

Manufacturing System: Flexibility Perspective

Rajan Garg¹, Vineet Kumar²

¹Research Scholar (Pre-PhD), Mechanical Engineering Department, U.I.E.T, MDU, Rohtak, Haryana, India

²Professor & Head, Mechanical Engineering Department, U.I.E.T, MDU, Rohtak, Haryana, India

Abstract—Manufacturing, Planning and Control systems are one of the key that determine development of modern production systems. The article presents the importance of flexibility factor in the process of manufacturing, planning & control systems development during the 20th century. Finally, actual problems and trends in production system design and control over the design were noticed and probable directions of development of manufacturing systems in 21st century were indicated. Production planning & control are generally considered to be the one of the most significant issue in the planning and operation of a manufacturing system. Better planning system has significant impact on cost reduction, increased productivity, customer satisfaction and overall competitive advantage. In addition, recent customer demand for high variety products has contributed to an increase in product complexity that further emphasizes the need for improved planning. Proficient planning leads to increase in capacity utilization efficiency and hence thereby reducing the time required to complete jobs and consequently increasing the profitability of an organization in present competitive environment. There are different systems of manufacturing, planning & control including flow-shop in which jobs are to be processed through series of machines for optimizing number of required performance measures.

Keywords—PPC, ERP, MPS, MRP, FMS, DMS, FFMS, RMS etc.

I. INTRODUCTION

In the current business scenario the competitiveness of any manufacturing industry is determined by its ability to respond quickly to the rapidly changing market and to produce high quality products at low costs. However, the product cost is no longer the predominant factor affecting the manufacturers' perception. Other competitive factors such as flexibility, quality, efficient delivery and customer satisfaction are drawing the equal attention. Manufacturing industries are striving to achieve these capabilities through automation, robotics and other innovative concepts such as just-in-time (JIT), Production planning and control (PPC), enterprise resource planning (ERP) etc. We have organized the paper into two major sections. In the first section we present a framework for the awareness, issues and tradeoffs involved in implementing & designing of manufacturing, planning and control systems for accurate production planning. In the second section we present very new and high customized production model from flexibility point of view for producing consistently good quality and cost effective products. Flexibility is an attribute that allows a mixed model manufacturing system to cope up with a certain level of variations in part or product style, without having any interruption in production due to changeovers between models.

Flexibility measures the ability to adapt “to a wide range of possible environment”.

II. MANUFACTURING & MANUFACTURING SYSTEMS

The word was derived from the Latin words *manus* (meaning ‘hand’) and *facere* (meaning ‘to make’) [2]. In Late Latin, these were combined to form the word *manufactus* meaning ‘made by hand’ or ‘hand-made’. Indeed, the word factory was derived from the now obsolete word *manufactory*. In its broadest and most general sense, ‘manufacturing’ is defined as [1]: the conversion of stuff into things. In modern context: the making of products from raw materials using various processes, equipment, operations and man power according to a detailed plan. Therefore, manufacturing is ‘adding value’ to the material. The value added to the material through processing must be greater than the cost of processing to allow the organization to make money or a profit. Therefore, added value can be defined as [3]: the increase in market value resulting from an alteration of the form, location or availability of a product, excluding the cost of materials and services. This definition adds the dimension of the processing being cost-effective.

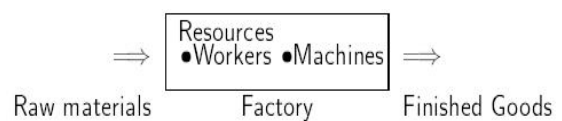


Fig. 1 Basic model of manufacturing.

Based on the above definition, a ‘manufacturing system’ can be defined as: a system in which raw materials are processed from one form into another, known as a product, gaining a higher or added value in the process and thus creating wealth in the form of a profit. According to Lucas Engineering manufacturing system is defined as [4]: an integrated combination of processes, machine systems, people, organizational structures, information flows, control systems and computers whose purpose is to achieve economic product manufacture and internationally competitive performance. Generally, the input/output analysis of a manufacturing system will be as shown in Fig. 2. It can be seen from this that the system does not have an influence or control over all the inputs, for example, social pressures. This means that the system must be flexible enough to deal with input variations [5].

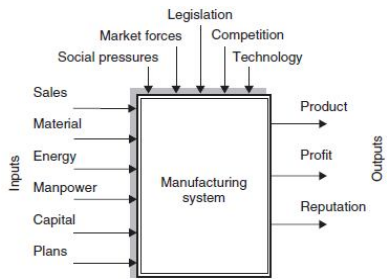


Fig. 2 Inputs and outputs of a manufacturing system

The main output of the manufacturing system is obviously the consumer product or producer products. In some instances, the output of one manufacturing system is the input of another. Thus, there may be considerable interaction between systems. Finally, it should also be noted that not all the outputs are tangible or measurable. For example, how is reputation measured although it can have a marked effect on the manufacturing system?

III. CHARACTERISTICS OF MANUFACTURING SYSTEM

Regardless of the nature of the manufacturing organization or the product being manufactured, all manufacturing systems have a number of common characteristics, which are:

- All systems will have specific business objectives to meet in the most cost-effective manner.
- All systems consist of an integrated set of sub-systems, usually based on functions, which have to be linked according to the material processing.
- All systems must have some means of controlling the sub-systems and the overall system.
- To operate properly, all systems need a flow of information and a decision-making process.

All of the above must be incorporated into the manufacturing system to allow stable operation in the rapidly changing global market in which most organizations compete. Each organization has its own unique manufacturing system, developed to support its specific objectives and deal with its own unique problems [6].

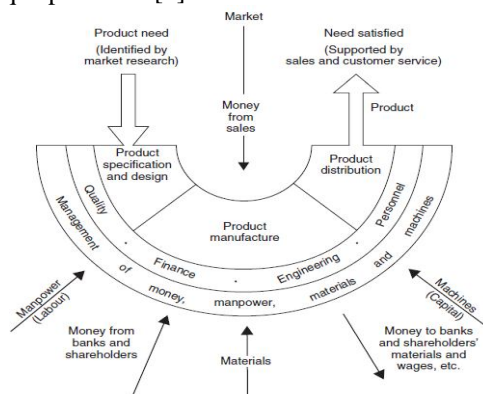


Fig. 3 The manufacturing system

However, the sub-systems within each can be represented as shown in Fig. 3. It is clear from the figure that the sub-systems are built around the main functions or departments of the organization and these can be further broken down.

IV. HOW TO DEVELOP MANUFACTURING STRATEGY

The business strategy should be developed to allow the organization to meet its business objectives but be flexible enough to accommodate change. The business strategy in turn is used to formulate both the *marketing strategy* and the *manufacturing strategy*. Finally, the implementation of these strategies will require people and processes as illustrated in Fig. 4. The manufacturing strategy can be defined 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 [7]. This in turn requires a number of decisions to be made to allow the formulation of the manufacturing strategy. Six basic decision categories have been identified and these are [8]:

- *Capacity decision*
- *Process decision*
- *Facility decision*
- *Make or buy decision*
- *Infrastructure decision*
- *Human resource decision*



Fig. 4 Developing a manufacturing strategy.

V. FUNCTIONS IN MANUFACTURING ORGANIZATION

Although every manufacturing organization is unique in some respect, there are six broad functions that can be identified in almost any manufacturing organization. These are sales and marketing, engineering, manufacturing, human resources, finance and accounts and purchasing. The general responsibilities of these functions are as follows:

- *Sales and marketing*
- *Engineering*
- *Manufacturing*

A. Production planning

With responsibility for producing manufacturing plans such as the master production schedule (MPS) and the materials requirements plan (MRP).

B. Quality assurance

Whose job it is to ensure that products are being made to the required specification.

C. Plant maintenance

With the responsibility of ensuring that all equipment and machinery maintained at an appropriate level for its use.

D. Industrial engineering

Whose responsibilities include the determination of work methods and standards, plant layouts and cost estimates?

E. Manufacturing engineering

Whose responsibilities include manufacturing systems development, process development, process evaluation and process planning?

F. Production/materials control

Who coordinate the flow of materials and work through the manufacturing plant (work-in-progress). Stores will usually be included in this function.

Production whose responsibility it is to physically make the product.

- *Human resource*
- *Finance and account*
- *Purchasing*

VI. PRINCIPLE OF MANUFACTURING, PLANNING & CONTROL

The highest efficiency in production is obtained by manufacturing the required quantity of a product, of the required quality, at the required time by the best and cheapest method. PPC is a tool coordinates all manufacturing activities in a production system. PPC essentially consists of planning production in manufacturing organization before actual production activities start and exercising control activities to ensure that the planned production is realized in terms of quantity, quality, delivery schedule and cost of production. The various activities involved in production planning are: designing the product, determining the equipment and capacity requirement, designing the layout of physical facilities and material and material handling system, determining the sequence of operations and the nature of the operations to be performed along with the requirements and specifying certain production quantity and quality levels.

VII. FACTORS EFFECTING PRODUCTION PLANNING

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

A. Volume of Production

The amount and intensity of production planning is determined by, the volume and character of the operation and the nature of the manufacturing processes. Production planning is expected to reduce manufacturing costs. The planning of production in case of custom order job shop is limited to

planning for purchase of raw materials and components and determination of works centres, which have the capacity of manufacturing the product.

B. Nature of Production Processes

In job shop, the production planning may be informal and the development of work methods is left to the individual workman who is highly skilled. In high volume production, many product engineers are involved and they put enormous amount of effort in designing the product and the manufacturing processes.

C. Nature of operations

Detailed production planning is required for repetitive operation. For example in case of continues production of a single standardized product. The variants in manufacturing approach are:

- Manufacture to order, which may or may not be repeated at regular intervals.
- Manufacturing for stock and sell (under repetitive batch or mass production). Example: Manufacture of automobiles, watches, typewriters etc.

D. Lead Time

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

E. Flexibility and efficiency

The manufacturing process needs to be flexible enough to adapt contemplated changes and volume of production should be large enough to lower costs.

VIII. OBJECTIVES OF PRODUCTION PLANNING & CONTROL

The ultimate objective of production planning and control, like that of all other manufacturing controls, is to contribute to the profits of the enterprise. As with inventory management and control, this is accomplished by keeping the customers satisfied through the meeting of delivery schedules. Specific objectives of production planning and control are to establish routes and schedules for work that will ensure the optimum utilization of materials, workers, and machines and to provide the means for ensuring the operation of the plant in accordance with the plans. Three stages in Production Planning and Control function are:

A. Planning

To choose the best course of action among several alternatives.

B. Operation

Execution as per plan.

C. Control

To maintained the performance by comparing the actual results with performance standards set and taking appropriate correction action if necessary to reduce variance.

IX. DESIGNED STEPS OF PRODUCTION PLANNING & CONTROL

Production Planning and Control is a process that comprises the performance of some critical; functions on either side, viz., planning as well as control. See Fig. 5. Actual performance is then compared to the planned performance, and, when required, corrective action is taken. In some instances re-planning is necessary to ensure the effective utilization of the manufacturing facilities and personnel.

A. Production Planning:

B. Production Control:

1) *Planning*: Production planning may be defined as the technique of foreseeing every step in a long series of separate operations, each step to be taken at the right time and in the right place and each operation to be performed in maximum efficiency. It helps entrepreneur to work out the quantity of material manpower, machine and money requires for producing predetermined level of output in given period of time.

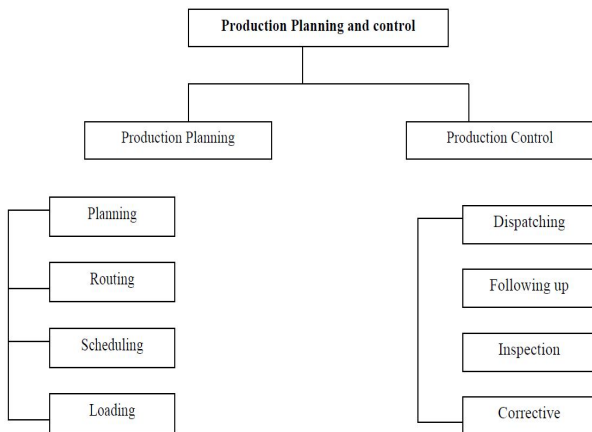


Fig. 5 PPC Process

2) *Routing*: Under this, the operations, their path and sequence are established. To perform these operations the proper class of machines and personnel required are also worked out. The main aim of routing is to determine the best and cheapest sequence of operations and to ensure that this sequence is strictly followed. In small enterprises, this job is usually done by entrepreneur himself in a rather adhoc manner. Routing procedure involves following different activities.

- An analysis of the article to determine what to make and what to buy.
- To determine the quality and type of material
- Determining the manufacturing operations and their sequence.
- A determination of lot sizes.
- Determination of scrap factors.
- An analysis of cost of the article.
- Organization of production control forms.

3) *Scheduling*: It means working out of time that should be required to perform each operation and also the time

necessary to perform the entire series as routed, making allowances for all factors concerned. It mainly concerns with time element and priorities of a job. The pattern of scheduling differs from one job to another which is explained as below:

3.1) *Production schedule*: The main aim is to schedule that amount of work which can easily be handled by plant and equipment without interference. It is not independent decision as it takes into account following factors.

- Physical plant facilities of the type required to process the material being scheduled.
- Personnel who possess the desired skills and experience to operate the equipment and perform the type of work involved.
- Necessary materials and purchased parts.

3.2) *Master Schedule*: Scheduling usually starts with preparation of master schedule which is weekly or monthly break-down of the production requirement for each product for a definite time period, by having this as a running record of total production requirements the entrepreneur is in better position to shift the production from one product to another as per the changed production requirements. This forms a base for all subsequent scheduling acclivities. A master schedule is followed by operator schedule which fixes total time required to do a piece of work with a given machine or which shows the time required to do each detailed operation of a given job with a given machine or process.

3.3) *Manufacturing schedule*: It is prepared on the basis of type of manufacturing process involved. It is very useful where single or few products are manufactured repeatedly at regular intervals. Thus it would show the required quality of each product and sequence in which the same to be operated.

3.4) *Scheduling of job order manufacturing*: Scheduling acquires greater importance in job order manufacturing. This will enable the speedy execution of job at each center point. As far as small scale industry is concerned scheduling is of utmost importance as it brings out efficiency in the operations and s reduces cost price. The small entrepreneur should maintain four types of schedules to have a close scrutiny of all stages namely an enquiry schedule, a production schedule, a shop schedule and an arrears schedule out of above four, a shop schedule is the most important most suited to the needs of small scale industry as it enables a foreman to see at a glance.

- The total load on any section.
- The operational sequence.
- The stage, which any job has reached.

4) *Loading*: The next step is the execution of the schedule plan as per the route chalked out it includes the assignment of the work to the operators at their machines or work places. So loading determines who will do the work as routing determines where and scheduling determines when it

shall be done. Gantt Charts are most commonly used in small industries in order to determine the existing load and also to foresee how fast a job can be done. The usefulness of their technique lies in the fact that they compare what has been done and what ought to have been done. Most of a small scale enterprise fail due to non-adherence to delivery schedules therefore they can be successful if they have ability to meet delivery order in time which no doubt depends upon production of quality goods in right time. It makes all the more important for entrepreneur to judge ahead of time what should be done, where and when thus to leave nothing to chance once the work has begun.

B. Production Control

Production control is the process of planning production in advance of operations, establishing the exact route of each individual item part or assembly, setting, starting and finishing for each important item, assembly or the finishing production and releasing the necessary orders as well as initiating the necessary follow-up to have the smooth function of the enterprise. The production control is of complicated nature in small industries. The production planning and control department can function at its best in small scale unit only when the work manager, the purchase manager, the personnel manager and the financial controller assist in planning production activities. The production controller directly reports to the works manager but in small scale unit, all the three functions namely material control, planning and control are often performed by the entrepreneur himself production control starts with dispatching and ends up with corrective actions.

1) *Dispatching*: Dispatching involves issue of production orders for starting the operations. Necessary authority and conformation is given for:

- Movement of materials to different workstations.
- Movement of tools and fixtures necessary for each operation.
- Beginning of work on each operation.
- Recording of time and cost involved in each operation.
- Movement of work from one operation to another in accordance with the route sheet.
- Inspecting or supervision of work

Dispatching is an important step as it translates production plans into production.

2) *Following up*: Every production programme involves determination of the progress of work, removing bottlenecks in the flow of work and ensuring that the productive operations are taking place in accordance with the plans. It spots delays or deviations from the production plans. It helps to reveal defects in routing and scheduling, misunderstanding of orders and instruction, under loading or overloading of work etc. All problems or deviations are investigated and

remedial measures are undertaken to ensure the completion of work by the planned date.

3) *Inspection*: This is mainly to ensure the quality of goods. It can be required as effective agency of production control.

4) *Corrective measures*: Corrective action may involve any of those activities of adjusting the route, rescheduling of work changing the workloads, repairs and maintenance of machinery or equipment, control over inventories of the cause of deviation is the poor performance of the employees. Certain personnel decisions like training, transfer, demotion etc. may have to be taken. Alternate methods may be suggested to handle peak loads.

X. MEASUREMENT OF EFFECTIVENESS

In determining the effectiveness of a production planning and control system, there are quite a few problems. The key criterion might well be whether or not shipping promises are being kept the percentage of the order shipped on time. This, however, would not be a true criterion if excessive overtime of expediting costs were involved in getting any of these orders shipped. The cost of the control system in relation to the value of goods shipped is another possibility. Again, however, this may not be sound: if markets slump, a bad ratio will develop. Many good production planning and control systems have been discontinued because of "high costs" under these conditions- and have never revived after business picket up. In a study of benefits and costs of computerized production planning and control systems [9] list the following performance criteria by which production planning and control systems might be judged:

- Inventory turnover
- Delivery lead time
- Percent of time meeting delivery promises
- Percent of orders requiring "splits" because of unavailable material.
- Number of expeditors.
- Average unit cost.

XI. EVOLUTION OF FLEXIBILITY

The first Flexible Manufacturing System named "System24" was introduced in England in 1960. It was designed to produce light flat alloy components. Manufacturing flexibility is a major factor in development of production system. It also determines the level of competitiveness of manufacturing units and the ability of flexible production of goods compatible with the requirements of customers. The reason, the FMS is called flexible, is that it is capable of processing a variety of different part styles simultaneously with the quick tooling and instruction changeovers. Also, quantities of productions can be adjusted easily to changing demand patterns. Generally flexibility means ability of a system to respond to potential internal or external changes affecting its value delivery, in a timely and

cost-effective manner [9]. Flexibility measures the ability to due to changeovers adapt “to a wide range of possible environment”. To be flexible, a manufacturing system must possess the following capabilities:

- Identification of the different production units to perform the correct operation.
- Quick changeover of operating instructions to the computer controlled production machines.
- Quick changeover of physical setups of fixtures, tools and other working units.

The reason, the FMS is called flexible, is that it is capable of processing a variety of different part styles simultaneously with the quick tooling and instruction changeovers. Also, quantities of productions can be adjusted easily to changing demand patterns. Generally flexibility means ability of a system to respond to potential internal or external changes affecting its value delivery, in a timely and cost-effective manner [9]. Uncertainty can create both risk and opportunities in a system, and it is with the existence of uncertainty that flexibility becomes valuable [10]. When taking into account the problem of flexibility in the process of manufacturing systems design it is possible to distinguish three levels of manufacturing flexibility [12]:

A. Basic flexibilities

1) *Machine flexibility*: the ease with which a machine can possess various operations.

2) *Material handling flexibility*: Different part types can be transported and positioned properly at various machine tools in a system.

3) *Operation flexibility*: Alternative operation sequences can be used for a processing part type.

B. System flexibilities

1) *Volume flexibility*: a measure of a system’s capability to be operated profitably at different volumes of existing part types.

2) *Expansion flexibility*: the ability to build a system and expand incrementally.

3) *Routing flexibility*: the alternative paths that a part can effectively follow through a system for a given process plan.

4) *Process flexibility*: the volume of the set of part types that system can produce without incurring any setup.

5) *Product flexibility*: the volume of the set of part types that can be manufactured in a system with minor setup.

C. Aggregate flexibilities

1) *Program flexibility*: the ability of a system to run for reasonably long periods without external intervention.

2) *Production flexibility*: the volume of the set of part types that a system can produce without major investment in capital equipment.

3) *Market flexibility*: the ability of a system to efficiently adapt to changing market conditions.

XII. DIFFERENT TYPES OF FLEXIBLE SYSTEMS

A. Craft manufacturing system

The craft production is a method of creating goods by hand, often with simple tools. This type of one-off production was widely used prior to the industrial revolution, and is still practiced around the world. Unlike mass production, craft production results in items that are each unique in small ways, since they are made by hand one at a time. Craft produced goods can vary in quality, though they are often thought to have higher production values than mass produced versions. It is often possible for a craftsman to achieve certain effects or levels of detail using techniques that are not viable in mass production. Goods made by craftsmen are rather exclusive goods and for most people these are too expensive [13]. The automotive industry is one example that began with craft production but moved to mass production. When each automobile was a craft built product, new replacement parts needed to be created specific to each vehicle. This made owning and maintaining an automobile very expensive and led to the industry-wide adoption of mass production techniques. It can be concluded that this method was in other hand very flexible, but on the other hand very expensive.

B. Dedicated manufacturing system(DMS's)

The conception of mass production introduced by Henry Ford, contributes to development of dedicated manufacturing systems which generally appear in two forms [14]. Dedicated manufacturing lines (DML) are based on fixed automation and produce a company’s core products or parts at high-volume. Each dedicated line is typically designed to produce a single part (e.g., specific engine block) at high production rate. When the volume is high, the cost per part is relatively low. Therefore, DMSs are cost effective as long as market demand matches the supply; but with increasing pressure from global competition, there are many situations in which dedicated lines do not operate at full capacity, and thereby create losses. Of course, producing product variety is impossible with a DMS, and therefore their role in modern manufacturing is decaying.

C. Continuous manufacturing systems

In continuous manufacturing systems each production run manufactures in large lot sizes and the production process is carried on in a definite sequence of operations in a pre-determined order. In this system the items are produced for

the stocks and not for specific orders. Before planning manufacturing to stock, a sales forecast is made to estimate likely demand of the product and a master schedule is prepared to adjust the sales forecast according to past orders and level of inventory. Here the inputs are standardized and a standard set of processes and sequence of processes can be adopted. Due to this routing and scheduling for the whole process can be standardized. First in first out priority rules is followed in the system. In short, here the input-output characteristics are standardized allowing for standardization of operations and their sequence. In this system the items are produced for the stocks and not for specific orders.

D. Intermittent manufacturing systems

In this system, the goods are manufactured specially to fulfill orders made by customers rather than for stock. Here the flow of material is intermittent. Intermittent production systems are those where the production facilities are flexible enough to handle a wide variety of products and sizes. These can be used to manufacture those products where the basic nature of inputs changes with the change in the design of the product and the production process requires continuous adjustments. Considerable storage between operations is required, so that individual operations can be carried out independently for further utilization of men and machines. Examples of intermittent system are: machine shops, hospitals, general office etc. Following are the characteristics of intermittent manufacturing systems:

- Most products are produced in small quantities
- Machines and equipment are laid out by process.
- Workloads are generally unbalanced.
- Highly skilled operators are required for efficient use of machines and equipment.
- In-process inventory is large.
- Flexible to suit production varieties.

E. Flexible manufacturing systems (FMS's)

A Flexible Manufacturing System (FMS) is a group of numerically-controlled machine tools, interconnected by a central control system. The various machining cells are interconnected, via loading and unloading stations, by an automated transport system. Operational flexibility is enhanced by the ability to execute all manufacturing tasks on numerous product designs in small quantities and with faster delivery [15]. It has been described as an automated job shop and as a miniature automated factory. In other words, it is an automated production system that produces one or more families of parts in a flexible manner [16].

FMSs are still oriented to produce a large variety of parts in small quantities and they are conceived to react to most of the possible products changes. Unfortunately the cost of investment to acquire an FMS is very high and it considerably affects the cost to produce a part; indeed its flexibility is frequently too high and expensive for needs of a producer of parts. The high financial and organizational impact of FMSs

has reduced their diffusion in the past; indeed the initial outlay is so high it severely strains the financial resources of the firms.

F. Reconfigurable manufacturing systems (RMS)

The RMS main goal is summarized by the statement – *Exactly the capacity and functionality needed, exactly when needed*. Aim of achieving cost effective and rapid system changes needed, by incorporating principle of modularity, integrability and scalability as this new manufacturing system. Reconfigurable manufacturing system promises customized flexibility in a short time, while the other manufacturing system provides generalized flexibility designed for anticipation variations [20]. A reconfigurable manufacturing system (RMS) having an adjustable structure is designed based upon market demand and can be readily changed from a first desired production capacity to a second desired production capacity to manufacture a desired amount of product from a family of products [12]. In general, reconfigurable manufacturing systems are designed at the outset for rapid change in structure, as well as in hardware and software components, in order to quickly adjust production capacity and functionality within a part family in response to sudden changes in market or regulatory requirements [17]. The system typically includes a plurality of workstations including reconfigurable machines. The system also includes a control system including an operation station [18] and reconfigurable controllers for controlling the reconfigurable machines. The operator station is in communication with the reconfigurable controllers and the reconfigurable controllers [19] are in communication with each other. As distinguished from flexible manufacturing systems (FMSs), an RMS has the structure which allows for rapid adjustment of production capacity and functionality, in response to new market circumstances, by basic change of its hardware and software components. This system will be open-ended, so that:

- It can be continuously improved by integrating new technology
- It can be rapidly reconfigured to accommodate future products and changes in product demand rather than scrapped and replaced.

G. Focused Flexible manufacturing systems (FFMS's)

It represents a competitive answer to cope with the need of customized flexibility and guarantee the optimal trade-off between productivity and flexibility. The customization of flexibility on specific production problems leads to the minimization of the system cost during its life cycle. The required level of system flexibility impacts in the architecture of the system and the explicit design of flexibility often leads to hybrid systems, i.e. automated integrated systems in which parts can be processed by both general purpose and dedicated machines [18]. This is a key issue of FFMSs and results from the matching of flexibility and productivity that characterize FMSs and DMS's respectively. FFMSs are hybrid systems, in the sense that they can be composed both of general purpose and dedicated resources [19]. This innovative architecture

derives from the consideration that system flexibility is related both to the flexibility of each single selected resource and to the interaction among the resources which compose the system. For instance, a flexible system can be composed of dedicated machines and highly flexible carries. At first sight FFMSs could appear to be similar to Reconfigurable Manufacturing Systems (RMSs); the difference between these two classes of systems is in the timing of flexibility acquisition. Deciding about flexibility and reconfigurability means to consider two options. The first option deals with designing a dedicated system in which the reconfiguration option can be implemented in the future when production changes occur. This leads to design a system with the minimum level of flexibility required to cope with the present production problem. In this case FFMSs and RMSs have similar performance. FFMSs have some “extra” flexibility designed to cope with future production changes, i.e. degree of flexibility designed to cope with future production changes, i.e. a degree of flexibility tuned both on present and future production problems.

XIII. CONCLUSION & FUTURE SCOPE

It is difficult to forecast long term trends for manufacturing systems, since the changes are happening at a fast pace. However, it is possible to extrapolate future trends from the current situation by analyzing and specifying the key drivers behind the changes. Certainly, availability and distribution of information plays an important role in this transition and it is considered as one of the key drivers. In this regard, there are needs for improvements and standardization of various components. FMS have been adopted to produce a large variety of parts in small quantities and are conceived to react most of the possible changes. Nowadays manufacturing flexibility has a strategic role for firms that want to compete in a reactive or proactive way. In fact, the ability of designing production systems whose flexibility degree is customized on the present production problem and at, the same time, it takes into account future product evolutions, can lead to competitive advantage.

The investment to acquire flexibility is very high and may considerably affect the cost to produce a part and flexibility may be expensive for the needs of a manufacture.

From the scientific perspective, focusing the flexibility of a production system on the specific needs represents a challenging problem. Indeed, the customization of system flexibility provides economic advantages in terms of system investment costs, but on the other hand, tuning on the production problems reduces some of the safety margins which allow decoupling the various phases of manufacturing system design. In consequence, from the designer of modern manufacturing systems point of view further research may be conducted to investigate the:

- The conceptions of FFMS and RMS proper for modern companies
- Which of conception – FFMS or RMS is much suitable for defined company?

- How to define the desired level of system’s flexibility?
- Which of the types of flexibility are the most important in the process of system design?
- How to forecast the way of development of manufactured parts?
- How to plan and optimize the cost of manufacturing system in its life-cycle?

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