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Challenges in Flexible Manufacturing Systems: A Review

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***Abstract*: Challenges in FMS include some intricate problems in planning and implementation. FMS planning and implementation problems can be classified as design, planning, scheduling, control problems. The design problems include obtaining the required number of tools and the various buffers along with required amount the material handling system can handle. Apart from this the planning problems are also there where sequential machining of parts is to be done, along with pallets allocation and required partition of various cutting tools accurately and also considering the limited amount of tool magazines of various tools to assign operations. The various scheduling problems include the determination of required sequence of parts and optimal sequence at every tool for the required part mix. Control Problems deal with system monitoring ensuring the due requirements and dates are met and there are no unreliability issues. The goal of the paper is to identify the various problems that occur in the modern manufacturing industry regarding the FMS system and to identify the possible remedial actions for the use of various industries dealing with Flexible Manufacturing.**

***Keywords*: Flexible Manufacturing System, Computerized Numerically Controlled, Automatic guided vehicles, Computer Aided Design, Computer Aided Manufacturing**

1. Introduction

Flexible Manufacturing System have been a breakthrough of the modern era where they have been providing the conventional manufacturing with minimal human efforts. Competitive business environments offer enormous amount of pressures to be met with increasing variety and shorter delivery commitments while maintaining the quality and also providing a reasonable cost. Therefore, to sustain in such competitive modern era, the focus has been on development of automated ways of manufacturing to deliver the most like conventional manufacturing with minimal efforts to reduce effort and time tremendously. Hence Flexible Manufacturing system is defined as the computer-controlled configuration of semi dependent workstations and material handling systems designed to efficiently manufacture various part types with the required volumes. The key advantages include improved capital/ equipment utilization, reduced work in process and set-up, substantially reduced throughput times and lead times, reduced inventory along with highly reduced manpower. However, it doesn't come that easy and the FMS comes with a wide range of problems which are due to automation and the control of its preciseness needs to be dealt accurately. Hence in this paper only various problems and their control is discussed which arises at the various levels of FMS life cycle i.e. right from conception to implementation & operation. It is very difficult to quantify the abilities to respond to the FMS products, or to quickly introduce new part numbers.

2. FMS Challenges in Industry

So, for industries when the management decision is made that FMS is being adopted, the companies will have to address few major issues including:

A. Design problems

In designing phase various challenges that need to be tackled are to be sorted with priority as then only any further progress can be made, hence it is one of the most critical challenges for any firm or industry implementing FMS, as listed below:

- Here the range of components to be produced is determined. From all the parts which are to be produced identifying the subset is must where FMS is to be done. From this broad idea of what FMS will manufacture, capacity and functional requirements will be specified, which eventually will specify the number and types of processes required along with the required equipment's, design and no. of fixtures, along with their capacities.
- Example: In automotive industry incorporating FMS the specific parts needed on FMS are determined. The clutch plate assembly and brake assembly's various parts are similar and in mass production of these parts FMS works very efficiently provided the design challenges are satisfied. The various robotic arms, their manipulators are used, along with the fixtures for the brakes and clutch's assembly is determined so that capacity is identified and accordingly the FMS is designed, considering all the automotive parts that can be made on such FMS
- Types of flexibilities required along with their amounts because all FMS require different amount of flexibilities which need to be specified and defined to address design problems which eventually helps in identifying the degree of flexibility of various automated equipment's and particularly the spatial and

directional flexibility of robotic arms. Also, the number and design of each fixture needs to be determined to avoid over waiting time and wasted space

- Example: In a typical assembly workshop HONDA Motors, as well in FMCG plants all assemblies of components as well as the packaging is done with the help of automated equipment which have designed amount of flexibilities which are predetermined in order to ensure best results with 0 tolerance margin.
- Specifying the type and capacity of material handling system which includes equipment like conventional conveyor belts, automated guided vehicles, self-pick-ups and drops robots are required to address at the design stage for a FMS.
- Example: Typical examples of this are the warehouses of companies like DHL, Flipkart and Amazon where all automated material handling capacities are specified for design of FMS
- The layout has to be determined as it determines the travel time from machine to machine and impacts the total system time which helps in forming scheduling strategies later. This includes determining the type and size of the buffers to provide queuing place for in process inventory. Central buffer area and local buffer area should be present at each tool which helps in keeping all the tools utilized. A very important point here is to determine the optimum number of pallets as per the layout of the working area as having too less pallets causes underutilisation while too many number of pallets causes congestion hence an appropriate no is to be determined.
- Example: Manufacturing industries shop floors layout as well as warehouses of all industries are all such designed that all automation is carried out in most efficient way and as well the number and arrangement of pallets is such that congestions of all sorts are avoided to ensure maximum efficiency of FMS
- The hierarchy among the computers controlling the different aspects of production need to be specified. This control structure specifies the communication of computers at various levels for efficient FMS. The software development tasks need to be specified including control structure, tool management, inventory control, and scheduling. Piu (2013)

B. Planning problems:

These are the problems which need to be fixed before the manufacturing begins. The various problems that are meant to be addressed are:

- From the list of part types for which production orders of various sizes are specified, a subset of part types for immediate and simultaneous manufacture has to be chosen and also the production ratios are determined.
- Example: This is a typical case in casting industry where planning for FMS has to be done prior where planning for similar parts filling and drafting operations has to be done for FMS, so that no problem arises later during the manufacturing stages
- Partition of machines of each type into various groups has to be done by pooling to improve efficiency. Allocation of the operations and associated cutting tools of selected part types among machines.
- Example: In a typical process layout, in the manufacturing firms making parts through repeated process on the same part, this format is adopted. Similar jobs are fed through a group of machines performing similar operations.

C. Scheduling problems

- These are concerned with running FMS during real time once it has been set up during planning stage. Determination of optimal sequence at which parts are to be inputted into the system with appropriate scheduling methods and algorithms that need to be developed along with the determination of various priority sequence.
- Example: Use of IOT can be done here in highly precise industries where there is frequent scheduling smart machines of FMS can be used themselves to make use of artificial intelligence to schedule process in a way that efficiency and effectiveness are maintained

D. Machine loading

Machine loading as set of tools that are required to produce parts using different resources such as material handling systems, pallets, jigs and fixtures and considers how the parts be assigned so that optimum productivity can be reached. Following are the issues associated with it:

- Allocation of jobs to various machines under technological constraints to meet certain performance measures. And, also to encompass various types of flexibilities pertaining to part selection and operation assignment along with constraints ranging from simple algebraic to potentially very complex conditional constraints like capacity of machine, capacity of tool magazine, tool requirement of different operations, overutilization and underutilization cost of machines
- Example: Proper algorithms are designed for optimum machine loading which are done through coding in all automobile, manufacturing industries so that allocation of jobs is done in a right way in coordination with all the jigs and fixtures, material handling systems.

E. Control Problems

- These are associated with the continuous monitoring

of the system, keeping the track of production to be certain that production requirements are met as per schedule. This is actually a challenge forth the actual work has been done. FMS control includes policy to handle machine tool and breakdowns, Determination of scheduled, periodic and maintenance policies also, determining procedures for tool life and process monitoring as well as data collection for updating the estimates of tool life.

- Example: Frequent failures in machines and equipment, along with parts that require close preciseness and frequent inspections can be automatically scheduled in various power plants as well manufacturing industries as a part of control challenges using automation, IOT as well as AI.

3. Applications of FMS

Taking an example for application of FMS in industry and the issues faced in the same:

A. Automatic guided vehicles

An FMS requires a capable material handling system to move material/parts safely and economically across the system. Automatic guided vehicles (AGV's) are defined as the driverless transport system to move the one or more parts at same time. AGV technologies have enhanced the flexibility and autonomy and it is one of the effective way for material handling of different parts due to better routing flexibility, space utilization, safety and product quality.

- Deadlock and collisions are one of the critical issues affecting the performance of FMS and AGV's should have capability to obstacles and the ability to return to its original path without any collision.
- There are three methods to avoid the condition of deadlock and collisions within the FMS. These are:
- Design the layout of guide paths in such a way that conflicts and deadlocks are avoided
- Divide the traffic area into several nonoverlapping control zones
- Develop routing strategies to prevent conflicts and deadlocks

Load of an AGV is always on its shortest path, resulting in higher system performance and avoiding unnecessary waiting times.

4. Solutions and Research techniques

There are multiple models available that can be used to solve each of issues discussed above. All the problems discussed might not be addressed at the same time but prioritizing and aggregating the issues to focus on particular aspect All these have provided either qualitative or operational insights into some of the FMS decision problems. Few of the models are discussed below which can or have been applied by now:

- *Analytic Hierarchy Process (AHP)*- It is a multiple criteria decision-making methodology in assessing an FMS. It decides the general significance of an arrangement of qualities and criteria;like, customer satisfaction, set-up time, cutting speed, profitability, etc. It helps to affirm that individual decision makers capture logical and reasonable preferences while deciding. Bayazit (2004), Cheng and Li (2003)
- *Expert Systems*- It is an efficient tool for formulating strategies for placing different FMS parts. However, these suffer from deficiencies like, it relegates some of the important aspects involved in FMS design such as cost and quality. Borenstein, D., Becker, J. and Santos, E. (1999)
- *Genetic Algorithm*- This algorithm helps in determines the sequence of the jobs while taking into consideration the interaction with operation machine allocation. Tiwari et al., (2007)
- *Artificial Intelligence (AI) and Fuzzy Logic*- It helps in analysing the problems that are close to real-life situations and giving a better quality solution for largesized real-life problems. The procedure makes the scheduling decisions in real time trying to meet several measures of performance simultaneously, as can be verified in the simulations accomplished with the developed prototype. Domingos and Politano (2003), Chan et al. (2005)
- *Computer Aided Process Planning*- CAD/CAM helps the majorly in the flexible or programmable manufacturing systems, from product design to manufacturing control. It sorts out the issues in the manufacturing hardware and software, manufacturing systems and devices, automation, flexible automation, and computers in manufacturing using the tooling and fixturing, Programmable Logic Controllers and Concurrent Engineering. Tien-Chien Chang and Richard A. Wysk (1997)
- *Petri nets (PNs)*- Works as a powerful tool to formalize rules for allocating and dislocating the zones in AGVS. Tamini et al (2012)

Apart from the above model discussed there are few others which have been provedto be useful in the recent times for improving the efficiencies and productivity of FMS systems such as Simulation, Group technology, Queueing networks, Mathematical programming (linear, nonlinear, integer), Perturbation analysis.

5. Conclusion

Flexible Manufacturing System (FMS) is a capital-venture concentrated and complex framework. In the present market situation, the customer request and detail of any product changes quickly so it is critical for an assembling framework to oblige these progressions as fast as conceivable to have the capacity to contend in the market. This advancement prompts

regularly a contention for an assembling framework on the grounds that as the assortment is expanded the profitability diminishes, consequently FMS is a decent mix among assortment and efficiency.

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