CELLULAR MANUFACTURING SYSTEM

- A cellular manufacturing system (CMS) is one in which production shop is partitioned into production cells, each dedicated to the production of part families with similar processing requirements
- By dedicating a machine cell to the production of part family, many of the efficiencies of mass production can be realized in a less repetitive batch environment
- Group of machines used to produce the family of parts forms a cell
- Generic fixtures are possible as a cell process a family of parts
- Tools can be stored locally since a part will always be processed through a given machine
- Set-up-time reduction by using part family tooling and sequencing

Setup Time Reduction Results In:

  saving in machine and labour time,
  reduced inventory cost and storage space – reduced WIP and finished goods inventory,
  reduction in throughput time – waiting time reduction
  batch size become small
  better material coordination

Numerical Demonstration of Effect of Setup Time Reduction on WIP and Waiting Time

- Consider a system where jobs arrive in batches of 50 units. Assume that the system process two jobs (A and B) intermittently. Setup time for each job = 1 hour, Processing time of 50 units = 3 hours. A job is sent out after processing all units of a batch. That is, transfer batch size is equal to production batch size. Assume that both jobs have same setup and processing time.
- After 4 hours of arrival of job A, the next job B arrives. If the jobs are arriving in the sequence A first and then B, in a duration of 8 hours two jobs (two batches) are out.
- WIP = 50 units, Waiting time in system = 4 hours
- If the setup time is reduced by half, and the jobs arrives in batches of 25, for the same duration
  - WIP = 25 units, Waiting time in system = 2 hours
- Initially the system process two batches of jobs within the 8 hours duration. Later, in the same duration 4 batches of jobs are processed. i.e. production rate of batches of jobs increased (doubled) but the actual production rate in terms of units manufactured is not changed
Demonstration Using Mathematical Model

- Assume that set up is cut in half
- For the same amount of production the batch size can be cut into half
- If batch interval arrival time and service time are exponentially distributed, then the workcell can be modelled as M/M/1 queue
  
  Arrival rate $\lambda$
  
  Service rate $\mu$
  
  Utilisation $\rho = \frac{\lambda}{\mu}$

\[
W = \frac{\rho}{\lambda(1 - \rho)}
\]

- Assume that above are the parameters before setup reduction and after the setup time reduction the parameters be $\lambda' = 2\lambda$ and $\mu' = 2\mu$
- Utilisation is not changed
- Waiting time $W' = \frac{\rho}{\lambda'(1 - \rho)} = \frac{1}{2}W$

An Illustration of inventory reduction

- Make-to-stock environment can now become just-in-time environment as a result of set up time reduction

For instance,

- The monthly requirement of an item were produced earlier
- After set up time reduction it can be produced on weekly basis.
- This reduces finished goods inventory by 75 percent and is likely to reduce the safety stock by 50 percent

- Let us assume that monthly requirement be 2000 units
- Average cycle inventory is 1000 units
- (Cycle inventory is the average on-hand inventory due to production batches of more than one unit)
- After set up reduction the production batch size is 500 units
- Average cycle inventory is 250 units
- A reduction in cycle inventory of 75% is obtained
Safety stock calculation

- Safety stock is often taken as a multiple of the standard deviation of demand in the uncertainty period.
- Assume that the uncertainty period is one month before setup reduction and after the setup reduction the uncertainty period is reduced to one week.
- Assume independent weekly demand, then monthly demand variance would be four times weekly variance.
- Monthly standard deviation is twice the weekly standard deviation.
- For instance weekly standard deviation is 50 units, then monthly standard deviation is 100 units.
- If safety stock is 1.26 times the standard deviation, the safety stock before and after setup reduction are 126 and 63 respectively.
- Safety stock is reduced by 50% after setup reduction.

Some More Features of CMS

- In a cell machines or processes are located in close proximity, and it assists in simplifying production schedule and control, and implementation of visual production control procedure like kanban.
- Cellular configuration is suitable for a repetitive production environment.
- All these indicate that cellular manufacturing and JIT go hand in hand.
- In a JIT system of manufacturing, cell uses pull production methods.
- Pull production requires repetitive manufacturing, that is, fairly smooth continuous production of somewhat standardised items.
- Cellular manufacturing system create conducive environment for team work.
- Allows each work group to deal with problems that arise within its boundaries.
- Permits different role for the worker.

The cellular manufacturing system design problems are concerned with:

1) Grouping of parts or Part family formation.
2) Design of a cellular layout.
3) Design of a machine layout.

Grouping of parts or Part family formation

Grouping can be achieved by:

1. **Visual inspection** - using best judgment to group parts into appropriate families, based on the parts or photos of the parts.
2. **Production flow analysis** - using information contained on route sheets to classify parts.
3. Parts classification and coding – identifying similarities and differences among parts and relating them by means of a coding scheme

Production Flow Analysis

- Burbridge proposed the Production Flow Analysis (PFA)
- It is a technique for simplifying material flow systems
- PFA consists of five sub-techniques used progressively to simplify the material flow system in an enterprise
- The sub-techniques are
  - Company flow Analysis (CFA)
  - Factory Flow Analysis (FFA)
  - Group Analysis (GA)
  - Line Analysis (LA) and
  - Tooling Analysis (TA)
- Company flow Analysis (CFA): analyses the existing flow of materials between the different factories in a large company and develops a new, simpler and therefore more efficient system in which each factory completes all the parts it makes.
- Factory Flow Analysis (FFA): studies each factory in turn. It plans the division of the factory into major groups or departments each of which completes all the parts it makes, and it plans a simple unidirectional flow system joining these departments.
- Group analysis (GA): uses matrix resolution to divide each department in turn into groups, each of which completes all the parts it makes.
- Line analysis (LA): analyses the flow of materials between the machines in each group to find the information needed for plant layout.
- Tooling analysis (TA): studies each machine in each group in turn, in order to find “tooling families” of parts which can all be made on the machine with the same set of tools at the same setup and also to find the sequence of loading which will minimize setup times.
- PFA is a systematic procedure for dividing the complete organization
- Identification of part families and machine groups is one of the steps in PFA
- The identification of part families and machine groups is commonly referred to as cell formation
- Consider cell formation as a reorganization of an existing job shop into GT shops using information given about the processing requirements of parts
• The processing requirement information used are generally two types:
  Machine-part matrix or process matrix and
  Route matrix

**Machine-Part Matrix**

• Machine-part matrix contain zero, one data
• If a part visit a machine, the part machine interaction element is 1, otherwise 0

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**Fig. 1 Machine-part matrix**

**Route Matrix**

• This matrix shows the machine required for a particular operation of a part
• For example, the operation 3 of part 1 is carried out in machine 5

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**Fig. 2 Route matrix**
QUESTIONS:

1. Define a cellular manufacturing system.

2. How does the setup reduction affect batch size, cycle inventory and safety stock?

3. Jobs arrive to a production system at the rate of one job per two hours and the jobs are serviced at the rate of two jobs per three hours. A job is a batch of 10 units and the setup time is 30 minutes. The company undertakes setup time reduction measures and as a result, the setup time is reduced by one third.
   
   a) What is the saving in waiting time if the jobs arrive at the same rate?
   
   b) How many jobs waiting in the system are reduced as a result of setup time reduction?
   
   c) Find the improvement in waiting time as a result of setup time reduction?
   
   d) What is the utilization of the production facility?

4. Illustrate using queuing theory the effect of setup time reduction in waiting time of jobs in a production shop.

5. How does a cellular manufacturing system maintain variety in the customers point view, and reduces variety in the production point view?

6. What are the ways the setup reduction possible when a batch production system is converted into cellular manufacturing system?

7. What is a cellular layout? What is its advantage over other types of layout?

8. List the major steps involved in the production flow analysis