispatching and ends up with remedial procedures.

(a) Dispatching: Dispatching involves the release of the production orders on behalf of the groundwork of the operations. Necessary authority and conformation be specified for:

- Movement of the materials to particular workstation(s).
- Movement of the tools and the fixtures compulsory for the chase of everyone operation.
- Beginning of work on each operation.
- Recording of time, alongwith the expenditures involved in each operation.
- Movement of work since one operation to a new in accordance with the route sheet.
- Inspecting or supervision of work.

Dispatching is a very essential step as it translates production plans into production.

(b) Following up: Every production program involves the determination of the progress of work, removing bottlenecks in the flow of job along with making sure that the production operations are taking place by the plans. It spots delays or deviations from the production plans. It assists to reveal detects in routing and scheduling, misunderstanding of orders and instructions, under loading or overloading of work, etc. All problems or deviations are inspecting, and remedial measures are commenced on the way to make sure of the completion of work by the planned date.

***(c)* Inspection:** This is mainly to make sure of the quality of goods. It can be required for a valuable organization of production control.

***(d)* Corrective measures:** Corrective action may engage some of those activities of adjusting the route, rescheduling of work altering the workloads, repairs, and maintenance of machinery or equipment, control over inventories of the cause of the deviation is the poor performance of the employees. Convinced personnel decisions like training, transfer, demotion, etc. may have to be taken. Alternate methods may be possible towards the grip peak loads.

Measurement of the Effectiveness of a Production Planning & Control (PPC) System

In determining the effectiveness of a production planning and control system, there are relatively few problems. The key criterion might well be whether or not shipping promises are being situate aside the percentage of the order shipped on time. This key criterion, however, would not be factual if excessive overtime of expediting costs were involved in receipt of any of these orders shipped. The cost of a control system about the worth of goods shipped is another possibility. Again, however, this might not be sound: if markets break down, a shocking ratio will grow. Many high-quality production planning and control systems have been discontinued because of "high costs" under these conditions and have never revived after business protest up. In a study of profits and operating cost of a computerized production scheduling along with its control systems, (Schroeder et al.) record the following performance criterion by which production planning and control systems may be evaluated:

- An inventory turnover
- The delivery lead time
- The percent of time meeting with delivery promises
- The percent of orders requiring "splits" for the reason that of unavailable material.
- The number of expeditors.
- An average unit price tag.

Evolution of a Flexibility (A Mixed Model Manufacturing System) Term

The term, Flexibility, is an attribute that allows a mixed model manufacturing system to cope up with a certain intensity of variations in a part or in a product approach, without having any interruption in production due to changeovers between models. Flexibility measures the ability to adapt "to a wide range of possible environment." En route for flexible, a manufacturing system is required to possess the subsequent capabilities:

- Identification of the different production units to achieve the correct operation.
- A quick changeover of operating instructions to the computer-controlled production machines.
- A quick changeover of physical setups of fixtures, tools, and other operational units.

The reason, the FMS is called flexible system, is that system could be capable of processing a variety of diverse part styles concurrently with the quick tooling and the instruction changeovers. Also, amounts of production can be adjusted easily to changing demand patterns. Generally, flexibility means the ability of a system to respond to the potential internal or external changes affecting its delivery value in a timely and cost-effective way (Sethi A. K. et al.). Thus, flexibility for an engineering proposal is the ease with which the system can respond to uncertainty in a mode to sustain or increase its value delivery. Ambiguity is an element in the definition of a flexibility term. An ambiguity can create risk collectively, and opportunities in a system, and it is with the existence of uncertainty that flexibility becomes precious (Fulkerson B). Diverse approaches to flexibility, along with their meanings, are exposed in Tab. 1.

Table 1. Different approaches to Flexibility along with their meanings (Koste, L et al.)

Approach	Flexibility meaning
Manufacturing	• The capability of producing different parts without major retooling • A measure of how fast the company converts its process or processes from making and old line of products to produce a new product • The ability to change a production schedule, to modify a part, or to handle multiple parts
Operational	• The ability to efficiently produce highly customized and unique products
Customer	• The ability to exploit various dimension of speed of delivery
Strategic	• The ability of a company to offer a wide variety of products to its customers
Capacity	• The ability to rapidly increase or decrease production levels or to shift capacity quickly from one product or service to another

When taking into account the problem of flexibility in design of various manufacturing systems, it is feasible to distinguish three different points of a manufacturing flexibility (USA Patent):

i. Basic flexibilities:

(a) Machine flexibility: ease with which a machine can acquire various operations.

(b) Material handling flexibility: a measure of an ease with which different part types can be transported and suitably placed at the special machine tools in a system.

(c) Operation flexibility: a measure of the ease with which alternative operation sequences can be developed for processing an element style.

ii. System flexibilities:

(a) Volume flexibility: determinations of a system's capability to be operate profitably at unusual volumes of existing element categories.

(b) Expansion flexibility: the facility to compose a system and expand it incrementally.

(c) Routing flexibility – a compute of the alternative paths that a component can effectively follow through a system in favor of a prearranged process plan.

(d) Process flexibility – quantify the volume of the set of element types that the system can produce without incurring the system.

(e) Product flexibility: the volume of the element types that can be authentic manufactured in a system with the minute arrangement.

iii. Aggregate flexibilities:

(a) Program flexibility: the ability of a system to sprint for reasonably long periods without an exterior interference.

(b) Production flexibility: the capacity of the set of part types that a system can produce without the investment in capital tools,

(c) Market flexibility: the capability of a system to proficiently adapt to the changing market environment.

Different Types of Flexible Manufacturing Systems

1) Craft manufacturing system:

This type of production is not essential from the mechanized system's design point of view. In craft manufacturing, it is hard to converse manufacturing systems, but it is very striking when focusing on the task of flexibility. A craft manufacturing used high skilled workers and straightforward but flexible tools to produce goods precisely desired by customers. Most often, it was a unique product. Examples of products are furniture made against specific order, decoration elements, or sports cars. Generally, even at the present, people like the ideas of craft manufacturing. Still, this method of production is associated with one noticeable problem: goods made by craftsmen are rather limited commodities, and for most people, these are too expensive (Womack, J. P. et al.). It can be fulfilled as this method was, on the other hand, very flexible, but on the other hand, very expensive.

2) Dedicated manufacturing systems (DMSs):

The conception of mass production was introduced by Henry Ford, which contributes to the development of the dedicated manufacturing systems which commonly appear in two types (Everett, E. A.):

(i) Continuous manufacturing systems: In continuous manufacturing systems, each production manufactures in large lot sizes, and the production progression is going on within a definite sequence of operations in a pre-determined order. First, in first out, priority rules are chased within the system. In short, here, the input and output characteristics are standardized, intending for homogeny of progression and their succession chain. In this system, the products are produced for the stocks and not for specific orders. For proceeding to the planned manufacturing to store, a sales forecast is prepared to estimate likely demand of the product along with a master schedule. A master schedule is arranged towards the adjustment of the sales forecast according to the past orders and level of inventory. Due to this, routing and scheduling for the whole process can be standardized.

(ii) Intermittent manufacturing systems: In this system, the commodities are manufactured, especially to fulfil the orders made by customers rather than for stock. At this point, the stream of material is intermittent. Intermittent production systems are those where the production facilities are more flexible enough to handle a wide variety of products and product sizes. These can be consuming to manufacture those goods wherever the fundamental character of inputs changes with the change in the design of the product, and the production process requires continuous adjustments. A considerable storage between the operations is mandatory so that entity operations can be processed out independently intended for further utilization of the men and the machines.

3) Flexible manufacturing systems (FMSs):

A Flexible Manufacturing System (FMS) is a group of numerically controlled machine tools, interrelated by a central control system. A variety of machining cells are interconnected, via loading and unloading stations, through an automated transport system. Operational flexibility is an improving ability to execute all manufacturing tasks on numerous product designs in small quantities and with faster a release (Warnecke, H. J. et al.). It has been described as an automated job shop and as a miniature automated factory. In other words, FMS is a programmed production system with the intention of the production of one or more element families in a flexible mean (Chen, J. H. et al.).

FMSs are still leaning to produce a large variety of parts in small extents in addition to they are painstaking to react to most of the possible product changes. Unfortunately, the investment to acquire FMS is very far above the ground, and it considerably affects the operational cost to produce a part; indeed, its flexibility is frequently too high and expensive for the needs of a producer of parts.

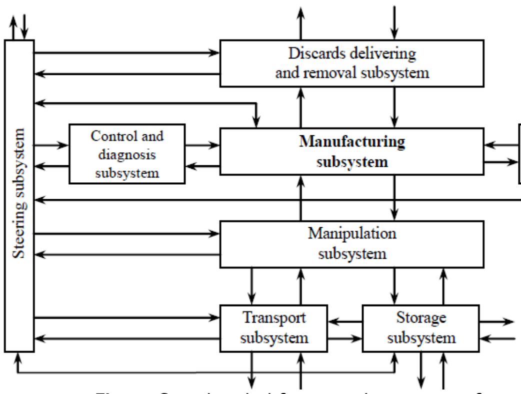

Figure 6: A detailed functional structure of an FMS

The prominent financial and organizational bang of FMSs has reduced their diffusion in the past; indeed, the initial outlay is so high it strictly strains the financial resources of the firms.

4) Reconfigurable manufacturing systems (RMS):

The RMS's key goal can sum up from the statement – *Exactly the capacity and functionality needed, exactly when needed.* A reconfigurable manufacturing system (RMS) having an amendable structure is designed based upon market demand. It can be willingly changed from a first desired production capacity to a second desired production capacity to manufacture a preferred amount of product from a family of products (USA Patent). In general, reconfigurable manufacturing systems are designed at the beginning for rapid change in arrangement, like within the hardware along within the software components, to quickly adjust production capacity and functionality within a part family in response to unexpected changes in the market or regulatory necessities (Koren, Y. et al.). A system typically includes a plurality of workstations, including reconfigurable machines. A system as well contains a control system including an operation location (Tolio, T.) and reconfigurable controllers for controlling the reconfigurable equipment. An operator station is in communication with the reconfigurable controllers, and the reconfigurable regulators (Terkaj, W. et al.) are in correspondence with each other. As distinguished from flexible manufacturing systems (FMSs), the RMS has the structure which allows for rapid adjustment of manufacture capability and functionality, in response to new market circumstances, by basic amend of its hardware along with its software components. So, while the structure of DMSs and FMSs is static, RMSs be dynamic with the level of flexibility, capacity, and functionality directly fulfilling the needs of the manufacturing system in any moment of its life.

5) Focused Flexible manufacturing systems (FFMSs):

The required level of system flexibility impacts the structural design of the manufacturing system, along with the open design of flexibility often leads to hybrid systems, i.e. automated, integrated systems in which parts can operate by both general-purpose and committed machinery (Tolio, T). These hybrid systems are the base issues of FFMSs and results from the matching of flexibility and productivity that characterize both FMSs, and DMSs, respectively. FFMSs are hybrid systems, in the logic that they can compose both of general-purpose and dedicated assets (Terkaj, W. et al.). This innovative design derives from the reflection that system flexibility is related both to the flexibility of every single selected resource and to the interaction among the resources which composed the system. For an instance, a flexible system consists of intense machines and highly flexible carries. At first sight, FFMSs could appear to be similar to Reconfigurable Manufacturing Systems (RMSs). The differentiation between these two modules of manufacturing systems is in their flexibility acquisition timings. When deciding about flexibility and reconfigurability, we have to consider two different options. The first option deals with proposing a committed scheme in which the reconfiguration option can implement in the nearby future when production changes arise. This option leads to the blueprint of a system with the minimum level of flexibility required to cope with the present production problem. In this case, FFMSs and RMSs have identical performance. The alternative option is to obtain more flexibility than the quantity strictly required by the current production problem to avoid future arrangement reconfigurations and ramp-ups. In this case, FFMSs have a little "extra" flexibility planned on the way to cope up with the future production changes, i.e., degree of elasticity intended to supervise with future production changes, i.e., a degree of elasticity tuned both on present and future production problems.

Table 2. Comparison of various varieties of Flexible Manufacturing Systems

	DMS	FMS	FFMS	RMS
System structure	Fixed	Changeable	Changeable	Changeable
Machine structure	Fixed	Fixed	Fixed	Changeable
System focus	Part	Machine	Machine	Part family
Scalability	No	Yes	Yes	Yes
Flexibility	No	General	Focused	Customized
Simultaneously operating tools	Yes	No	No	Possible
Productivity	Very high	Low	Average	High
Cost per part	Low	Reasonable	Medium	Medium
Cost of investment	Average	Very high	Average	High

Conclusion & Expected Future Scope

At present days, the manufacturing flexibility has a strategic liability for firms those want to compete in a reactive or proactive means. The ability to design the production systems whose flexibility degree is custom-made on the present production problems and at the same time, it takes into account future product evolutions, and can lead to competitive advantages. From the scientific perspective, focusing on the flexibility of a production system on specific needs represents a challenging problem. Indeed, the customization of system flexibility provides economic advantages in terms of system investment costs. Still, on the supplementary hand, amendment in the production problems reduces some of the safety margins, which allow decoupling the various design phases of a manufacturing system. Therefore, manufacturing system flexibility must streamline, and it is necessary to find out the best trade-off between productivity and flexibility by optimum designing of manufacturing systems, which are capable with the exact level of flexibility as required by the production troubles. During consequences, from the point of view of a designer of modern manufacturing systems, further research may be conducted to explore the:

- The philosophy of FFMS and RMS proper for modern companies
- Which of commencement – FFMS or RMS is much appropriate for the defined company?
- How to define the desired level of flexibility of a system?
- Which of the types of flexibility are the mainly important in the whole process of system design?
- How to forecast the approach of development of manufactured parts?
- How en route for plan in addition to optimize the cost of the manufacturing system in its lifecycle?

Acknowledgment

Inspiration and guidance are invaluable in all aspects of life, especially when it is academic. I acknowledge my gratitude to all those who have given me timely help me in completing my research. I am highly obliged to Dr. Rakesh Kumar for guiding me for my learning and in allowing me to write this research paper.

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