INTRODUCTION TO MODERN MANUFACTURING SYSTEMS

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LECTURE GOAL

Discuss general characteristics and design principles of modern manufacturing systems:

• FMS
• CIM
• Agile Manufacturing

Manufacturing Concepts: Brief History

• FMS (early 1980’s)
• CIM (late 1980’s)
• Agile Manufacturing (US) (mid 1990’s)
• Fractal (Germany)
• Biological (Japan)

Modern Manufacturing System (MMS) = a universal term

Modern Manufacturing System (MMS)

Manufacturing Concepts: Recent Concepts

• virtual manufacturing
• e-manufacturing
• digital manufacturing

FUNCTIONAL AREAS IN MANUFACTURING

BUSINESS INFORMATION SYSTEM

CAD
-Part and product design

CAPP
-Process planning

CAM
-Programming

CAQE
-Design of experiments

ASR
-Automated storage and retrieval

Tool and fixture design

Machining

Assembly

Maintenance

Process control

Inspection

Functional Area

Question:

What are the benefits and pitfalls of separation of manufacturing into functional areas?
Benefits: Simplicity, sharing common values, …

Pitfalls: Inefficiency due to interfaces

Eliminate interfaces by merging different functional areas (e.g., product and process design = process engineering)

Is standardization helping or preventing proliferating of information systems?
Observations

O1. INCREASED DEGREE OF AUTOMATION

- Robots
- AGVs
- Computer control

http://www.activmedia.com/

O2. REDUCED NUMBER OF MACHINES

OLD SYSTEM  NEW SYSTEM

M1  MC1  AGV
M2  MC2
M3  M4

EXAMPLE: System layout

Automated Storage and Retrieval System

Machining Cell 1  Machining Cell 3  Functional Machining Facility

Assembly Cell 1  Assembly Cell 2  Assembly Facility

O3. LAYOUT PATTERN DETERMINED BY MHS

Linear Single-Row  Circular Single-Row

Linear Double-Row  Multi-Row

AGV  Automated Guided Vehicle  R  Robot  Machine

M1  M2  M3  M4  RACKS

M8  M7  M6  M5

Machines arranged along racks of an ASRS

http://www.knapp.com/
O4. DECREASED NUMBER OF SETUPS

New Paradigm:
Divide a manufacturing task into small number of larger subtasks so that the number of setups can be reduced

EXAMPLE: Three-Dimensional Part

Classical Process Plan

<table>
<thead>
<tr>
<th>Setup number</th>
<th>Machine number</th>
<th>Operation</th>
<th>Volumes to be removed</th>
<th>Required tools</th>
<th>Required fixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M1</td>
<td>Milling</td>
<td>v₁,v₄</td>
<td>T₁,T₂</td>
<td>F₁</td>
</tr>
<tr>
<td>2</td>
<td>M2</td>
<td>Drilling</td>
<td>v₂,v₃</td>
<td>T₃,T₄,T₅</td>
<td>F₁</td>
</tr>
<tr>
<td>3</td>
<td>M1</td>
<td>Milling</td>
<td>v₅</td>
<td>T₆</td>
<td>F₁</td>
</tr>
<tr>
<td>4</td>
<td>M4</td>
<td>Milling</td>
<td>v₆</td>
<td>T₇</td>
<td>F₂</td>
</tr>
<tr>
<td>5</td>
<td>M3</td>
<td>Milling</td>
<td>v₇</td>
<td>T₈</td>
<td>F₁</td>
</tr>
<tr>
<td>6</td>
<td>M4</td>
<td>Drilling</td>
<td>v₈</td>
<td>T₉</td>
<td>F₃</td>
</tr>
</tbody>
</table>

Process Plan for a Modern Manufacturing System

<table>
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<tr>
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<tbody>
<tr>
<td>1</td>
<td>MC1</td>
<td>Milling and Drilling</td>
<td>v₁,v₂,v₃,v₄</td>
<td>T₁,T₂,T₃,T₄</td>
<td>PF₁</td>
</tr>
<tr>
<td>2</td>
<td>MC2</td>
<td>Milling and Drilling</td>
<td>v₅,v₆</td>
<td>T₅,T₆</td>
<td>PF₂</td>
</tr>
</tbody>
</table>

Question:
What is an ideal manufacturing system from the reduced number of setups point of view?

Answer:
Raw material → Machine → Final part
O5. INCREASED PROCESSING TIME PER LOAD

- More than one part on a fixture
  [http://www.royalworkholding.com/default.htm]
- More operations performed on one part on one machine

Benefit:
Decreased unit machine loading/unloading time

O6. INCREASED VOLUME AND FLOW OF INFORMATION

- New resources, sensors, robots, etc.
- Increased need for monitoring and decision making

O7. BATCH SIZE IS DETERMINED BY CONSTRAINTS, E.G., CAPACITY OF FIXTURES, ORDER SIZE, AND SO ON

- Reduced order size
- High cost of fixtures

O8. OPERATIONAL CHARACTERISTICS OF A MANUFACTURING SYSTEM ARE TO A LARGE DEGREE DETERMINED BY ITS DESIGN

Which design is superior?

[1: Machine center
2: Fixture
3: Robot
4: Pallet
5: Pallet with fixture
6: Conveyor]

[http://www.royalworkholding.com/default.htm]
[http://www.handlinginnovations.com/homePallets.php]
Do the observations discussed apply to other processes besides machining? If yes, give examples.
Advantages
• a backup set of tools is available
• a backup machine is available
• tool handling system is simple

Disadvantages
• more than one set of identical tools is required
• identical NC programs are stored in more than one machine
• high tool magazine capacity is required

Advantages
• a backup set of tools is available
• NC program is stored in one machine only
• tool handling system is simple

Disadvantages
• more than one set of identical tools is required
• no backup machine
• high tool magazine capacity required
Type 4 Tool Assignment

Tool storage and handling system (TSHS)

Tools in TSHS: subset of \{t_1, t_2, t_3, t_4, t_5, t_6\} + set of alternative tools

1 + copy of each tool

TOOL STORAGE DEVICES AND SYSTEMS

http://www.hanel.us/pc/ie/index_ie.htm

Conclusion

- Design of a manufacturing system impacts its operations
- Products and components should be designed for manufacturing as well as a manufacturing system should be designed for the products and components