FMS (Flexible Manufacturing System)
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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.
• 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.
Why use F.M.S.?

- 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.
Figure 1: - Volume versus variety capabilities of various Manufacturing Systems, Courtesy Material and Processes in Manufacture, Lindberg
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.
What is F.M.S.?

- It basically contains a number of machining cells called Flexible Manufacturing Cells (F.M.C.), as per shown in 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.
Figure 2: - Block Diagram of a Flexible Manufacturing Cell (F.M.C.),
Courtesy Flexible Manufacturing systems in Practice, Bonneto
What is F.M.S.?

- 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
Components of F.M.S.

- **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
  - Washing station
  - Tool Room
  - Swarf Disposal System
  - Inspection Hardware (C.M.M. facilities)
  - Programmable Logic Controllers (P.L.C.)
Figure 3: - The generalised Block Diagram of an F.M.S., courtesy Flexible Manufacturing, Parrish
Components of F.M.S.

- **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.

- Software for the intrinsic functions is used to load and control the components within the physical boundaries of the F.M.S.
Figure 4: - Extrinsic and intrinsic functions of F.M.S.,
courtesy Handbook of Flexible Manufacturing Systems
Components of F.M.S.

- Extrinsic Functions incorporate the following operations: -
  - Production Scheduling
  - Process Planning
  - Tool Management
  - Maintenance Planning
Components of F.M.S.

- 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 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.
Working Of an F.M.S.

- 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.
Working Of an F.M.S.

- 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.
Working Of an F.M.S.

- 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.
Working Of an F.M.S.

- 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 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.
Working Of an F.M.S.

- 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.
Working Of an F.M.S.

- 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.
Working Of an F.M.S.

- 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.
Working Of an F.M.S.

• 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.
Working Of an F.M.S.

- *Simulation* is an important tool to test the part program of a new workpiece 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.
Working Of an F.M.S.

- 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.