Flexible Manufacturing System

L-17

Contents

What is FMS

- A flexible manufacturing system (FMS) is a highly automated GT machine cell,consisting of a group of processing workstations (usually CNC machine tools), interconnected by a automated material handling and storage system, and controlled by a distributed computer system
- The reason the FMS is called flexible is that it is capable of processing a variety of different part styles and quantities of production can be adjusted in response to changing demand patterns
- The FMS is most suited for the mid-variety, mid-volume production range

Three capabilities that a manufacturing system must possess to be flexible

1) The ability to identify and distinguish among the different part or product styles processed by the system
2) Quick changeover of operating instructions
3) Quick changeover of physical setup.

To qualify as being flexible, a manufacturing system should satisfy several criteria

1)Part variety test

2) Schedule change test

3) Error recovery test

4) New part test

Types of flexibility in manufacturing

[23], [26]

Flexibility Type	Definition	Depends on Factors Such As:
Machine flexibility	Capability to adapt a given machine (workstation) in the system to a wide range of production operations and part styles. The greater the range of operations and part styles, the greater the machine flexibility.	Setup or changeover time. Ease of machine reprogramming (ease with which part programs can be downloaded to machines). Tool storage capacity of machines. Skill and versatility of workers in the system.
Production flexibility	The range or universe of part styles that can be produced on the system.	Machine flexibility of individual stations. Range of machine flexibilities of all stations in the system.
Mix flexibility	Ability to change the product mix while maintaining the same total production quantity; that is, producing the same parts only in different proportions.	Similarity of parts in the mix. Relative work content times of parts produced. Machine flexibility.
Product flexibility	Ease with which design changes can be accommodated. Ease with which new products can be introduced.	How closely the new part design matche[s] the existing part family. Off-line part program preparation. Machine flexibility.
Routing flexibility	Capacity to produce parts through alternative workstation sequences in response to equipment breakdowns, tool failures, and other interruptions at individual stations.	Similarity of parts in the mix. Similarity of workstations. Duplication of workstations. Cross-training of manual workers. Common tooling.
Volume flexibility	Ability to economically produce parts in high and low total quantities of production, given the fixed investment in the system.	Level of manual labor performing production. Amount invested in capital equipment.
Expansion flexibility	Ease with which the system can be expanded to increase total production quantities.	Expense of adding workstations. Ease with which layout can be expande[d]. Type of part handling system used. Ease with which properly trained worke[rs] can be added.

Classification of FMS

1) According to processing operations
2) According to assembly operations
3) Number of machines
4) Level of flexibility

FMS Components

1) Work-stations
2) Material handling and storage system
3) Computer control system
4) People are required to manage and operate the system.

1) workstations

a) Load/ Unload Stations
b) Machining Stations
c) Other Processing Stations
d) Assembly
e) Other Stations and Equipment

2) Material Handling and storage System

Functions of the Handling System:

a) Random, independent movement of workparts between stations
b) Handle a variety of workpart configurations
c) Temporary storage
d) Convenient access for loading and unloading workparts
e) Compatible with computer control

3) Computer control system

The functions performed by the FMS computer control system:

a) Workstation control
b) Distribution of control instructions to workstations
c) Production control
d) Traffic control
e) Shuttle control
f) Workpiece monitoring
g) Tool control (i) Tool location (ii) Tool life monitoring
h) Performance monitoring and reporting
i) Diagonistics

4) Human Resources

FMS functions typically performed by humans include

(i) Loading raw workparts into the system
(ii) Unloading finished parts (or assemblies) from the system.
(iii) Changing and setting tools
(iv) Equipment maintenance and repair
(v) NC part programming in a machining system
(vi) Programming and operating the computer system
(vii) Overall management of the system

FMS applications

1) Flexible Machining Systems
2) Pressworking and forging

FMS Benefits:

1)Increased machine utilization
2) Fewer machines required
3) Reduction in factory floor space required
4) Greater responsiveness to change
5) Reduced inventory requirements
6) Lower manufacturing lead times
7) Reduced direct labor requirements and higher labor productivity
8) Opportunity for unattended production

FMS planning and implementation issues

a) FMS Planning and Design Issues

The issues are similar to those in GT machine cell planning. They include:

i)Part family considerations

(ii) Processing requirements

(iii) Physical characteristics of the workparts

(iv) Production volume

Contd.

(b) Important factors that must be specified in FMS design include:

(i) Types of workstations
(ii) Variations in process routings and FMS layout
(iii) Material handling system
(iv) Work in process and storage capacity
(v) Tooling
(vi) Pallet fixtures

FMS Operational Issues

a) Scheduling and dispatching
b) Machine loading
c) Part routing
d) Part grouping
e) Tool management
f) Pallet and fixture allocations

Quantitative analysis of flexible manufacturing systems

FMS analysis technique can be classified as follows: (i) Deterministic models (ii) queueing models (iii) Discrete event simulation (iv) other approaches, including heuristics

a) Bottleneck model:

The term bottleneck refers to the fact that the output of the production system has an upper limit, given that the product mix flowing through the system is fixed

Terminology and Symbols:

i) Part mix
ii) Workstations and servers
iii) Process routing
iv) Work handling system
v) Transport time
vi) Operating frequency

Contd.

b) Extended Bottleneck Model:

This extended model assumes queuing network in which there are always a certain number of workparts in the FMS

difficult, sometimes even worse). He called his approach the ***extended bottleneck model***. This extended model assumes a closed queueing network in which there are always a certain number of workparts in the FMS. Let N = this number of parts in the system. When one part is completed and exits the FMS, a new raw workpart immediately enters the system, so that N remains constant. The new part may or may not have the same process routing as the one just departed. The process routing of the entering part is determined according to probabilities p_j.

N plays a critical role in the operation of the production system. If N is small (say, much smaller than the number of workstations), then some of the stations will be idle due to starving, sometimes even the bottleneck station. In this case, the production rate of the FMS will be less than R_p^* calculated in Eq. (16.5). If N is large (say, much larger than the number of workstations), then the system will be fully loaded, with queues of parts waiting in front of the stations. In this case, R_p^* will provide a good estimate of the production capacity of the system. However, WIP will be high, and manufacturing lead time (MLT) will be long.

In effect, WIP corresponds to N, and MLT is the sum of processing times at the workstations, transport times between stations, and any waiting time experienced by the parts in the system. We can express MLT as follows:

$$\mathrm{MLT} = \sum_{i=1}^{n} WL_i + WL_{n+1} + T_w \tag{16.11}$$

where $\sum_{i=1}^{n} WL_i$ = summation of average workloads over all stations in the FMS (min), WL_{n+1} = workload of the part handling system (min), and T_w = mean waiting time experienced by a part due to queues at the stations (min).

WIP (that is, N) and MLT are correlated. If N is small, then MLT will take on its

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c) Sizing the FMS

16.4.3 Sizing the FMS

The bottleneck model can be used to calculate the number of servers required at each workstation to achieve a specified production rate. Such calculations would be useful during the initial stages of FMS design in determining the "size" (number of workstations and servers) of the system. The starting information needed to make the computation consists of part mix, process routings, and processing times so that workloads can be calculated for each of the stations to be included in the FMS. Given the workloads, the number of servers at each station i is determined as follows:

$$s_i = \text{minimum integer} \geq R_p(WL_i) \tag{16.22}$$

Contd.

d) What the equations tell us:

... the Equations Tell Us

Notwithstanding its limitations, the bottleneck model and extended bottleneck model provide some practical guidelines for the design and operation of FMSs. These guidelines can be expressed as follows:

- For a given product or part mix, the total production rate of the FMS is ultimately limited by the productive capacity of the bottleneck station, which is the station with the maximum workload per server.
- If the product or part mix ratios can be relaxed, it may be possible to increase total FMS production rate by increasing the utilization of non-bottleneck workstations.
- The number of parts in the FMS at any time should be greater than the number of servers (processing machines) in the system. A ratio of around 2.0 parts/server is probably optimum, assuming that the parts are distributed throughout the FMS to ensure that a part is waiting at every station. This is especially critical at the bottleneck station.
- If WIP (number of parts in the system) is kept at too low a value, production rate of the system is impaired.
- If WIP is allowed to be too high, then manufacturing lead time will be long with no improvement in production rate.
- As a first approximation, the bottleneck model can be used to estimate the number of servers at each station (number of machines of each type) to achieve a specified overall production rate of the system.