Paper on
Flexible Manufacturing Systems (F.M.S.)

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Guide: -

Prof. H. G
ABSTRACT

One of the most revolutionary concepts of Machining Processes to emerge in the last two decades has been the concept of Flexible Manufacturing System (F.M.S.). It is a concept of machining where a set of machine tools can be used to perform a wide range of machining operations to produce a variety of products. This dynamic nature of the machine tools can be achieved by developing a beautiful amalgamation of Hardware and Software components.

The paper attempts to put forth the concept of Flexible Manufacturing System. It tries to explain as to why such a system of machining is the need of the hour. It enlightens us about the various Hardware and Software components of this system and how each of them works in co-ordination with each other. The paper also explains how a F.M.S. can be designed to suit the requirements of a particular company’s job profile. Once the F.M.S. has been designed the paper also tells us how to go about implementing this system right from procuring the required components to starting production on the system. With the help of Case Studies the paper explains how companies have set-up F.M.S. and have gained from it. The paper also tells about the various improvements in results that companies have achieved by implementing this system. The paper also tells how implementing F.M.S. in Indian companies can help them face global challenges.
Introduction

Since the dawn of civilisation, man has been continuously trying to ease and improve his work by developing better tools. This process started with the development of stone tools and will culminate into development of a totally automated factory. This factory would be able to do all the things associated with a product, right from designing it to packaging. Since the human operator tends to be the weakest link in the production process, the need for automation has been felt throughout the industry. A Flexible Manufacturing System (F.M.S.) is a part of this process and a step towards complete automation of the factory. This system automates the metal cutting part of the product manufacturing. A F.M.S. is a form of flexible automation in which several machine tools are linked together by a material-handling system, and all aspects of the system are controlled by a central computer.

Why use F.M.S.?

The current market scenario is such that a customer has the requirement to demand a wide variety of good quality product at a very short notice. The traditional systems of product manufacture like Transfer Line system were unable to cope up with the market requirements. The Transfer Line system of manufacture had a very high production level but offered limited flexibility. On the other hand, Workshop system of product manufacture offered a very high degree of flexibility but had a very low production level. These systems were unable to satisfy the requirements of variety, quantity and speed at the same time. This lead to the work of development of a system, which combines the seemingly conflicting objectives of high flexibility and high productivity.

The emergence of F.M.S. technology has proved to be an ideal solution to this problem. With the help of F.M.S. we are able to produce a wide variety of products without making any changes in the hardware set-up. As a result of this the changeover time between two products can be reduced to the time required by the machine tools to receive the necessary instructions. It also reduces the lead-time drastically. This is of prime importance as lead-time is equated with the
cost of the product. It is a market-sensitive technology as it can produce the required proportion of product variety quickly and efficiently.

What is F.M.S.?

It is a collection of production equipment logically organised under a host computer and physically connected by a central transport system. It is group of manufacturing cells linked by an automatic material handling system and a central computer. It is able to manufacture a mix of piece-part types while being flexible enough to sequentially manufacture different piece-part type mixes without costly, time-consuming, changeover requirement. It is a medium size batch production system. The parts requiring the same machining operation is sent to the to the appropriate machine tools irrespective of the type of part.
It basically contains a number of machining cells called Flexible Manufacturing Cells (F.M.C.), Figure 2. These cells if installed as stand-alone entities can offer a certain amount of flexibility in machining. A typical F.M.C. consists of a C.N.C. machine with a transfer system to load and unload the work piece and a tool magazine. The work pieces move from machine to machine in a sequence independent of the physical arrangement of the machine tools.

When a number of F.M.C.s are integrated together with a common controller called Distributed / Direct Numerical Controller and a Material Handling System and Tool Handling system it evolves into and a Flexible Manufacturing System. Each unit has its own Controller (either D.N.C. or P.L.C.) whose activities are in turn co-ordinated and supervised by the central host computer. This interaction between the Hardware and Software modules results into an organisation capable of performing multiple machining operations.

**Components of F.M.S.**

Components of a F.M.S. can be broadly classified into two categories.

- Hardware
- Software
**Hardware:** - The Hardware component (Figure 3) basically consists of Machine Tools and Handling systems.

It incorporates the following equipments

- Machine Tools e.g., Universal Machining Centres, Turning Centres, Drilling Machines etc
- Host Computer.
- Load/ Unload station
- Guided Vehicles e.g., wire-guided trolley, shuttle, over-head conveyor etc
- Robots
Software: Software for F.M.S. can be divided into 2 broad categories – extrinsic functions and intrinsic functions (Figure 4).

Software for the extrinsic functions is used to plan and control the functions that take place outside the physical boundaries of the F.M.S.²

Software for the intrinsic functions is used to load and control the components within the physical boundaries of the F.M.S.²

Extrinsic Functions incorporate the following operations: -

- Production Scheduling
- Process Planning
- Tool Management
- Maintenance Planning
Intrinsic Functions incorporate the following operations:

- Production Control
- Production Monitoring/ Reporting
- Machine/ Process Control
- Machine Diagnostic

**Working Of an F.M.S.**

F.M.S. is a system where a high degree of flexibility in the machining process is achieved by an integration of the hardware and software components. The flexibility in F.M.S. is achieved with the help of software controlling the hardware. The first step in the production of any component is scheduling the production. The flexibility in F.M.S. is achieved by proper scheduling of the production process. This is achieved with the help of the production scheduling software. A variety of computer-based scheduling methods can be used in production. In order to prepare an ideal scheduling process, certain inputs are required by the software. These data include Part Data, Pallet Data, Program Data and Machine Data.

It selects the optimal method based on the production objectives, available resources and the economic considerations to select the batch size. It determines the allocation of part to machines depending upon the operation to be performed, the availability of the machines and priority.

Once the scheduling operation is complete, the process planning software takes over. It determines the type of manufacturing processes that the work-piece has to undergo to be converted into a finished product. It does so by retrieving specific information from the central database, and considering machine tool capabilities and tooling.

After the type of machining operation to be performed on a work-piece is decided, the tool management software selects the appropriate tool to be supplied to the machining centres. It does so by taking into consideration the tooling status and inventory records and a tool replacement strategy. Proper interfacing should be provided between these three software.
Once the scheduling and process planning stages are completed, the manufacturing of the work-piece actually starts. The raw work-piece is first fixed on the pallet and placed in the pallet store. The Robotic arm then picks up the required pallet and loads it on the guided vehicles (G.V.). The G.V. transports the pallet to the appropriate machining centre according to the scheduling program. If the machining centre is busy, the pallet is kept in centre's buffer station. The buffer stations are provided so that work is always available for the machining centre.

The tool management software selects the tool from the tool room and supplies it to the machining centres through the tool transport system. The machine performs the metal cutting operation according to the part program it receives from the D.N.C. The acts as the single-point supplier of part programs as required by the various machining centres.

After the machining is completed on one machine a G.V. takes it to the next machining centre, if required, for the further processing of the work-piece. In this way the G.V.s transport the work-piece from machine to machine till it is transformed into the finished product. At regular interval intervals of time, the machining operation stops, allowing probes to come out and measure the dimensions of the work-piece being operated on. This product is taken to the washing centre for cleaning and then to the inspection station for checking the product. At the end of the work process, the work-piece is unloaded with the help of a Robotic arm.

One of the characteristics of an F.M.S. is that a machine tool can work in various modes depending upon the requirements of the user. These are:

- **Automatic mode:** - this is the normal mode of operation of the machine tool when part of the system.
- **D.N.C. mode:** - In this mode any operation can be initiated at N.C.’s panel without being watched by the host.
- **Maintenance mode:** - This mode is used when maintenance is planned for a machine. The machine is also put in this mode when it is expected to be out of operation for a long period.
• **Stand-alone mode:** - This mode can be used to test the part program of a new piece part before introducing it in the system. The machine is unsynchronised by the host in this mode.

All the processes carried out by the hardware are being monitored in real-time by the various intrinsic software(s) loaded on to the Host Computer. Thus the Host Computer controls the whole system.

*Production Control* software selects the suitable work-piece to be machined and monitors its progress through the machining centres and inspection stations according to the production schedule.

*Production monitoring and reporting* software collects the various data related to product management like number of completed parts, inspections results, tool change data etc and provides standard and custom reports for managing the F.M.S. resources. It also monitors the utilisation of the different units and the current status of machining operation. If any problems arise they are promptly reported to avoid delay in taking corrective measures and maximising machine utilisation.

The *Machine/Process control* is the lowest level in the communication hierarchy. It operates at the machine level and provides both control and monitoring functions. It monitors tool status and provides tool replacement strategies. It can also adapt to variation in process variables in real-time.

*Machine Diagnostic software* detects and can predict malfunctions, the probable reasons for the malfunctions and offers solutions for the same. In case of a failure, it can switch control of the failed unit to a back-up system.

For the optimum performance of the system, it is necessary to carry out maintenance operations on a regular basis. In case of a failure, corrective measures have to adopted by the maintenance personnel. A *Maintenance Planning software* performs the auxiliary functions required for the actual maintenance of the F.M.S. This includes activities like scheduling maintenance activities, issuing maintenance reports, supporting real-time supervision of machine components etc. It should also be able to track the status of maintenance and determine crew assignments.
Simulation is an important tool to test the part program of a new work-piece that is to be introduced or to check any alterations made in the part program of an existing work-piece and identify any bottlenecks. It is also used to compare alternative design and performing work scheduling and job sequencing. Examples of some simulation software are SIMAN, SLAM II etc.

CAD software is used to design the product and represent it in a solid model. While a CAM software is used to convert this solid model into part programs incorporating all the information about the machining operations to be performed on the work-piece.

The information based on which the whole system performs its functions is accessed from the central database system.

The software is supplied Artificial Intelligence capability to be able to take decisions based on the actions of the system performed till now. The program development should be menu-driven and have a user-friendly software. The concept of Blueprint Programming is widely used in the system, which involves the use of data for cutting parameters.

Thus the various components of the F.M.S. work in co-ordination with each other to create a super machine of a versatile character.

Developing an F.M.S.

As F.M.S. is such an elaborate technology, its standardisation has been difficult. Thus each F.M.S. has to be customised to suit the requirements of a particular company. Thus each time a company wants to install an F.M.S., it has to go through the entire process of designing the system according to its own needs. A company that wants to build a successful F.M.S. has to go through 5 major stages of development.

They phases can be classified as follows:

- Awareness phase
- Planning phase
- Procurement phase
- Installation phase
- Operation phase
**Awareness Phase:** - The Company first has to gather all the information it needs to understand the concept of F.M.S. and the potential it holds for the company. It should see whether the F.M.S. fits the company’s job profile and whether it can derive any significant benefits from it.

**Planning Phase:** - Once the company decides to go forward with the implementation of F.M.S., it must start planning an F.M.S., which suits its requirements. The first step in this direction would be the setting up of a project team with a project leader to oversee the entire project. The team should then carry out a financial evaluation of the company before taking any further steps towards the development of the F.M.S. Based on the evaluation report, the team should formulate a long-term strategy for the effective utilisation of the F.M.S.

The team should then decide as to which machining processes it must include in its F.M.S. to fulfil the job requirement. The F.M.S. that the company develops should be modular in nature, as it would enable the company to add new modules like machines and/or pallet stackets. As F.M.S. is a relatively new technology, the team should chalk out an orientation programme for the company’s employees. It will make the employees more responsive towards this technology. Along with this, the team should make the necessary changes in the company’s production environment and organisation. This will help in the smooth integration of the F.M.S. in the company’s scheme of things.

The team should now proceed towards determining the type of F.M.S. most suited to the company’s needs considering the level of flexibility it requires. F.M.S.s can be broadly classified into three categories:

- **Sequential Flow F.M.S.** - In this system all the work pieces follow the same path. It is suitable for machining work pieces belonging to a well-defined family of parts.
• **Single-Station F.M.S.**: In this system a single machine is supplied with all the tools necessary for complete machining operation of the work piece. Thus all the work on a work piece is done on a single machine. This system can achieve a high productivity by increasing the number of machines and providing the same tooling. But this leads to higher expenditure due the replication of the same set of tools on each and every machining station.

• **Random Flow F.M.S.**: In this system the work pieces move from machine to machine in any sequence. The flow sequence depends upon the operations required for the work piece and the availability of the machines carrying out those operations. Thus a wide range of dissimilar products can be manufactured simultaneously within the system. This system allows the designers to make changes in design without making any changes in the hardware set-up.

Once the type and layout of the F.M.S. is decided upon we can test its feasibility by simulating its operation on a suitable simulation package. A suitable model must be created consisting of design features that need to be studied. The model mimics the system behaviour under various operating conditions. By operating the F.M.S. model in a virtual environment, it is possible to detect any flaws in the F.M.S. design and help us in taking the required corrective actions. Thus a simulation package saves the company the money it would have lost in experimentation.

At the end of the planning phase the team comes out with a concrete set of specifications to be passed on to the procurement phase.

**Procurement Phase**: - The procurement team is entrusted with the job of buying all the hardware and software components required for setting up the F.M.S. in the company. For this it selects suitable suppliers based on certain criteria like long-term financial stability of the supplier, support and level of training provided, reputation of the supplier etc.

**Installation Phase**: - Once all the components are procured they need to be properly installed and integrated to form the F.M.S. For this it is imperative that the various suppliers and the F.M.S. user be present to sort out any problems
that may arise during the integration process. The co-ordinated efforts from all
the parties involved will ensure a relatively smooth installation of the F.M.S. The
installation phase involves the following tasks:

1. Construction of the F.M.S. site.
2. Setting up of the hardware and software components of the system.
3. Integration of components to form the F.M.S.
4. Integration of the other departments to the F.M.S.
5. Planning the test and acceptance methods suitable to all parties.
6. Planning for the training and take-over activities.

**Operation Phase:** - Once the F.M.S. is installed operation process
commences. During the initial process errors are likely to crop up in the hardware
and/or software. These errors have to be debugged for the smooth operation of
the system. Over time the F.M.S. user learns to fine-tune the system to suit his
requirements. This constant fine-tuning may bring him to a stage where he could
run the system in a way previously unplanned.

**Advantages of F.M.S.**

Implementation of F.M.S. has resulted in advantages in wide ranging
fields and has enabled industries to produce high quality goods efficiently and
with a great degree of flexibility. The advantages obtained by implementing
F.M.S. can be tabulated as follows:

- Reduction in personnel: Virtually unmanned
- Reduction in designing cost: 15-30%
- Reduction in overall lead time: Equal to manufacturing time
- Reduction in work in progress: 30-60%
- Gain in overall production: 40-70%
- Gain in capital equipment operating time: 200-300%
- Product quality gain: 200-500%
- Gain in engineering productivity: 300-500%

**Reliability:** - A high level of reliability is one of the major advantages of
F.M.S. operation. In the event of a computer breakdown, the F.M.S. can still
continue production for some time but at a lower efficiency level. The average
breakdown rate in an F.M.S. can be as low as 10 – 14%. The F.M.S. is in operation for a longer duration of time, with the spindle being engaged in metal cutting operation for a period, which is 4-5 times longer than that in an isolated machine. Because of this they are subjected to much less variations and generally function better. This was evident from the perfect operational record of the first generation F.M.S. in the U.S. even 12-14 years after they were set up.

**Safety:** - This system is inherently safe, as human presence in the machining area is minimised when the machining operation is in progress. As a result the factor of safety of the system is very high, after the incorporation of certain basic safety measures.

The modular nature of the system enables it to cater to any future requirements.

**Disadvantages:** -

Any system will have certain disadvantages. The possible disadvantages associated with the system are as follows: -

1. Very high start-up cost.
2. Problems may occur in the various components of the systems, which may require a long debugging process.

However, the magnitude of flexibility that the system offers and the volume of production completely justifies the high initial investment made to develop this system.

Any system of this magnitude and complexity it bound to develop some problems. However, the returns offered by this system completely justify the time spent on debugging it.

**Case Studies**
The Hattersley Newman Hender (H.N.H.) F.M.S.: -

This company is located at Ormskirk, U.K. and manufactures high and low pressure bodies and caps for water, gas and oil valves. These components require a total of 2750 parts for their manufacture. That is why they decided to go for the system of F.M.S. to fulfil their machining requirements in a single system. Their F.M.S. consists of primary and secondary facilities. The primary facilities include 5 universal machining centres and 2 special machining centres. The secondary facilities consist of tool setting and manual workstations.

System layout and facilities (Figure 6): -

Primary facilities: -

1. Machining centres: - The F.M.S. contains two 5-axis horizontal ‘out-facing’ machines and five 4-axis machining centres under the host control. All the machines have a rotating pallet changer each with two pallet buffer stations. These stations transfer pallets to and from the transport system (8 Automated Guided Vehicles). The 5 universal machining centres have 2 magazines with capacity of 40 tools in each magazine. The special purpose out-facing machines (O.F.M.) each have one magazine having a capacity of 40 tools. The tool magazines can be loaded by sending instructions to the tool setting room either from the host computer or the machine’s numerical controller.
2. **Processing centres**: The system contains two processing centres – a wash machine and two manual workstations.

   **Wash machines**: it contains two conveyor belts (one for input and one for output of pallets), each with a capacity of three pallets to transfer the pallets. The wash booth has a capacity of three pallets. The pallets are washed in the booth and turned upside-down to drain out the water and then it is dried with blown air.

   **Manual workstations (ring fitting area)**: The operator fits metal sealing rings into the valve bodies at the manual workstations. The operator receives work instructions from a computer interface with the host.
Secondary facilities:

1. Auxiliary stations:
   Load/unload stations: - The F.M.S. has four piece part load/unload stations. Loading and unloading is performed at these stations with the instructions received on a computer interfaced with the host.

   Fixture-setting station: - At this stations the fixtures are readjusted to accommodate different piece parts.

   Administration of tools: - Tools are assembled manually. The tool-setting machine checks the dimensional offsets of the tools and generates a bar code for further identification of the tool that has been set.

2. Auxiliary facilities:
   Transport system: - The transport system consists of a controller and 8 Automated Guided Vehicles (A.G.V.). The system also contains an A.G.V. battery charging area.

   Buffer stores: - The F.M.S. has 20 buffer stores in order to store the empty and loaded pallets while they are waiting to be taken to another transfer station (i.e. a load/unload station or a machine tool etc.).

   Maintenance Area: - This facility cater for pallets that may be damaged or need servicing or for scrapped piece-parts.

   Raw Material Stores: - These stores are located in front of the load / unload stations and are used to store the raw materials (like forged valve bodies etc). The store is served by two fork-lift-stacker cranes and motor roller conveyors. It has a capacity of 80 containers.

   Fixture store: - The fixtures that are not used live in F.M.S. are stored here. It has a capacity of storing 120 fixtures. The store is served by a stacker crane and motor roller conveyors.
The Vought workshop F.M.S.

The Vought Aerospace plant located at Dallas makes two elements for the B-1 Bomber fuselage which is made up of some 2000 machined parts, 600 of which are suitable for reduction in an F.M.S. This programme is somewhat shorter than the majority of American aerospace production runs which often require 1000s of parts. This presented a problem to the company since it is not profitable to introduce specialised equipment for such short runs. So the company decided to develop an F.M.S. for this particular project.

Elements of the Vought F.M.S.: -

1. Eight 4-axes Milacron 20 HC horizontal machining centre with Allen Bradley numerical control and a 90 capacity tool magazine.
2. A washing station.
3. 4 wire-guided vehicles.
4. Two Carousals, each with 10 spaces.
5. Two D.E.A. vertical measuring machines, with transverse movement and heads with two axes of rotation.
6. A rectification centre.
7. Swarf treating system.

The implementation of F.M.S. brought the following benefits to the company:

- The manufacturing process of the parts on traditional machines took about 200,000 hours. The same set of machining operations could be accomplished on the F.M.S. in about 70,000 hours. Thus it reduced the manufacturing time by 65%.

- The total cost of installation of the F.M.S. was about 15 million dollar. The operation of the F.M.S. in a period of three years resulted in an estimated saving of 25 million dollars. This represents a return of 40% on the initial investment.

- The whole workshop occupies an area of 2,800 square metres, which is relatively small as compared to that of the traditional workshops of the same capacity.

**Factory of the future**
We have achieved complete automation in the Machining operation part of the F.M.S. and to a lesser degree in the assembly system. Automation of the various aspects of the industry has been achieved in isolation. Efforts are now being made towards integrating these isolated systems into a single entity.

This will eventually result in the formation of a completely automated super system, in which all the operations, from designing a product to packaging is fully integrated into the system. This factory would be able to function without any human interference. This will require an immense level of co-ordination between the various departments at the hardware and software levels.

The hardware used should be of a very high quality and compatibility and the software must possess an extremely high level of Artificial Intelligence (A.I.). The roles of humans in this system are that of supervision and ensuring that the system follows the direction the humans envisage. F.M.S.

**Indian Context**

Some companies in India have adopted F.M.S. technology for its operations. However this technology is still not widely implemented in India. For the Indian industries to sustain itself and compete in the global market it is necessary that they adopt some new generation manufacturing process like F.M.S. For this to happen the Government should also take an active part in encouraging the development of F.M.S. in India.

**Conclusion**

F.M.S.s are now being widely employed to improve productivity and quality of the product. It also improves the quality of life for the operator. The new techniques will have a major impact on economic factors. Research must be carried out in the development of the technical aspects of software and hardware to develop a better F.M.S to suit various requirements. Research must also be conducted in developing a standardisation process in certain areas, to enable its easier implementation, as present Research being done is not sufficient.
Thus F.M.S. technology has been able to fulfil the needs of the industry quite successfully. Therefore, implementation of F.M.S. will benefit both the Manufacturer and the Consumer.
References: -

2. Flexible Manufacturing System in Practise, Roger Bonetto.
3. Flexible Manufacturing, David Parrish.
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Paper on Flexible Manufacturing Systems (F.M.S.)

Guide: - Prof. H. Gondhalekar
What is F.M.S.?

• Highly automated machine system.
  Consists of:
  ➢ a group of processing workstations

• Interconnected by
  ➢ an automated material handling and storage system

• Controlled by
  ➢ a distributed computer system
What is F.M.S.?

Flexible Manufacturing Cells (F.M.C.)
- Building blocks of F.M.S.

Consists of :-
- C.N.C. Machine.
- Transfer System
- Tool Magazine
What makes F.M.S. flexible?

- The ability to identify and distinguish among the different part or product styles processed by the system
- Quick changeover of operating instructions
- Quick changeover of physical setup
Why use F.M.S.?

Customer requires:

- Wide variety of Goods
- High Quality
- Speed of Delivery
- Low Cost
Components of F.M.S.

- **Hardware components**
  - Machine Tools
  - Host Computer
  - Material Handling Systems
    - Transport System
    - Tool Handling System
  - Auxiliary Systems
    - Load / Unload Stations
    - Washing Stations
    - Swarf Disposal System
    - Inspection Hardware (C.M.M. Facilities)
Components of F.M.S.

- Software components
  - Extrinsic functions
  - Intrinsic functions
Components of F.M.S.

- Software components
  - Extrinsic functions – Carried out outside the physical boundaries of the F.M.S..
Components of F.M.S.

- Software components
  - Extrinsic functions
    - Production Scheduling
    - Process Planning
    - Tool Management
    - Maintenance Planning
Components of F.M.S.

- Software components
  - Intrinsic functions – Takes place inside the physical boundary of the F.M.S.
Components of F.M.S.

- Software components
  - Intrinsic functions
    - Production Control
    - Production Monitoring / Reporting
    - Machine / Process Control
    - Machine Diagnostics
Components of F.M.S.

- Software components
  - Auxiliary functions
    - Simulation
    - CAD / CAM
    - Blueprint Programming
    - Central Database System
    - Artificial Intelligence
Developing an F.M.S.

Phases involved in developing an F.M.S.: -
- Awareness Phase
- Planning Phase
  - Types of F.M.S.
    - Sequential Flow F.M.S.
    - Single Station F.M.S.
    - Random Flow F.M.S.
- Procurement Phase
- Installation Phase – construction, integration, planning
- Operation Phase
### Advantages Of F.M.S.

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<th>Advantage</th>
<th>Percentage</th>
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Advantages Of F.M.S.

- **Reliability** – High Level of Reliability
- **Safety** – Inherently safe
- **Working Environment** – Excellent
- **Workshop Area** – Reduces as compared to traditional systems
- **Modular Nature of System** – System can be expanded in the future
Disadvantages Of F.M.S.

- High startup cost
- Long debugging process
Factory of the Future
Factory of the Future

- Completely automated factory
- Negligible Human interference
- High level of Artificial Intelligence

Role of Humans
- Supervision
- Direction
Indian Context

- Not widely implemented
- Lack of Awareness
- Needed to compete in the global market
- Requires active participation of the Government and Industry
Conclusions

- FMS is inherently flexible – adaptable to changing production needs
- FMS requires a substantial investment of both time and resources
- Further research required to develop this system
- System must be standardized
- Thus F.M.S. technology has been able to benefit both the Manufacturer and Consumer.
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  - a distributed computer system →
What is F.M.S.?

Flexible Manufacturing Cells (F.M.C.)

- Building blocks of F.M.S. →

Consists of: - →

- C.N.C. Machine. →
- Transfer System →
- Tool Magazine (Hive / storage)

Magazine – 4 the machining centre
Hive / storage – overall tool storage
What makes F.M.S. flexible?

- The ability to identify and distinguish among the different part or product styles processed by the system
- Quick changeover of operating instructions
- Quick changeover of physical set-up ➔
Why use F.M.S.? →

Customer requires: - →

- Wide variety of Goods →
- Speed of Delivery →
- High Quality →
- Low Cost →
Components of F.M.S.

→
Hardware components, Software components →
❖ Hardware components →

➢ Machine Tools →
➢ Host Computer →
➢ Material Handling Systems →
  ✓ Transport System
  ✓ Tool Handling System →
➢ Auxiliary Systems →
  ✓ Load / Unload Stations
  ✓ Washing Stations
  ✓ Swarf Disposal System
  ✓ Inspection Hardware (C.M.M. Facilities) →
Components of F.M.S.

- Software components →
  Intrinsic Functions, Extrinsic Functions →

  ➢ Extrinsic functions: - outside the boundary of system →

  ✔ Production Scheduling →
  ✔ Process Planning →
  ✔ Tool Management →
  ✔ Maintenance Planning →
Components of F.M.S.

Software components

- Intrinsic functions: - Inside the boundary of the system
  - Production Control
  - Production Monitoring / Reporting
  - Machine / Process Control
  - Machine Diagnostics
Components of F.M.S.

- Software components
  - Auxiliary functions
    - Simulation
    - CAD / CAM
    - Blueprint Programming
    - Central Database System
    - Artificial Intelligence
Developing an F.M.S.

Phases involved in developing an F.M.S.: - →
  ❖ Awareness Phase →
  ❖ Planning Phase →
    ➢ Types of F.M.S.
      ✓ Sequential Flow F.M.S.
      ✓ Single Station F.M.S.
      ✓ Random Flow F.M.S. →
  ❖ Procurement Phase →
  ❖ Installation Phase → – construction, integration, planning →
  ❖ Operation Phase
## Advantages Of F.M.S.

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in personnel</td>
<td>Virtually unmanned</td>
</tr>
<tr>
<td>Reduction in designing cost</td>
<td>15-30%</td>
</tr>
<tr>
<td>Reduction in overall lead time</td>
<td>Equal to manufacturing time</td>
</tr>
<tr>
<td>Reduction in work in progress</td>
<td>30-60%</td>
</tr>
<tr>
<td>Gain in overall production</td>
<td>40-70%</td>
</tr>
<tr>
<td>Gain in capital equipment operating time</td>
<td>200-300%</td>
</tr>
<tr>
<td>Product quality gain</td>
<td>200-500%</td>
</tr>
</tbody>
</table>
Advantages Of F.M.S.

- **Reliability** – High Level of Reliability →
- **Safety** – Inherently safe →
- **Working Environment** – Excellent →
- **Workshop Area** – Reduces as compared to traditional systems →
- **Modular Nature of System** – System can be expanded in the future →
Disadvantages Of F.M.S.

- High start-up cost
- Long debugging process
Factory of the Future

(Diagram)

❖ Pioneers in FMS use

➢ In the United States:
  ✓ Ingersoll-Rand Co.
  ✓ Caterpillar
  ✓ John Deere
  ✓ General Electric Co.

➢ Around the World:
  ✓ Germany
  ✓ Russia
  Japan – Fuji Xerox ➔
Completely-automated factory – Textile Industry in Japan, Business Information System (B.I.S.)
Negligible Human interference

High level of Artificial Intelligence

Role of Humans
  ➢ Supervision
  ➢ Direction

Indian Context

Not widely implemented
Lack of Awareness
Needed to compete in the global market
Requires active participation of the Government and Industry
Conclusions

- FMS is inherently flexible – adaptable to changing production needs →
- FMS requires a substantial investment of both time and resources →
- Further research required to develop this system →
- System must be standardized →
Thus F.M.S. technology has been able to benefit both the Manufacturer and Consumer.

(References)