**Operations Management**
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**Lecture – 25**
**Tools and Techniques used for Plant Layout Planning**

[FL] friends, welcome to session 25 in our course on Operations Management. Currently we are in week 5 of our discussion on the topic and in week 5, we are covering the Plant Layout. In the previous 4 weeks, we have covered the fundamental aspect of operations management, the functions, scopes; scope of operations management. We have covered product design and development and various aspects related to product design such as value engineering and also we have covered design for manufacturing, design for assembly principle of ergonomics and then, we have covered rapid prototyping.

In week 3, if you remember we have seen sales forecasting; qualitative and quantitative methods of forecasting. And in week 4, we have seen plant location and factors affecting plant location. In week 5, we are covering plant layout. Now, if you see the overall story that we have built till today, we have try to understand that what the organization is required to make in order to be successful and how to decide the quantity that has to be made in order to be successful. And finally, we have seen that once you have decided what you have to make how much you have to make? Finally, we are saying that how to make it. How to make it we have seen plant locations that how or what are the factors responsible for selecting a specific location for setting up the manufacturing plant or manufacturing industry.

Now, once we have decided that this is going to be the location. The next stage is the layout of the plant. How the bird or maybe from a height, how we will look at the various facilities within the plant and that is basically the layout. And in layout we try to optimize, we try to figure out that what can be the best location of the facilities in which we can make maximum possible utilization of the space available with us.

We can also decide that what will be the sequence of operations in order to minimize the movement of men and material; minimize means unnecessary movement of material and men needs to be avoided. There will be certain operations that are redundant or can be

combined together. So, we will see, what are the operations that can be eliminated? What are the operations that can be combined together?

And in order to make judicious decisions related to our layout of the facilities, we sometimes make use of the various tools which helps in making these decisions. These tools help us to have a overview of our layout. These tools help us to combine the various operations these tool help us to identify the bottlenecks in the operational, may be in the operational procedure or during the operations. They help us to identify the unnecessary movement of men and material and these tool overall helps us to optimize our overall layout as well as improve the productivity of the organization.

These also help us in achieving the overall objectives of operations management. That is to produce the right quality of product in right time with minimum cost as well as in appropriate quantity. So, the 4 terms that are very important are the quality, quantity, time and the cost. So, if our layout is productive, if our layout is efficient; we will be able to make use of the infrastructural facilities in the best possible manner for the advantage of the organization.

Today, we will try to see that what are the various tools and techniques that are used for identifying the bottlenecks in order to identify the unnecessary movement of men and material in the plant. And we will see that how to represent the overall manufacturing activity graphically on a piece of paper and how, this is going to help us to identify the problem area. So, let us quickly start our discussion on the topic.

So, we will basically be covering 4 types of the diagrams or the charts that help us to identify the problem areas in a plant and in order to optimize the layout for us; various tools and techniques are listed on the slide.

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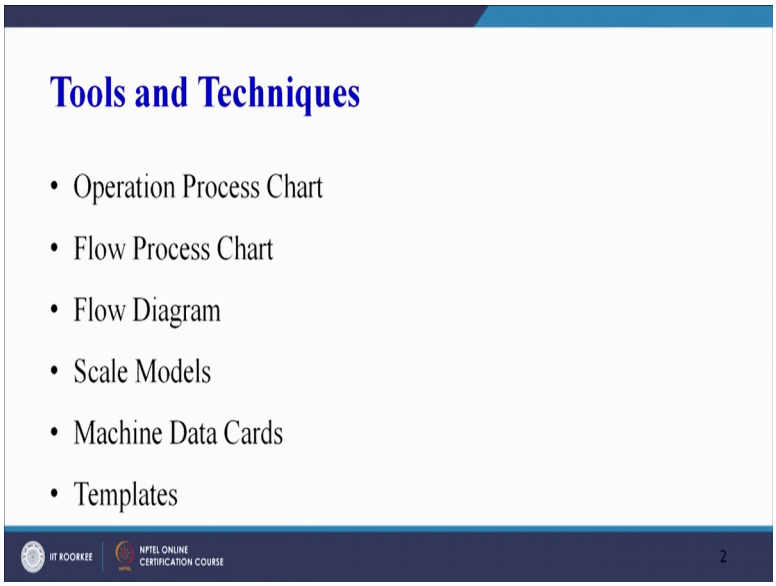


You can see we have Operation Process Chart; we have a Flow Process Chart; we have a Flow Diagram; Scale Models; Machine Data Cards and Templates.

So, we will try to cover as much as possible in our session of 30 minutes. So, quickly let us first go to the Operation Process Chart.

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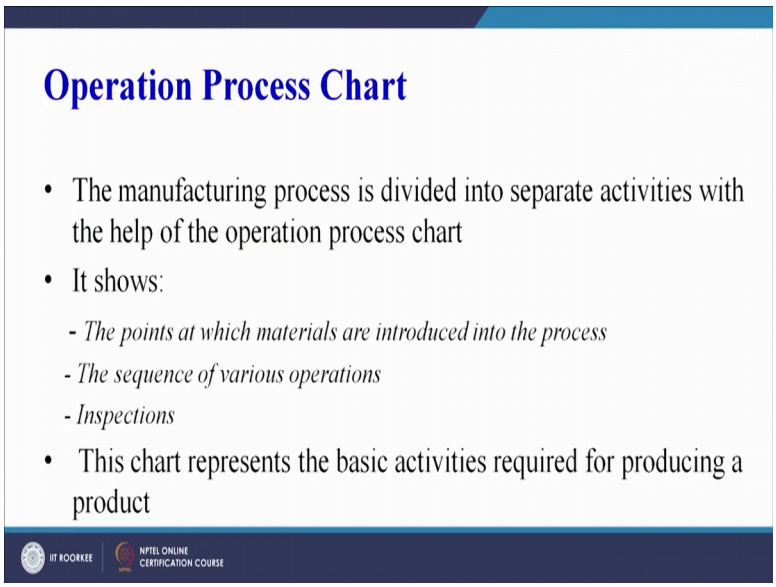


And for each one of these, we have taken a diagram. So, that the explanation becomes more may be clear to all, the learner. So, the first type of chart is the Operation Process Chart. Here, the manufacturing process is divided into separate activities. Now, what is

the manufacturing process I am referring to? The manufacturing process may be the production of electricity from coal; it is easier said than done.

So, you have a coal that is coming into the thermal power plant and then, this coal is going to a particular section where it is being fed to the boiler; the steam is being generated. It further moves forward; the turbine is there. The turbine will help in the production of the electricity. So, there will be a rotor stator arrangements. So, the complete process we can see is the conversion or the production of electricity.

So, it will encompass different types of may be sub processes, sub assemblies that will help in the achievement of the overall objective. For example, another example we can take. Suppose, we are producing a car so, for production of a car, it may represent a manufacturing activity and we can represent this manufacturing activity with the help of certain symbols and representations which will help us later on to do our analysis that how many operations are being done? How many time where are inspecting our product? Where the delay is happening? Where unnecessary work is getting piled up? So, the chart will help us to represent our overall process on a piece of paper.

So, basically the manufacturing process that we are talking here is, is not just one process that is casting or welding or machining; it is the overall manufacturing activity of an organization that we want to represent graphically and then, we can analyze based on that graphical representation. So, the manufacturing process is divided into separate activities. So, the complete cycle is divided into individual operations or processes with the help of Operation Process Chart.

One thing we must remember here is that this is the most comprehensive type of chart that we usually draw and gives us the overall view of the manufacturing activity. It will make use of certain symbols that we will see in the diagram and these symbols will help us to represent the process or the overall manufacturing activity. So, it may not be related to where, which process is located or how much time is being spent for a particular activity or maybe who, how many number of people are engaged in a particular activity. So, may not be that detailed, but it will give an overview that how the activity or how the manufacturing process is being carried out, how the manufacturing activity is being carried out within the organization. So, if you see layouts we have seen there are different types of layouts.

We can have a product or line type of layout. We can have a process or functional type of layout; we can have a fixed position layout; we can have a cellular type of layout. So, in layout, we have fixed the positions. But here we will represent the activity, maybe we will try to see the sequence of operations that how the complete product development cycle or the product, I think product development cycle may not be the right words to represent. We will see that overall product manufacturing is taking place, starting from the arrival of the raw materials to the final dispatch of the final product; what are the various operations been done on the raw material that is that will be represented by the Operation Process Chart.

Now, if you have understood the first sentence that is very important; it is a overall representation of the activities or the operations happening within the organization. So, the manufacturing process is divided into separate activities with the help of Operation Process Chart. It shows now, we can see what we can deduce out of the operation process chart. It shows the point at which the materials are introduced into the process that entry of the raw material.

It will show the sequence of various operations as well as the inspection. So, we will try to understand it with the help of a diagram, but this will help us to see the overall picture of the manufacturing. This chart represents the basic activities required for producing a productizing; I have used this word earlier also for manufacturing of the product, whatever operations are being done will be represented using a Operation Process Chart. So, let us see with an example.

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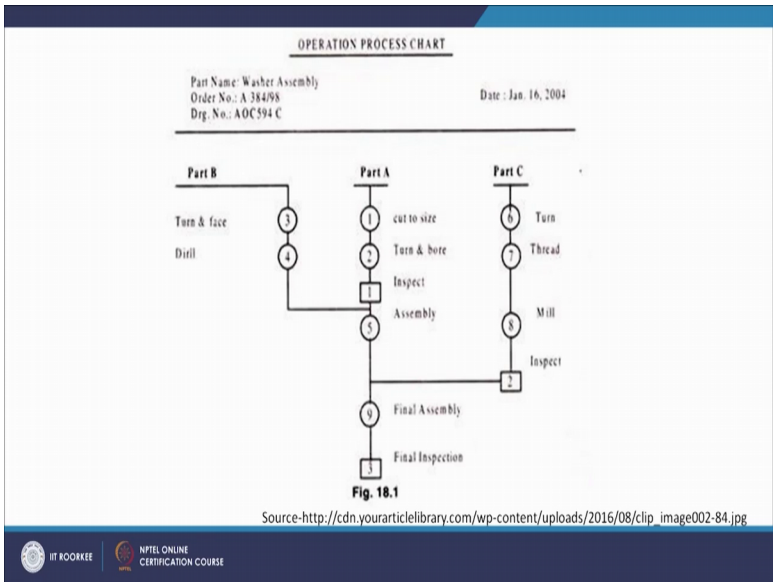


On your screen you can see may not be that clear, but this is a operation process chart. We can see there is a final product that we are making, operation number 9 on your screen. This is 9 number, Final Assembly. I will read it for you. It is Final Assembly here. And this is Part B which is coming from here. Part A is coming from here and Part C is coming from here.

So, you have part, 3 parts or 3 sub assemblies A B and C and Part B, the operation is mentioned here, Turn and Face. So, may be a lathe machine, we are doing the turning and facing operation and then, the second operation can be Drill. So, we are doing 2 operations and operations are represented by circles. So, here 3 and 4 represent the operations being done on Part B. Then, on Part A first operation is cut to size, second operation is Turn and bore.

So, the boring operation is. Then, we have to inspect whatever the specifications we have laid out. So, we have to inspect whether the cutting and the boring operation as well as a turning operation are as per specifications or the Part B sub assembly which is being produced after these 2 operations. Finally, is adhering to the specifications for which the product or the sub assembly has to meet. So, then we have the assembly number 5, which is also an operation. Thus this assembly basically is for Part B and Part A. So, we have seen that Part B is having the individual operations. The operations are Turning, Facing and Drilling.

On Part B we have, Cut in to size and then, Turning and boring operation and finally, the Inspection for Part A or sub assembly Part A and then A and B are getting assembled and this operation is been termed as 5.

So, basically we have Part A and Part B having different sequence of operations; but finally, getting assembled into 1 sub assembly. Now there is an independent Part C which we can see here. Now Part C, the operations are Turning, Threading, Milling and finally, the Inspection. Now 2 operations are very very clear or 2 process chart symbols are very very clear to you; 1 is the circle which represents an operation and there is a rectangle or a square that represents an inspection. So, the operation symbol and the inspection symbol are clear to you.

So, here we have 3 parts which are finally, getting assembled number 9 represents the final assembly. A and B have been assembled together at operation number 5 and A B and C are getting assembled at operation number 9. And finally, we do the inspection. So, we see that inspections are numbered. This inspection is number 1; this inspection is number 2 and this inspection is number 3. This is operation 1 2 3 4. Then, there is 5 6 7 8 9. So, we have 9 operations and 3 inspections in this overall process chart. So, we can see this is a washer assembly and the product name, part name is also mentioned there.

So, 3 parts are coming together and getting assembled. What we can understand from here? I have explained the operation process chart. What we can deduce? What we can infer? What we can analyze from this process chart? First thing is it gives a true representation of the overall manufacturing activity; looking at the chart we need not go to the shop floor. We can just look at the chat and try to understand may be this type of charts we can call as the language of engineers, just by looking at the chat we can see that for washer assembly, these are the 3 sub parts and what are the specific operations to be done on each sub part. And finally, where the final location, final not the location; final assembly is taking place.

How many operations are there? There are 9 operations. There are 3 inspections. So, we can do the analysis that whether these 3 inspections are mandatory or we can club some of the inspection. We can take a decision that all this processes 9 operations that we are doing; all 9 operations are important. Is there some technological advancement in which we can combine the 2 operations together or as per specifications can we reduce the

number of operations, can we eliminate some operation? So, overall analysis can be done and seen; that what are the operations? How they are being done at which, in which sequence they are being done? And how we are producing our final product?

So, the basic characteristics or advantages not the characteristic I have already explained; what are the various advantages of operation process chart that we can try to understand here.

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This can be used to improve the shop the plant layout. As we have seen will help us with the number of operation and number of inspections and we can see that how we can arrange our facilities in the most efficient and effective manner utilizing the space available with us in the best possible manner.

It will also help us in specifying the basic manufacturing system to be followed. So, we will, we can even take broader guidelines. We can try to identify that what type of layout will be more advantageous in this type of manufacturing activity. It will also help us in determining the actual sequence of operations or maybe it will also help us to re modify or may be redesign our sequence or recalculate our sequence in order to make optimal utilization of the facilities available with us. Also, as I have already told that these type of charts these type of diagrams are the language of engineers.

So, if we have new people joining our organization, we can show them these charts. They can make use of these charts to have a hands on understanding of what is going on in the manufacturing plant or what are the various sequence of operations being followed in the manufacturing plant? So, we can see this type of diagram is an overview of the activity that is happening within the organization; may be next in here if you see we are not focusing much on the time.

The time required for each activity we are also not focusing on the other aspect that is the number of men, number of resources or amount of resources being used at each and every level. So, this is just giving us a sequence of operations and also giving us the assembly and the inspection technique being or inspection positions that where we are doing the inspection after sub assembly of A and B, we are doing a inspections after assembly of A B and C, we are doing a inspection.

So, gives a overall picture. So, time domain is not mentioned in the Operation Process Chart, but in when we come to the Flow Process Chart which is a extension of operation process chart. It is basically the graphical representation of all the production activities occurring on the shop floor. So, some of you may be just be wondering that what is the difference between the Operation Process Chart and a Flow Process Chart. So, we will come to the difference when we see the examples. So, it includes operation, transportation, storage and delay.

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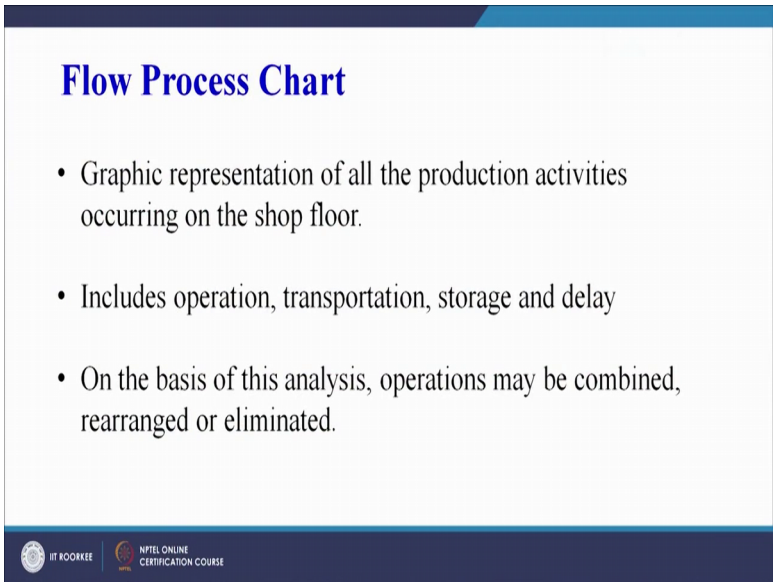

And each one of these activity is represented by a symbol. In operation process chart you have seen 2 symbols only; one symbol was a circle which was representing an operation and activity, then second symbol was a rectangle which was representing and inspection.

Now, we will see that how do we represent storage, how do we represent transportation? We will try to understand it in the next diagram. On the basis of this analysis that is once we are able to represent the process using the flow process chart, we are able to combine the various operations; we are able to rearrange the operations and we are sometimes able to eliminate certain relation operation. Also we are able to maybe reduce the work-in-process, avoid the delays in the manufacturing process. So, there are number of advantages of representing the overall manufacturing activity graphically.

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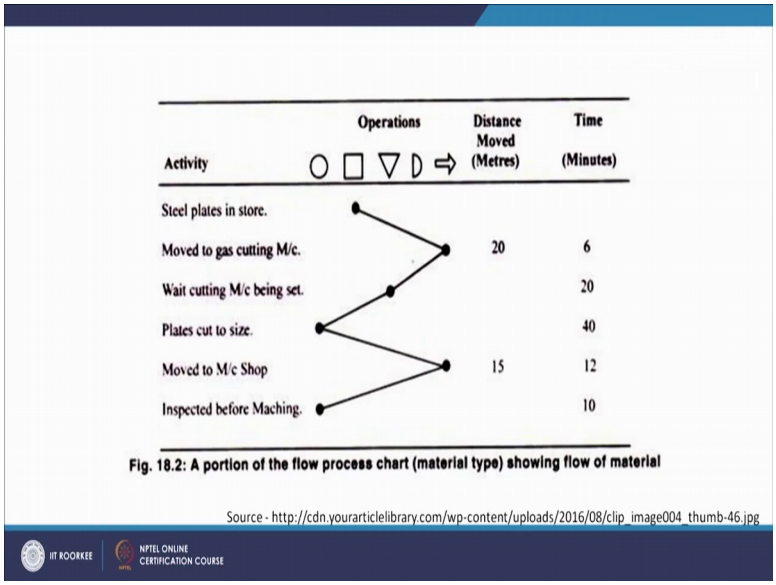


So, we will see graphically you can have a look at the diagram as given on the screen is much more clear as compared to the previous diagram. Let us first see the 5 operations which are very important. Circle represents an operation; square represents an inspection; inverted triangle represents storage; d represents delay and arrow represents transportation.

So, you have 5 symbols here; first symbol is operation, inspection, storage, delay and movement or transportation. One additional information that you see here is the distance moved in meters which was not represented in the operation process chart. Also we see the time taken for each activity which was also not represented in the operation process

chart. So, here we see this is a portion of a process, flow process chart material type. So, here, we are focusing on the material the movement of the material is being represented showing the flow of the materials.

Just let us try to understand what are the symbols representing here; you can see steel, what is the activity? First activity is steel plates are available in the store. So, maybe they may be inspected there, inspection is represented here. They are moved to the gas cutting machine. So, movement you see the circle here and the transportation because there is movement of these steel plates to the gas cutting machines and then, they are way, then the weight for cutting machine being set. So, we have the storage here it is here. So, they are waiting their chance to be cut and as the machine is being set up for the cutting operation.

And finally, the plates are cut to the size. So, we see operation is happening, this is the operation. The gas cutting is being used for cutting the steel plates. So, this is an operation. So, there plates are cut to the size. Then they are moved to the machine shop again transportation; here we have the transportation symbol. The cut plates or the plates cut to size are now moved to the machine shop.

And then, they are inspected before machining. So, this should come ideally below this. So, they are inspected before the machining operations. So, this is just representing a complete process of material type. So, what is the focus area? What is the material that we are focusing here? The material being focused are the steel plates and steel plates are moving from the store. They are going to the gas cutting machine, from gas cutting machine they are being cut into the shape whatever required dimensions. And finally, they are moving to the store and their being inspected before the machining operations. So, they are moving to the machining shop or the machine shops.

So, we have also represented the distance moved 20 meters and 15 meters and the time required for each operation, the delay, the plates cut to size 40 minutes; moved to the gas cutting machine 6 minutes. Waiting time is 20 minutes which we can say the delay sorry, the storage where they are been waiting. So, sometimes there is a little bit of may be confusion related to 2 things delay and the storage.

So, basically storage if we see is going to represent the wherever the material is being stored for a particular type of operation to be done. Whereas, delay can be accounted for

as a unavoidable may be break down into the overall process. So, delay for example, the material is moving to a specific machine and the immediately, the work could have been done on that work-in-process. But because of some unavoidable delay breakdown of the machine or the worker has to go out for a particular task or has been called by a supervisor; there is a delay in the process.

So, that delay basically is the wastage of time and has to be minimized. Storage may be where ever we are storing it, the machine is working continuously but, because this machine may be slower as compared to the overall speed of the line of machines. So, may be some work in process will pile up which is may be because of the slow nature of the machine. So, that we can say that there is a storage of material; there before being processed by the machine. The machine is working, but the speed may not be matching with the speed of the other machine.

So, we need to understand basically we need to find out what are the various symbols. As engineers all of us must know this symbol and then, depending upon the requirement, we must use these symbols to represent our process. Many times here, we are using single symbol only for the 5 types of activities or manufacturing activities. But in many cases we will see there will be a combination of symbols also; that operation is happening on top of that of operation inspection is also happening online on that point only. So, we will combine the 2 symbols together; we will have a circle and we will have a ray square. So, may be a circle, may be covered by square.

So, basically 2, 1 symbol only representing 2 things. The symbol represents operation also and it represents the inspection also at the same point. So, basically we need to understand that there are 5 symbols representing; 1 representing operation; then, the transportation; then, delay; then, storage and finally, inspection. So, we have 5 symbols. Again I will been able to miss 1 or the 2 symbols. So, this is operation, inspection, storage, delay and transportation. Now, what are the advantages? Now, we can see that based on the analysis, we can do a calculation that how many delays are there? How many storages are there?

How many operations are there? How many inspections are there? How many transportations are there? What is the distance the material is travelling within the organization? Then, how much is the time required for the various activities? And finally

we can say that if we have the complete picture of the manufacturing activity, very easily we can take decisions; we can analyze the situation and make an improvement related to the number of operations, related to the number of inspection, related to combination of various operations, related to reduction in the inspection procedures and the there can be number of decisions based on the analysis that we can we can do based on the information that we have represented on or we represented graphically. So, it can help us in the Simplification of operations, Simplification of inspection required.

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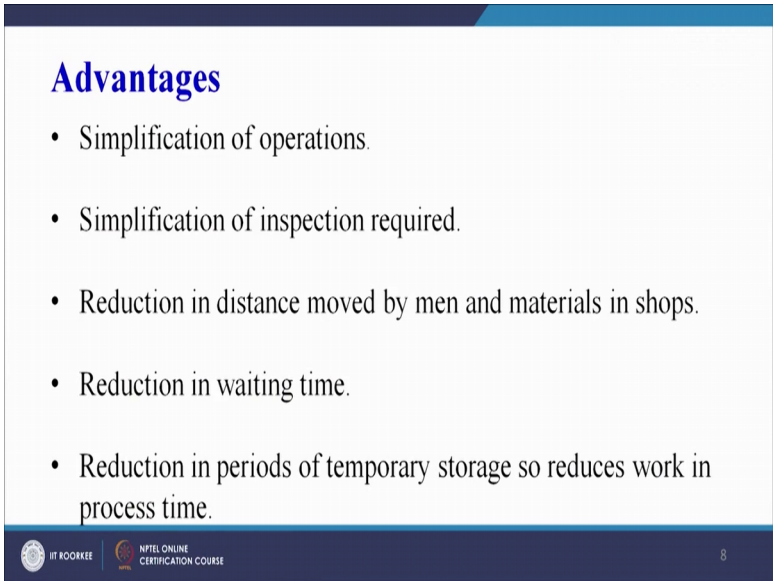


Reduction in the distance moved by men and materials in the shops, reduction in the waiting time; reduction in periods of temporary storage so reduces work in process time; so, you can see that it will try to make our manufacturing activity more lean, more wastage free; we will not waste men's time, we will not waste machines time. If we are able to analyze the data properly and make judicious decisions based on the data which is graphically represented using the flow process diagram.

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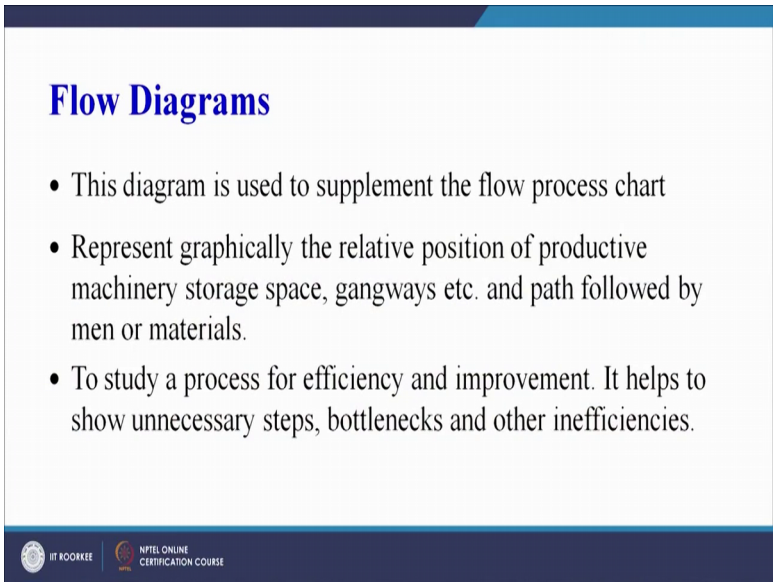


Then, we have Flow Diagrams. Let us quickly have a view of what is Flow Diagram? Some additional information will definitely be there as compared to the flow process chart. We have seen two types of graphical representations of the manufacturing activity; the first one was the operation process chart, the second one was the flow process chart wit all which also included the time and distance. Now we have a flow diagram. This diagram is used to supplement the flow process chart. Represent graphically the relative position of productive machinery storage space, gangways etcetera and path followed by the men or materials

So, it will give us a relative position also of the various facilities or the various machines and equipment and the accessories being used for the manufacturing activity. It also helps us for improving the efficiency of our operations. So, to study a process for efficiency and improvement, it helps to show unnecessary steps; bottlenecks and other inefficiency. So, overall objective of tools and techniques that are used for plant layout and planning is to improve the overall productivity, overall efficiency overall effectiveness of the manufacturing activity or the manufacturing system at large. So, this also will help us in the same in achieving the same objectives only.

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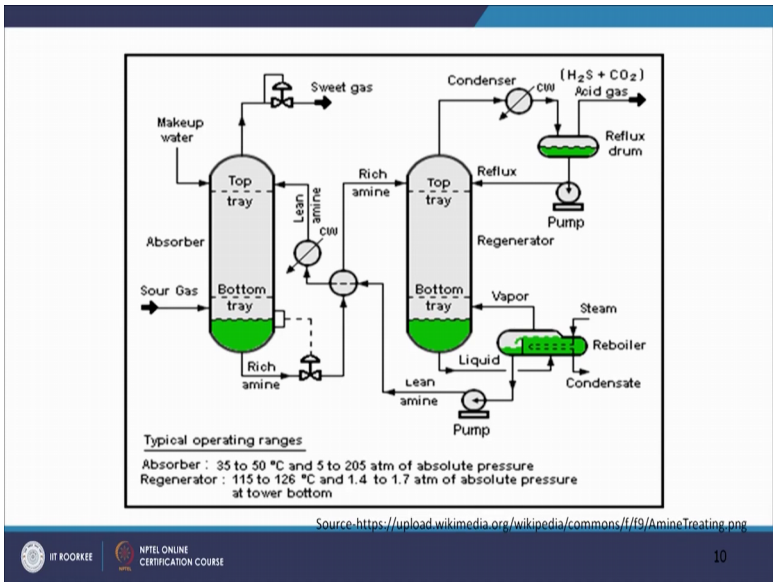


And here you can see one representation of a flow diagram and we can see that we have exact location that where which facility is located. So, Re-boiler is here; you have a steam here. Then this is may be another facilities, the condenser is here and this is a makeup water coming from here. So, we can just look at the diagram and try to understand, physically also that which facility is located where. So, this will help us to this is you can see absorber here. So, this will help us to see which facility located here and how much is the distance between the various facilities, how we can minimize that distance, how we can optimize our operations in such a way that the time of men the time of machines are properly utilized?

So, maybe we can discuss these things in much more detail, but the basic idea is to give you an basic understanding of the various tools and techniques that can be adopted for optimizing our plant layout and 3 types we have already seen; the Operation Process Chart, the Flow Process Chart and the Flow Diagram. This is specifically giving us an overview of the layout also. Then finally, the last things that we have seen I think all of us might have seen that whenever you enter into a industry or whenever you enter into an educational institute, there will be Scaled Model of the organization.

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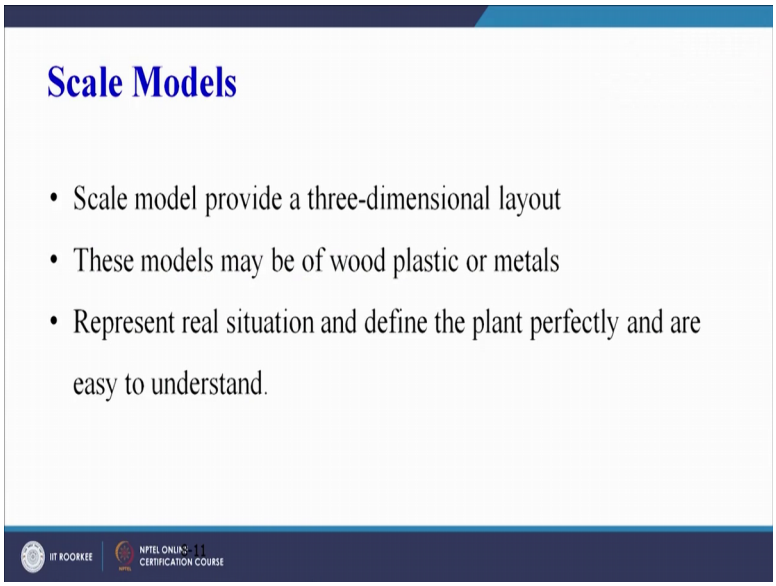


So, there will be 3-D models representing the various building, the ponds, the playground, the hostels. So, that is basically a Scaled down model of the overall plant. I, at least I have seen in when many organizations, they put a Scale down model at the entrance of the organization.

So, that you can have an idea that where you are. So, sometimes they point out you are here and then, they are standing there you can have an idea that where which facility is located. So, scaled model provide a 3-dimensional view of the layout. These models may be made up of wood or metal or plastic. Represent real situation and define the plant perfectly and are easy to understand. So, they are much easier to understand because if we are having a green field color coding is also used for scaled models.

So, basically when we have a green field, we will say [FL] ok, this is a ground or this may be a some green-green area where, there may be a forest or forest cover. Wherever we see a sky blue color, we may say there is a pond or any water facility created there. if is it buildings, we can say this is some facility. Sometimes we mark it by number and give a coding also that 4 represent boys hostel or 5 represent girls hostel; same type of scaled model can be done in industry also and we can have a overview of what is happening within the industry.

So, with this we come to the conclusion of today's session. We have tried to understand that how the overall manufacturing activity can be represented, with the help of

Operation Process Chart. We have seen we can do the optimization of movement of men and material using the Flow Process Chart and we have also seen that Flow Diagram will give us the relative location of the various facilities within the organization. The overall objective being to optimize the utilization of the resources, the utilization of the space available with us, the utilization of men, utilization of equipment, utilization of machine and with a broader objective of improving the overall productivity efficiency and effectiveness of the operations.

Thank you.