Pearson BTEC Levels 5 Higher Nationals in Engineering (RQF)

Unit 48:
Manufacturing Systems Engineering

Unit Workbook 1

in a series of 1 for this unit

Learning Outcome LO1 to LO4

Manufacturing Systems Engineering

5 MANUFACTURING SYSTEM ELEMENTS

5.1 What is System?

- A group of components, working together, have same goal
- Inputs: outputs
- Has regular/orderly interactions or interdependence
- Systematic, observable and measurable.

5.2 System Environment

- Exists in its "world"
- Affected by environment, i.e. elements outside the system
- Boundary –separate the system with its environment
- Boundary is defined base on system's purpose(s)

5.3 System Diagram

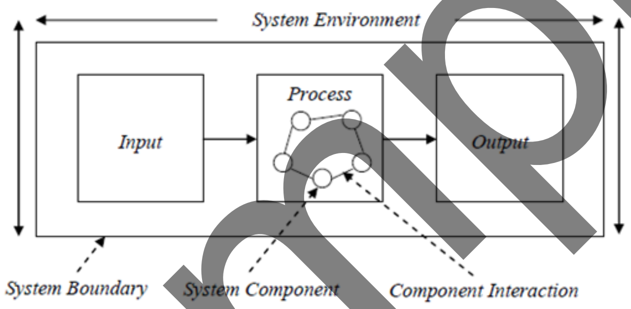

Figure 5:1 System Diagram

5.4 Elements of a System

- **Entities**: objects/components in the system.
- **Attributes**: Entities' properties that describe them.
- Interactions between the entities: **Activities** and **Events**
    - o Event: occurring instantly
    - o Activity: has a duration, begin-end, start-finish
- **State of a System**: system's snapshot at any time

5.5 Endogenous and Exogenous Events and/or Activities

- Endogenous: events and/or activities occurring within a system
- Exogenous: events and/or activities in the environment that affect the system

5.6 Examples of Systems & Their Components

System	Entities	Attributes	Activities	Events	State Variables

Banking	Customers	Account Balance	Making Deposits	Arrival, Departure	Number of busy tellers, Number of customers waiting
MRT	Passengers	Origin, Destination	Travelling	Arrive at Station, Arrival at Destination	Number of passengers waiting at a station, Number of passengers on a train
Communication	Messages	Length, Destination	Sending,	Arrival at destination	Delivered, Read
Inventory	Warehouse	Capacity	Withdrawing	Demand	Levels of inventory, Backlogged demands
Production	Machines	Speed, Capacity, Breakdown Rate	Stamping, Drilling	Breakdown	Status of machines (busy, idle, or down)

Figure 5:2 Examples of Systems and Components

5.7 Manufacturing as a System

- Manufacturing: Transformation of material into something more useful and valuable
- Manufacturing System: A set of machines, transportation elements, people, storage, computers, and other items that are used together for manufacturing
- Should be designed, operated and treated as a system to run most effectively

5.8 Types of Manufacturing System

- A complex system
- The system types do overlap
- Terminology, notation, basic assumptions are not standardized
- Could be divided from five perspectives:
  1. Product Type: Discrete Manufacturing and Continuous Process
  2. Product Variety: Single-Model and Multiple-Model
  3. Production planning/control: Make-to-stock Vs. Make-to-order
  4. Facilities Layout: Product layout, Process layout, Cellular Manufacturing/Group technology, and Fixed position
  5. Material flow: Assembly line, Batches, Buffers and JIT/Kanban

5.8.1 Discrete Manufacturing Vs. Continuous Process

Discrete Manufacturing	Continuous Processing
• Produce individual part/product that easily distinguishable • Example : Electronic Manufacturers, Automotive Manufacturers • Concerned with scheduling, material control and labor assignment	• Operate on product that continually flowing • Example : Chemical Industries, Oil Refineries • Capital intensive and concerned with capacity

Figure 5:3 Discrete versus Continuous Processes

5.8.2 Single Model Vs. Multi Model Manufacturing

- Capability of the system in producing variety of products or parts
- Two types: –Single-model type:
- Identical parts or products –Multi-model type:
- Batch-model: system produce different parts or products in batches therefore changeovers are required
- Mixed-model: system produce different parts or products but no need changeover: Flexible Manufacturing System

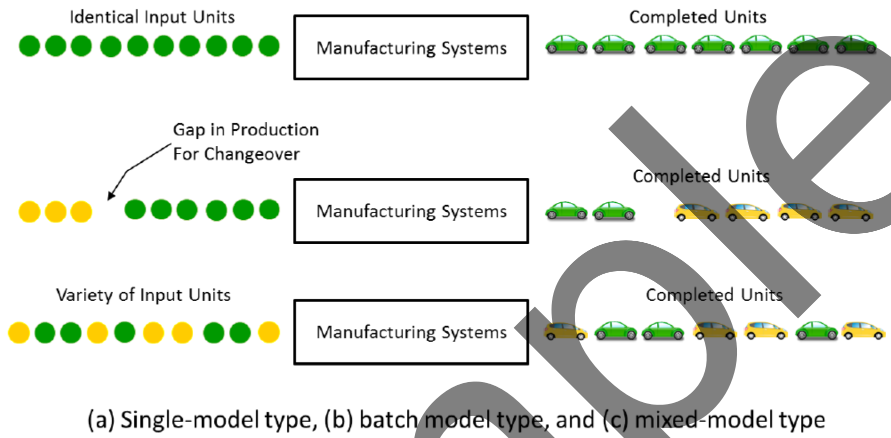

Figure 5:4 Single Model Vs. Multi Model Manufacturing

5.9 Flexible Manufacturing System

- Enable flexibility in multi-model manufacturing system
- Need a set of computer numerical control (CNC) machine tools
- Need automated material handling system to connect workstations
- Called **Flexible** because it is able to process a variety of different parts/products at same time at the various workstation and the mix parts/products variety and quantities can be adjusted in response to changing demand pattern

5.9.1 What Make It Flexible?

Three capabilities that a manufacturing system must have to be **Flexible**:

- The ability to identify and distinguish among the different part/product configurations and processes
- Quick changeover of operating instruction
- Quick changeover of physical setup

5.9.2 Key Elements of an FMS

- Automatic programmable machines
- Automated tools for:
  - Delivering material or parts
  - Changing the process or route
  - Setup machines
- Automated material handling:
  - For transferring and
  - For loading and unloading
- Coordinated control

5.10 Make-to-Stock Vs. Make-to-Order

Make-to-Stock	Make-to-Order
• Produce according to a periodic forecasted demand and sell the product to any incoming customer who wants to buy them • Example : Consumer Product Production • Concerned with sales history, inventory level and supply chain management	• Specially produce and deliver a product for a customer's order • Example : Production of Designer Jewelry, Production of Aeroplanes, Production of Special type of steel, High end instruments and vehicles etc., • Concerned with product specification/configuration, project management and delivery date target

Figure 5:5 Make-to-Stock Vs. Make-to-Order

5.11 Product Layout

- Design for a specific product
- The product flow from first machine to the second, from second to third and so on
- Upon completing processing at the last machine, the raw material has been converted into a finished product

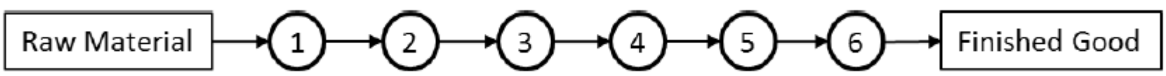

Figure 5:6 Product Layout

5.11.1 Process Layout

- Machines have similar capabilities and perform similar functions are grouped

- Product could follow various process routing
- Typical process is job order
- Configuration and specification of product could be varying from one to another

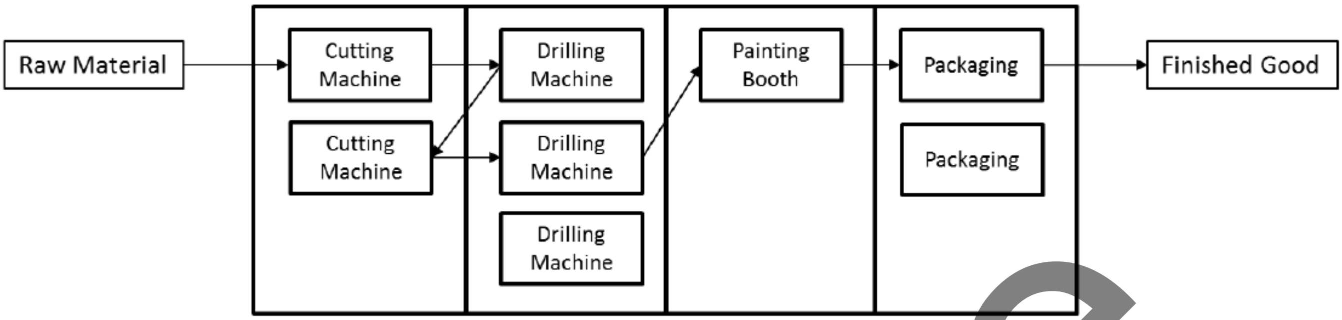

Figure 5:7 Process Layout

5.11.2 Group Technology Layout/Cellular Manufacturing

- Can be used to convert otherwise process layout system to pseudo product layout environments
- Similar parts are grouped together in sufficient quantity to justify their own machines
- A cell then laid out to produce just this set of parts
- Potentially as important a technological innovations as numerical control and robotic

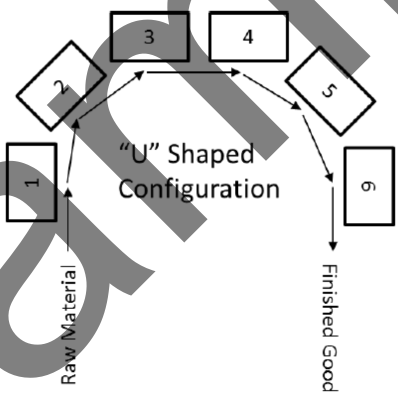

Figure 5:8 U-shaped configuration

5.11.3 Fixed Layout

Figure 5:9 Example of a Fixed Layout configuration

5.11.4 Assembly Line

- A set of sequential workstations, typically connected by a continuous material handling to transfer materials and parts
- The materials and parts are passed down the line, visiting each station in sequence to make a finished product
- The line is designed to assemble component parts and perform any related operations necessary to produce a finished product
- Upon completion of assigned tasks on an item/a part, the work station passes it to the next work station, obtain a new item/part from predecessor work station and repeat the tasks

5.11.5 Batches

- Products are produced in groups instead of in continuous streams as they are on assembly lines
- A specific process for each item takes place at the same time on a batch of items, and that group does not move onto the next stage of production or inspection until the whole batch is done.
- This type of production is necessary when a manufacturer is producing similar things, but with variants.
- Making in batches reduces unit costs, use of specialist machinery & skills can increase output and productivity
- Time lost switching between batches –machinery may need to be reset, need to keep stocks of raw materials. Cash also investment in work-in-progress

5.11.6 Buffers

- Provide or release materials before its schedule
- The purpose of buffer is to protect the system, meaning to ensure the system still running or operate when there is failure on one or more of its components/resources

- Buffer should be applied to constraint resources only
- Buffers are placed in front of the governing constraint, thus ensuring that the constraint is never starved.
- Buffers are also placed behind the constraint to prevent downstream failure from blocking the constraint's output
- Concern with buffer management –buffer quantity and buffer duration

Figure 5:10 Assembly Line Buffers

5.11.7 JIT/KANBAN

- Also known as Pull System or Lean Manufacturing
- Produce only exactly what needed, when need it and in the needed quantity
- Producing based on customer's order in small lot size (Ideal Lot Size = 1)
- Parts and materials are requested and delivered as they are needed.
- Materials & parts are pulled into the production operation when needed.
- Use KANBAN to move material/parts and produce products

5.11.8 Another Perspective

Another classification of manufacturing system is from automation and manning level of the machines/equipment perspective

- Manually operated machines are controlled or supervised by a human worker
- Semi-automated machines perform a portion of the work cycle under some form of program control, and a worker tends the machine the rest of the cycle
- Fully automated machines operate for extended periods of time with no human attention (This classification will lead to what we call Computerized Integrated Manufacturing (CIM) and Computerized-Aided Manufacturing (CAM))

5.12 Model of a System

To Study Manufacturing System, It Is Necessary to Develop Manufacturing Model Accordingly

- The representation of a system in some form other than the form of the system itself
- Modeling involves observing a system, noting the various components, then developing a representation of the system that will allow for further study of or experimentation on the system
- Why Model?
- Training or instruction
- To aid thought
- To aid communication
- Prediction
- Experimentation

- To aid decision making process

5.12.1 Types of Models

- Physical: an actual representation
- Schematic: a pictorial representation
- Descriptive: a verbal description
- Mathematical: components are described mathematically, in the form of equations
- Heuristics: descriptive model based on rules; algorithmic; computer based

6 MAINTENANCE PLANNING AND SCHEDULING

6.1 Eight Steps to Success in Maintenance Planning and Scheduling

Maintenance Planning and Scheduling are key elements that influence the true success of any organization. Many times, we have a planner or planner/scheduler, but do not know how to use him or her effectively or efficiently. When we talk about maintenance planning, we are talking about "higher wrench time", as the Americans call it. At this time of economic uncertainty, a higher wrench time equals lower cost, which results in job security for all. Past studies have shown that most companies do not perform maintenance planning effectively thus impacting negatively work effectiveness, wrench time, equipment uptime, equipment reliability, and cost. If we were "Effective in Maintenance Planning", it would result in Higher Wrench Time and Higher Equipment Reliability.

In Maintenance Scheduling, once we have achieved the discipline required and maintenance plans are completed on time the reliability of facilities and assets increase at a high rate.

Let's take a moment to look inside of what a proactive maintenance planner/scheduling role looks like.

Figure 6:1 Without Proper PM Proactive Work is not achievable

6.1.1 Where does proactive work come from?

Proactive Work Orders or Request comes from an effective preventive maintenance and effective condition monitoring program. Here is how it breaks out:

- PM Execution: 15% of Work
- Results from PM Execution: 15% of Work (Typically identify Functional Failures)

A Functional Failure (High or Critical Defect Severity – very little, if any time to plan and schedule proactive work) is the inability of an item (or the equipment containing it) to meet a specified performance standard and is usually identified by an operator

- Condition Monitoring Execution: 15% of Work
- Results from Condition Monitoring: 35% of Work (Typically, indentify Potential Failures)

A Potential Failure (Low Defect Severity- time to plan and schedule proactive work) is an identifiable physical condition which indicates a functional failure is imminent and is usually identified by a Maintenance Technician using condition monitoring or quantitative preventive.

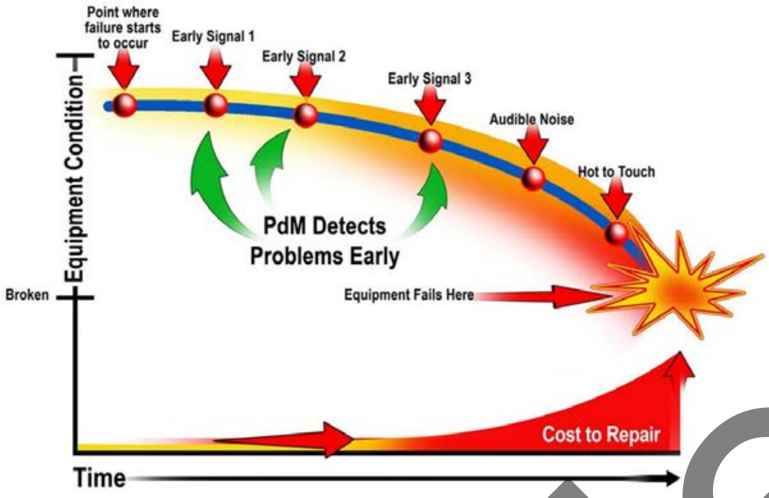

Figure 6:2 Preventive Maintenance (PM) Vs Condition Based Maintenance (CBM)

Prior to the beginning of the maintenance day shift:

The maintenance planner's day starts before the regular maintenance day shift in order to review the work orders that came in overnight. The planner will make an estimate of the man-hours, number of personnel and craft types needed for any emergency work orders that must be started that day then, move those work orders directly to the maintenance crew followed by a quick phone call to notify the maintenance supervisor responsible for that area of the plant. The planner will also code these jobs as Emergency work orders, so the level of this type work can be tracked over time. Application of well-disciplined proactive maintenance strategies (PM/CBM) coupled with effective planning and scheduling will make these emergency jobs fewer and fewer over time.

The planner should also use good planning and scheduling techniques on his own responsibilities. Once any emergency work has been estimated and sent to the maintenance crew, the maintenance planner will plug new work requests into his/her field inspection schedule. Some jobs may need to be worked into today's field inspection schedule in order to be put on tomorrow's maintenance schedule. Other new requests can be scheduled for field inspection and planning later in the week. It is important for a proactive planner to schedule all of his jobs (other than emergency work) for field inspections on a particular day to be most effective. The planner will also set planning status for these new requests to "Planning" to show planning is underway.

Early Morning:

Field inspections – Next, armed with an inspection schedule, Job Inspection forms, and a camera, the planner will begin making his/her inspection of all of the job sites. The planner has established a logical route to minimize travel time and will make notes of the specific needs of the request, any ancillary work that should be completed by the mechanic while at the job site, and all of the other applicable information required for a well-planned job. The planner will make note of the complexity and predictability of the various issues relative to the particular job in order to create a job plan most effective yet suited to the particular job. Also, the planner will pay particular attention to job issues where significant delays were identified in the Wrench Time study. Understanding and watching for complexity, predictability, and likely wrench time losses will enhance the likelihood of creating a job plan that will minimize delays during execution and result in a high performing work force. More on these topics can be found in the 3rd edition of "Planning and Scheduling Made Simple", Smith and Wilson.

Immediately after completing field inspections is a good time to start ordering parts, or at least creating a list of parts to order, depending on the time available before meeting with the supervisor, scheduler, and maintenance coordinator. In particular, identifying the parts that will require more than 24 hours to obtain will be important. These parts should be ordered today, and the status should be changed to "Waiting Parts". At this point in the process, it is not known when the job will actually be scheduled so, any parts not on site should be ordered on the same day they are identified as a need. Parts that are available from the storeroom should be put on reserve so that they will be available for ordering the day before the job is scheduled for execution. The planner will also need to review the status of parts previously ordered and update the status to "Ready to Schedule" on the work request where all parts have arrived, and storeroom parts are all on reserve. Some organizations go ahead and have storeroom parts delivered and placed in Parts Kit boxes for each job. This process can work fine however, one drawback is when jobs get pushed to the future for execution, you can end up with a lot of Parts Kits to keep track of or, you can end up sending some stuff back to the store room if jobs get cancelled for whatever reason. If you have a firm parts reservation system, it will be the best of both worlds where the parts can't be bought out for a different job, yet if the job gets cancelled it doesn't have to be returned. Less handling and better inventory accuracy provided by the reservation approach will reduce cost

Working from the Job Inspection Form, the planner will identify the various needs required by the jobs and will start documenting the job plan. First and foremost is the Job Summary page which will contain the basic information that a fully qualified mechanic, who is very familiar with this type of job would need. The Job Summary would provide reference numbers to the detailed information for the job which would follow in the job plan. This type of job plan format will allow those familiar with the task to quickly review the job only using the summary sheet. Anyone less familiar or skilled would have references on each item on the job summary sheet to the specific section of the job plan to access the specific information they need. This provides maintenance personnel with quick access to the information they need without having to read through information they don't need.

All free time that the planner has should be spent refining and permanently documenting job plans. As the planner's job plan database grows, he/she will have more and more plans that can be used on future jobs with only minor refinements. This will allow the planner to plan for a greater number of field maintenance personnel. As job plans are completed, the planner should update his/her backlog status to "Planning Complete". When all parts not available through stores have been received and the storeroom parts are on reserve, the status should be changed to "Ready to Schedule", assuming the job plan has been completed. The Scheduler will initiate the delivery of storeroom parts on reserve the day before the job is scheduled for execution.

Late Morning:

Planner meets with the maintenance supervisor, scheduler and maintenance coordinator:

Now armed with the information gathered during the field inspection route, processing parts needs and updating the status on jobs that have received some or all of the parts ordered, the planner should meet with the maintenance supervisor, scheduler and coordinator. The planner should bring a copy of the

7 MANUFACTURING SYSTEMS ANALYSIS

7.1 Performance Indicators

Challenge

You are required to undertake your own research on Performance Indicators. However, you may find the following links useful;

https://en.wikipedia.org/wiki/Performance_indicator

http://blog.lnsresearch.com/blog/bid/188295/28-manufacturing-metrics-that-actually-matter-the-ones-we-rely-on

http://isoconsultantpune.com/lean-enterprise/

https://www.solufy.com/blog

7.2 Lean

Many companies today are becoming lean enterprises by replacing their outdated mass-production systems with lean systems to improve quality, eliminate waste, and reduce delays and total costs. A lean system emphasizes the prevention of waste: any extra time, labour, or material spent producing a product or service that doesn't add value to it.

A lean system's unique tools, techniques, and methods can help an organization reduce costs, achieve just-in-time delivery, and shorten lead times. A lean enterprise fosters a company culture in which all employees continually improve their skill levels and production processes. Because lean systems are customer focused and driven, a lean enterprise's products and services are created and delivered in the right amounts, to the right location, at the right time, and in the right condition.

Products and services are produced only for a specific customer order rather than being added to an inventory. A lean system allows production of a wide variety of products or services, efficient and rapid changeover among them as needed, efficient response to fluctuating demand, and increased quality.

The Philosophy:

Consider the following Venn Diagram. Two circles, one inside of the other. The large circle represents the Value Stream (all of the activity and information streams that exist between the raw material supplier and the possession of the customer). The smaller circle represents Waste (Cost without Benefit)