ARCHITECTURE OF FMS

Typical Elements of FMS

- Versatile NC machines equipped with automatic tool changing and inprocess gauging, with capability to carry out a variety of operations
- An automated Material Handling System (MHS) to move parts and tools under the control of a central MHS controller. The MHS may comprise conveyers, carts, individual robots, AGVS, or a combination of these elements
- Load/unload station through which the entry and exit of the parts occur. Entering parts are fixtured and loaded onto pallets, and departing parts are defixtured at these stations
- Inspection stations equipped with coordinate measuring machines
- Storage in the form of local buffers adjacent to the machines and/or centralized automatic storage and retrieval system (ASRS) for raw and semi-finished workpieces
- Tool magazines on the machine tool and a centralized tool store provide tool storage
- A Hierarchical Control System (HCS) to coordinate the working of FMS
  - HCS coordinate the working of machines, tools, and MHS and the movement of workpieces
  - HCS generally comprises a local area network interconnecting the programmable controllers (PCs) of the machine tools, MHS controller, the supervisory controller, and a DataBase Management System (DBMS)
  - DBMS contains part programs, scheduling information, tool database (tool type, tool life, remaining life), and route sheets

Typical routing table for an FMS with 5 machines and 3 part types

<table>
<thead>
<tr>
<th>Part type</th>
<th>Op # 1</th>
<th>Op # 2</th>
<th>Op # 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>M1/M2</td>
<td>M3</td>
<td>M4/M5</td>
</tr>
<tr>
<td>Type 2</td>
<td>M1/M2/M3</td>
<td>M2/M3</td>
<td>M5</td>
</tr>
<tr>
<td>Type 3</td>
<td>M1/M5</td>
<td>M4</td>
<td>M3/M2</td>
</tr>
</tbody>
</table>

Two Kind of Integration

- Material flow integration provided by the MHS and computer control
- Information integration provided by the Local Area Network (LAN)-based computer control system and DBMS

Typical Sequence of Operation

- Supervisory computer provides the information for the next workpiece to be fixtured onto pallets at a load/unload station
- Incoming raw workpieces are fixtured onto pallets at a load/unload station
- Based on the route sheet information the processing station is identified
- MHS move the workpieces to the workstation for processing
- Completed workpieces are moved from workstations to load/unload station to defixture
Automated workpiece flow

- The flowchart provides
  - The manner in which an FMS control system keeps the parts moving
  - The decisions to be made
  - Real-time, on-line control software requirements

Assumptions

- Normal operations
- Given batch and part-mix
- Appropriate part programs are resident in the NC machine tool or in the central computer
- Necessary tools are loaded into the tool magazine or available in the central tool store
- Workpieces of different part types are waiting at or nearby load/unload station
Fixturing

- When raw workpieces arrive at the load/unload (L/U) station for fixturing, the laser pen reads the bar code and is communicated to the central computer (CC).
- CC retrieves the route sheet for this part type from the DBMS.
- DBMS has updated the information regarding:
  - Status of all machine tools
  - Status of all AGVs, robots, and other MHS equipments
  - Tool location and tool lives
  - Fixture location and availability
- CC instructs the L/U station controller to perform the appropriate fixturing operation.
- On completion, a ‘job done’ message is sent to the CC by the L/U controller.

Entry into the FMS

- The part to introduce next and when is a flow control problem.
- Depending on the scheduling policies:
  - Static, Dynamic or real-time scheduling.

Static Schedule

- At a given time the available jobs are scheduled and a fixed schedule is obtained.
- Next schedule is prepared on completion of all the jobs in the current schedule.

Dynamic Schedule

- Schedules are prepared considering the jobs arriving at various times.

Real-Time Schedule

- Scheduling decisions are based on the actual state of the system.
- Such as failed machines, raw material available, pallet and fixtures available, alternate route possible, traffic congestion, deviation from desired production rates, etc.

Certain situation depended scheduling decision are

- Part type has to be produced in a certain relative ratio, say for subsequent assembly purpose.
  - Like \{type 1, type 2, type 2, type 3, type 1, type 3\}; \{type 1, type 2, \ldots\}
  - This may suitable for dedicated types of FMS.

Closed-system mode operation

- When a pallet comes out of the system, a part is chosen that can be fixtured onto the pallet and the pallet with the fresh part is sent.
- If more than one part type can use a given pallet type, the part type that is most behind in production is generally chosen.
- Discrete event simulation is a suitable tool to analyse various strategies.
Raw parts available

Select next part type and the next part of this type for loading

Fixture/pallets available

Fixture the next part to be loaded

Transport part on AGV

Machine ready?

Tool ready?

A

B

C

Machine ready?

IB Free?

Wait for IB

Fetch tools

Yes

No

No

Yes

No

Yes

Wait in IB

Wait for AGV

Wait for fixtures/pallets

Wait until raw parts arrive

No

Yes

Yes

Yes

Yes
ENTRY INTO THE FMS

• The part to introduce next and when is a flow control problem
• Depending on the scheduling policies

No

Yes

A

Machining of part

Inspection of part

Part OK?

No

Yes

B

Rework possible?

No

Yes

Discard part

C

OB free?

No

Yes

Wait for OB

Wait in OB

More operations?

Yes

No

AGV ready?

No

Wait for AGV

Yes

Transport, defixture, and unload the finished part

IB – Input Buffer, OB – Output Buffer

Fig. 2 Flowchart for the automated operation of FMS
Static Schedule
- At a given time the available jobs are scheduled and a fixed schedule is obtained
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Material Handling and Machining
- CC finds the machine based route sheet, status of machines, number of parts waiting in front of each machine
- To select the machine for processing, the computer may use any of the following rules (machine loading problem)
  - Choose the machine, which is idle, and among the idle machine choose the fastest
  - If all machines are busy, choose the machine with the least number of parts waiting

Material Handling
- Part waits at the L/U station until the input buffer of the selected machine is free
- Computer sends the transporter to move the fixtured workpiece to the chosen workstation
- In front of the workstation, the CC actuates the transfer mechanism (Shuttle) and the workpiece is shifted from the transporter onto the shuttle
- Workpiece waits until the work currently being machined is completed and in-process inspection done
- Now the two parts and their pallet exchange positions
• When tools and part program are ready machining take place
• Finished part, now on the shuttle or the output buffer, waits for the transporter
• If the destination machine is not free then the transporter may unload the semi-finished workpiece in a central storage area for retrieval when the destination station become free

Defixturing
• When all the required operations are carried out, the workpiece is transported to the L/U station
• Part is removed from the fixture and the fixture is stored until needed

Intelligence incorporated at CC helps to take following decisions
• When to introduce a part type into the system and which part to introduce
• The routes along which the parts to be sent
• Which job to be loaded next on a workstation from among those waiting in the local or central buffer area
  ➢ Shortest processing time, arrived first, earliest due date, most behind schedule, etc
• Which AGV to be scheduled for pickup or which part to be picked up by the AGV

AGV Dispatching Rules

Vehicle assignment
• Selection of a vehicle from a set of idle vehicles to pick up a workpiece from machine centre

Machine centre assignment
• Selection of a machine centre from a set of machine centres simultaneously requesting service vehicles

QUESTIONS:

1. What are the typical elements in a FMS?
2. What are the situations suitable for application of FMS?
3. Describe the typical sequence of operation of a FMS.
4. What kinds of integration exist in an FMS? What components of the FMS make this integration possible?
5. What are the general types of integration present in an FMS and how is it achieved?
6. Distinguish between static, dynamic and real-time scheduling in FMS.
7. What are the scheduling policies used in an FMS? Explain.