

**Operations Management**  
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**Lecture – 24**  
**Material flow patterns**

[FL] friends. Welcome to session 24 in our course on Operations Management and currently we are due in the 5th week of our discussion on the course. And in every session, I usually revise what we have covered in the previous sessions. And today also I will not deviate from the, we can say tradition; I will again try to revise what we have already covered, but very briefly. We have seen the fundamental aspect that is the scopes, objectives, functions, types of production systems in our week 1; in which we have covered the introduction to Operations management.

In week 2, we have covered product design and development; in week 3, we have covered sales forecasting; in week 4, we have covered plant location and in week 5, we are covering plant layout or factory layout. Now, we have entered into the factory, we are trying to do a locational analysis or trying to design and develop a layout of our factory. We are trying to see that where which facility must be created, must be raised must be erected so that we are able to meet our overall objective of 4 keywords.

What are these 4 keywords? These 4 keywords are that we must be able to produce the product with desired quality, desired quantity, at appropriate time, at a competitive cost. So, these are the 4 parameters; quality, quantity, time and cost. So, we are trying to layout our factory in such a way that our 4 targets are achieved that we are able to produce a good quality product in right quantity with reasonable cost, competitive cost and at the time, it is required in the market.

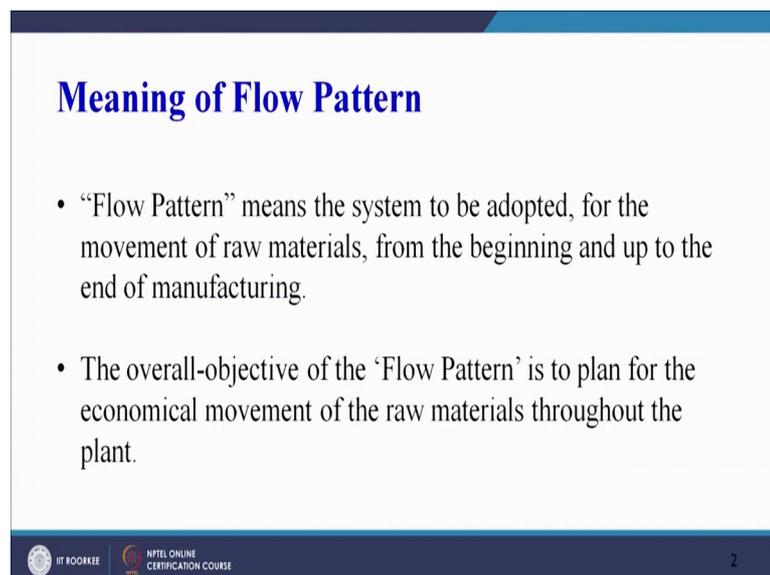
So, the layout also affects the overall productivity of the organization; within our discussion during this week, we have seen if you remember that why the layout is important? How do we define a layout? What are the different types of layout? Then, we have seen in the previous session, what are the most important factors which govern the type of layout? And we have already now maybe physically moved inside the premises and we are trying to see that how we can make a optimal layout which will help us to achieve our objectives of operations management.

We have seen that there are factors which will govern our decisions related to the selection of a particular type of layout. Today, we are going to cover the material flow patterns within the layout; how the raw material will enter into the organization or the factory or the industry and how it will traverse a different path? And then, how it will come out? How it is going to influence our layout? Then, we will see what are the advantages of following a material flow pattern or following a particular type of material flow pattern and what are the things which will be affected by the improper or maybe a non judicious or maybe a faulty selection of a material flow patterns.

So, all these things, we will try to cover dove cover in today's session. We may have a horizontal flow pattern or a horizontal material flow pattern and we may have a vertical material flow pattern. So, we will take examples of both and try to understand that once we are inside the factory, we have to see that how the material will move inside the factory or the plant. So that our overall objective is met and we can ensure a proper flow of the materials proper sequence of operations on the materials. And finally, we get our desired good quality output and our good quality output is our product that we are producing.

So, let us quickly have a brief introduction of material Flow Pattern.

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**Meaning of Flow Pattern**

- “Flow Pattern” means the system to be adopted, for the movement of raw materials, from the beginning and up to the end of manufacturing.
- The overall-objective of the ‘Flow Pattern’ is to plan for the economical movement of the raw materials throughout the plant.

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So, first of all, we need to understand the what do we mean by Flow Pattern? So, as I have already told our focus is on Material Flow Pattern. So, material all of you know,

how do we define flow pattern let us read it. “Flow Pattern” means the system to be adopted, for the movement of raw materials, from beginning and up to the end of manufacturing. So, what is the end of manufacturing that is the final product has been produced.

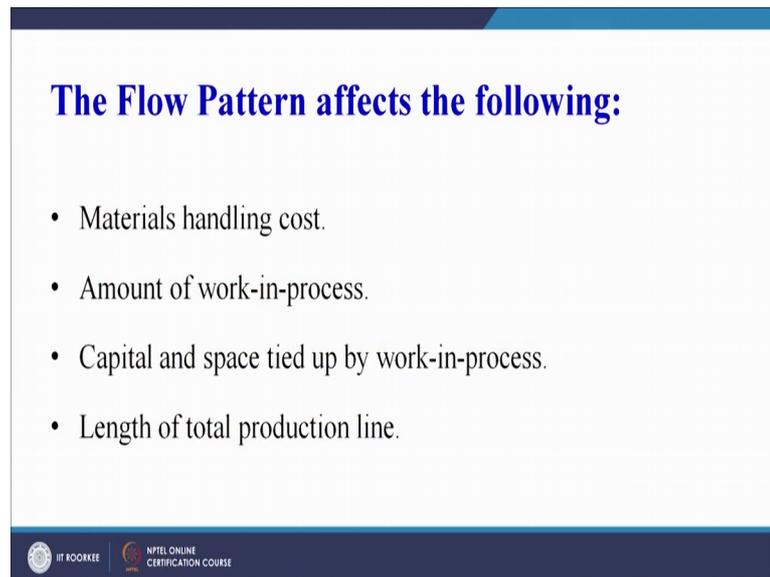
So, the flow pattern means the system to be adopted for the movement of raw materials from the entry to the exit, from the maybe beginning to the ending. So, with it is the flow of raw materials within the organization, within the factory, within the plant. The overall-objective of the ‘Flow Pattern’ is to plan for the economic movement of the raw materials throughout the plant. So, the word economical is coming into pictures. So, we have to ensure that there is no unnecessary movement of the material inside the plant.

We need to minimize the movement of material; we need to economize the movement of material inside the plant. Many a time you will see that you go to a plant and you will if you stay there for some time and observe the movement of material; even, using common sense you will try to find out that yes, when the plant was set up. This may have been the most optimal design or the layout of the machines.

But with passage of time we have seen that revision of layout is also done and in the revised layout, you will see that there is unnecessary movement of materials sometime which needs to be checked, which needs to be economized, which needs to be optimized in order to achieve our overall objective of high quality cost effective manufacturing. So, basically material flow pattern is the pattern or the flow that is being followed during the manufacturing process specifically for the material. So, we will see that how the raw material enters into the factory? What sequences of operations are done on the material? And, how it goes out from the factory? So, that is the basic meaning of the layout of the material flow pattern.

Now, why it is important? Because it affects the overall productivity of the organization; it affects the material handling cost; it affects the amount of work in process.

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**The Flow Pattern affects the following:**

- Materials handling cost.
- Amount of work-in-process.
- Capital and space tied up by work-in-process.
- Length of total production line.

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Now, work-in-process or WIP is a new term that has come in our course on operations management. We are using this for the first time. So, work-in-process is nothing but the materials, the sub assemblies, the subparts, components that are in the process of production.

For example, if you remember in our line type of layout, we have seen that there are work centers; work centre 1, work centre 2, work centre 3 and there are 3 components A, B and C that are being manufactured at different locations or different points and are coming to these 3 work centers are getting assembled to make a product x. Now these 3 parts will constitute the work-in-process. And finally, they are getting assembled and are being a part of the final product.

So, the amount of work-in-process is definitely influenced by the type of flow line or flow pattern that we have chosen within our organization or within our plant layout. Also the flow pattern will influence the capital and the space tied up by the work-in-process; surely, it is going to influence the capital and the space tied up. Because sometimes it may so happen that our work-in-process is getting piled up and we require space to keep that work-in-process at a particular location and it will definitely affect our flow line and the flow pattern will also affect means they will affect vice versa.

For example, we are having huge work-in-process piled up at a particular location; we would like to bypass that location and try to follow a different flow pattern. On the

contrary that of suppose, we have selected a particular flow pattern and there is a very slow machine in between what will happen the work-in-process will pile up at that location. So, the selection of a flow pattern will also influence the work-in-process or piling of the work-in-process. On the contrary, if the work-in-process is piled up because of 1 reason or the other, it may influence our dynamic change towards the new flow pattern in order to overcome that situation.

So, they are affecting each other. Length of the total production line is also influenced, we will see that. We have a I type of material flow; we will have U type; we will have S type of material flow that we will try to understand with the help of diagram, but the flow pattern will certainly influence the length of our total production line. Now, the flow pattern affects the following. The rate of the performance and coordination of operations. It also influences the Amount of physical and mental strain on the operators as well as Supervision and control mechanisms.

So, all points can be explained with the help of certain examples; because suppose, we say supervision and control mechanism. So, if we have I type of flow pattern, the raw material is entering from one end and it is getting converted in a linear fashion and at the other end the product is going out. So the supervisory control maybe not very affective. Because maybe we may require the length is large; we were required may be 2 or 3 supervisors to keep a check on may by 8 to 10 operations each. But suppose, we have a U type of pattern, we can have a centrally located supervisor who can control both the ends of U.

So, the type of flow pattern that we choose, it will affect the type of supervision and control that we can manage within our organization. Similarly, the amount of physical and mental strength also is affected by the flow pattern. So, the flow pattern will not only affect the materials; it will affect the people also, it will affect the procedures also. So, we have to understand the importance of flow patterns. So, we can see that the rate of performance and coordination of operation is also affected by the flow pattern.

So with these points, the overall objective of discussing these point is that we must an we must know, we must be able to highlight; we must be able to understand the importance of the material flow pattern as; otherwise, usually as students we feel that what how this is going to affect? It is a simple things that the raw material is coming; it is following a

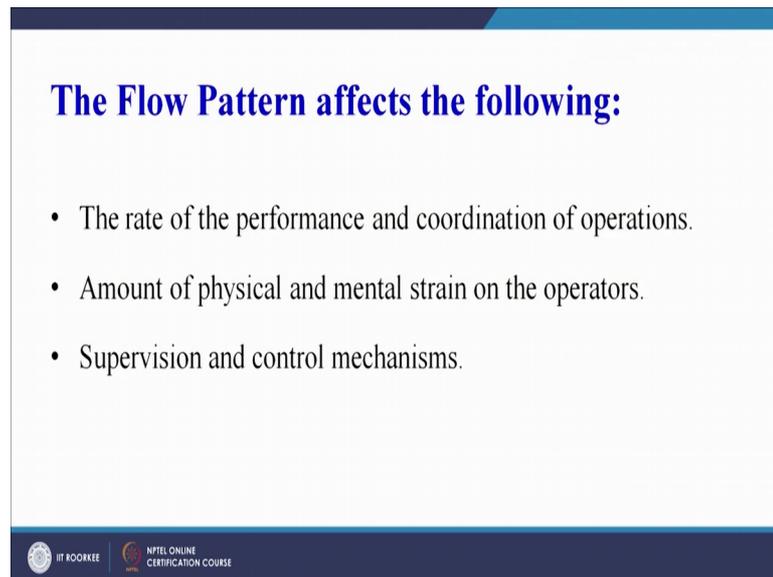
particular sequence of operations and it is the material is getting converted into a final product and it is going out. No, it has got certain importance and the importance lies in the overall productivity of the organization.

Suppose, it is whatever examples we have taken, we have tried to display or portray a positive picture; we have tried to take positive examples only. So, let us take if you select of wrong flow pattern, what can happen? Your supervision is not proper. The quality of work that we are producing is not proper; your work in process has piled up. So, we can see that there can be so many issues and challenges if we choose a wrong type of flow pattern.

So, it is also important and one thing that is also covered earlier; all earlier, in earlier discussion also is the effective and efficient use of the space. Suppose, we have some area or some floor space available with us; we have to see that how we should locate our machines? What should be the flow pattern of the material; material flow inside that floor or inside the organization, in that floor space. So, that the optimal utilization of the space is taking place. Many a time we will see that a lot of space is being wasted and not utilized properly.

So, the flow patterns, if we address this point in a emphatic manner; we will definitely be able to save a lot of space or a floor area for our organization. So, just I want to again retreat the importance of flow lines and I will read these points again for you. So, the flow patterns will definitely affect the material handling cost, amount of work-in-process, capital and space tied up by the work-in-process, length of the total production line.

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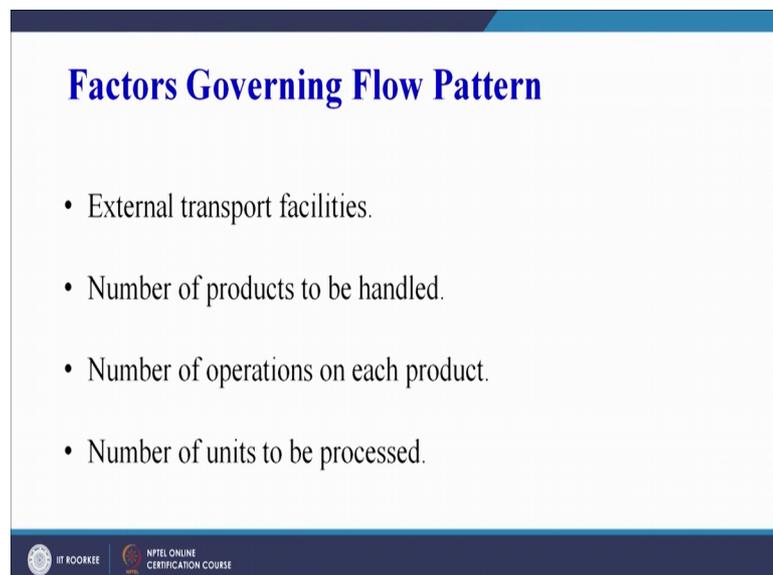


**The Flow Pattern affects the following:**

- The rate of the performance and coordination of operations.
- Amount of physical and mental strain on the operators.
- Supervision and control mechanisms.

The rate of the performance and coordination of operations, amount of physical and mental strain on the operators, supervision and the control mechanisms. So, all these factors, all these we can say points that has been written on these 2 slides are being affected directly or indirectly by the selection of the flow pattern.

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**Factors Governing Flow Pattern**

- External transport facilities.
- Number of products to be handled.
- Number of operations on each product.
- Number of units to be processed.

Now, what are the factors that govern the flow pattern that we are going to choose? One can be External transport facilities. Now one example can be a thermal power plant. In thermal power plant, we require coal as the raw material; coal will burn and then, it will

be used as a fuel for the boiler. Then will produce steam and then, will produce power from that steam.

So, basically we have a raw material that has to reach the plant. Many times you will see in thermal power plant, there will be a dedicated railway line which will bring the coal in the wagons. So we have to see that where we have that facility where the wagons can come, the material can be unloaded from those wagons and then, this can be brought to the place where it has to be used. So, that distance has to be optimized or minimized and from there, we see that the raw material is reaching at this point. What can be the material flow line in order to optimize the overall operations?

For example, there is a very big sheets of material or very bulky raw material which is coming to the organization; where it will be unloaded? Once it is unloaded, how to ensure that from there it travels the minimum possible path inside the factory. So, that the overall objective of converting that raw material into the product is achieved, but the movement of the material is minimized.

So, the external transport facilities will definitely affect we will see with the help of diagrams also that where the material is getting off loaded is important and will help us to select our flow pattern accordingly. Then, the number of products to be handled is also important. If you see specifically in case of assembly type of lines or assembly operations we will have a straight line or I type of a line or the flow patterns; because the number of products to be produced is large. So, we will see that the raw material should come from one end and the final product should go out from the other end.

Suppose, we some of you may be wondering that when the operations have to be done in one line only, why can't we use a U type of layout there? Because the sequence remains the same; absolutely true, but the explanation that comes to my mind is that when we are doing a large scale production, our raw material will also be huge and the final product that we are making will also be in huge numbers.

So, if we start from one end and follow a particular sequence of operations and the product also comes out as in the case of U type of flow pattern that we will see that in the diagram the U shape, U type of flow pattern. So, the final product is coming out at the same end only. Suppose again I am saying this is the U. So, the raw material enters from

one side and it is following a particular sequence of operations and it comes out from the same side in a horizontal U can be like this.

So, it is entering from a raw material; 1 operation, 2 operation, 3 operation, 5 operation. Then, sequence of operations and finally, final product. So, here we have huge pile up of the raw material because the process is continuous, we require to feed the material continuously and our final product is also coming out continuously.

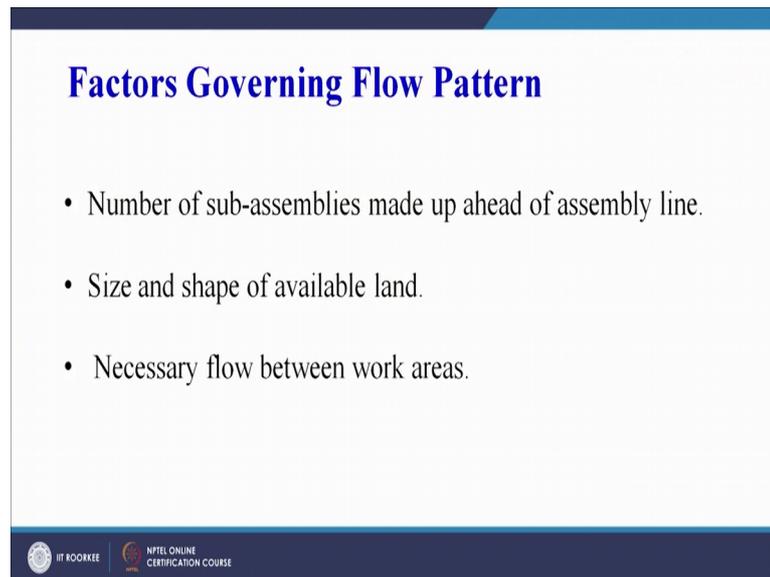
So, suppose both are in this location, this location or space requirement will be huge. So, we can do one thing that we can input the raw material from one end and the product can come out from the other end. So, on both ends we can have the space; on one end, we can have space for raw material; on the other end, we can have a space for the finished product. So, may be depending upon the number of products to be handled, we have to choose a type of flow pattern or the material flow pattern, number of operations on each product is also important that on each product what is the number total number of operations that we are performing.

Number of units to be processed, I think number of products and units I think this is one and same thing; number of sub assemblies made up head of assembly line.

So, that is also very very important. The number of sub assemblies as we have seen in our example of a line type of a layout in this week only. That there are work station 1, work station 2, work station 3. Then, the and there are 3 sub assemblies may be A B and C which are coming to these work stations in a line. The work stations are arranged in a line and these sub assemblies are getting assembled with a final product or getting assembled into a final product which is moving out from the factory layout.

So, how many such sub assemblies are there? What is the size of the sub assemblies? How many parts are there in these sub assemblies? All these factors will influence our selection of a material flow pattern.

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**Factors Governing Flow Pattern**

- Number of sub-assemblies made up ahead of assembly line.
- Size and shape of available land.
- Necessary flow between work areas.

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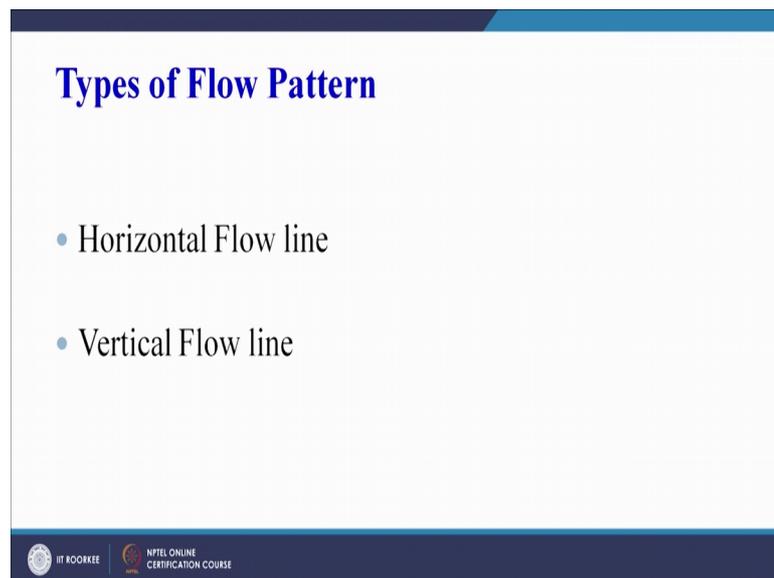
So, we will see that what are the number of sub assemblies? Made up a head of the assembly line. So, our material flow pattern we are only talking about final the assembly lines only. So, we have to see that how many sub assemblies lines coming into the main assembly line.

For example, we may take example of a river. So, our large river is or our main river is our material flow pattern. There can be number of tributaries that are coming at different points and are getting merged with the main river. Similarly, our flow pattern is analogous to the main rivers and their tributaries are analogous to the sub assemblies which are coming and getting merged with the main assembly line. So, size and shape of the available land; this is the most important parameters that is coming to my mind because space is the major limitation for setting up any factory.

So, we have always we are hard pressed we are constrained with space. So, we have to ensure the optimal utilization of space. So, if we have specific area available with us we will see that which is the most possible or which is the most optimal type of flow pattern that we must follow, necessary flow between the work areas that also will affect the flow pattern that we whatever is the necessary flow. Necessary may be there time, there may be times when there is we try to figure out that where is what is unnecessary movement what is necessary moments.

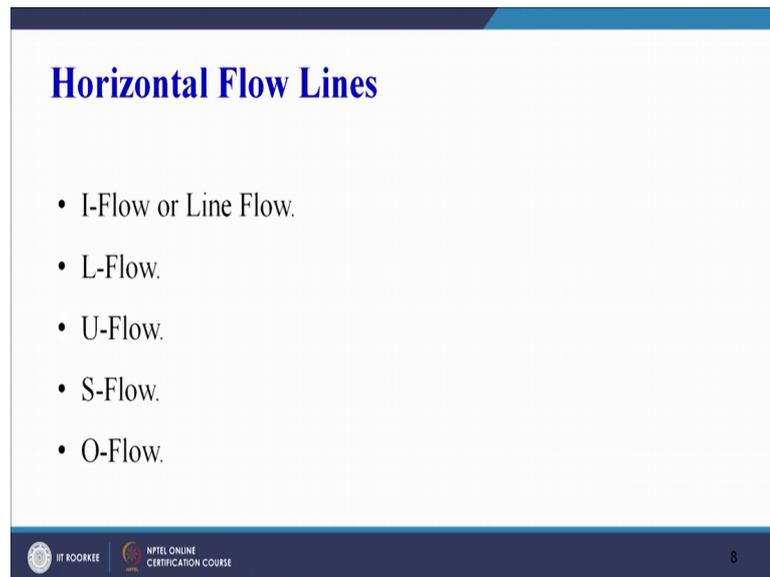
So, once we classify these 2 things we can very easily ensure that we have to plan only for the necessary flow between the different work areas. So, we have seen that how the flow pattern is going to affect our overall manufacturing or overall production and how the, what are the factors that governs the flow patterns. So, these may be theoretical. From practical point of view, let us see what are the different types of flow pattern? we have a Horizontal Flow line and we have a Vertical Flow line.

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So, we will try to make examples of each one of them these and try to understand that where which type of flow pattern more successful or more applicable.

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Horizontal flow lines, you can see there are so many examples. We can have a I-flow or Line flow. We can have a L-flow, U-flow, S-flow, O-flow.

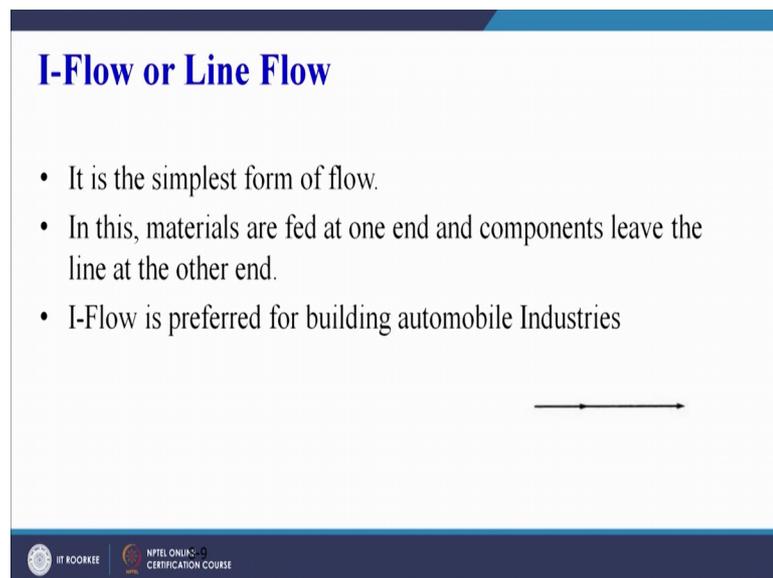
So, we can see that different types of space available with us, will force us to choose any one of these flow lines or any one of these flow pattern. So, let us see what are the maybe salient characteristics. Majorly, we will see in flow line the raw material will enter into the flow line and then, it will follow a particular sequence and then, it will come out as a final product. So, the overall may be the picture will remain same, but the physical location of the facilities or machines or equipment will be in this particular format only or in this particular shape only.

So, I means all of us know what is I? So, 'I' maybe 1 straight line. So, the location of various machines will be in a straight line and the material will move in this line and during this movement, it will get converted into the final product. So, we may have I-type of arrangement of machines. We can have a L-shape of arrangement of machines. We can have a U-shape of arrangement of machines and other facilities. So, this is basically I L U O are the shapes in which or may be the location in which the various facilities are arranged within the layout.

In previous session, we have seen different types of layout. For example, in line type of layout, we have to follow a particular sequence of operations. So, that can be may be one particular layout which is specially, we can say focused for this type of flow lines

because all machines are arranged in a particular sequence and in a particular shape and the product moves and undergoes the various operations and finally, comes out as the final or the raw material goes into the different operation and comes out as a final product. So, we will see how these flow lines look like.

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**I-Flow or Line Flow**

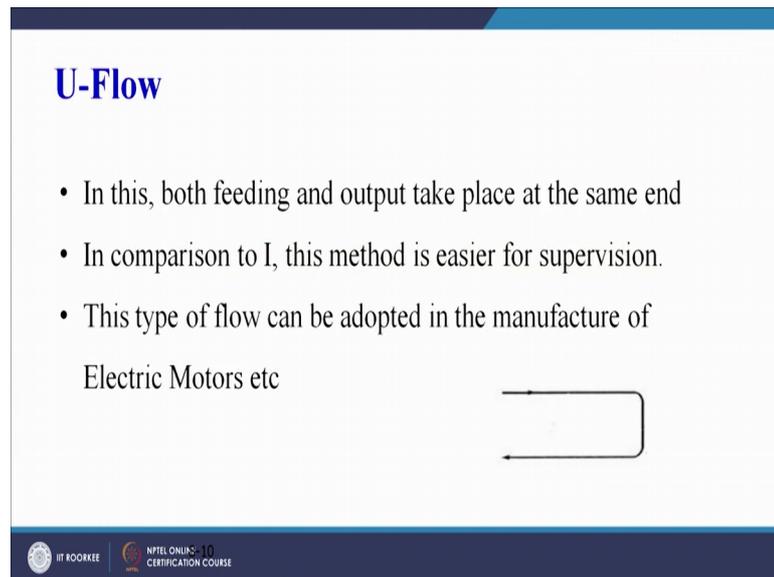
- It is the simplest form of flow.
- In this, materials are fed at one end and components leave the line at the other end.
- I-Flow is preferred for building automobile Industries

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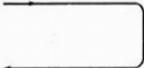
So, I-Flow, very simple example on your screen straight line. It is the simplest form of flow line. In this the materials are fed at one end and components leave the line at the other end. I-Flow is preferred for building automobiles in Industries or for developing automobile industries. As I have already taken an example that I flow line is most suitable for assembly lines.

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**U-Flow**

- In this, both feeding and output take place at the same end
- In comparison to I, this method is easier for supervision.
- This type of flow can be adopted in the manufacture of Electric Motors etc



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Then, we can have a U-Flow on your screen. In this both feeding; feeding means the input of raw materials and output that is the final products. So, in this both feeding or raw materials and output take place at the same end. Here we can see a U type and there is a arrow which points out at the movement of the raw materials and this arrow points out at the raw final product that has been made or manufactured.

So, in comparison to I. This method is easier for supervision because in between we can have this is the arrangement of machines. So, we can have supervision in between and we 1 person can keep a check on both sides. So, that can be ease of supervision and control mechanism and this type can be adopted in electric motors, manufacturing of electric motor.

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## S-Flow

- If the production line is so long that zig-zagging on the plant floor is necessary, than S-Flow is adopted.
- This type provides efficient utilization of space and is compact enough to allow effective supervision



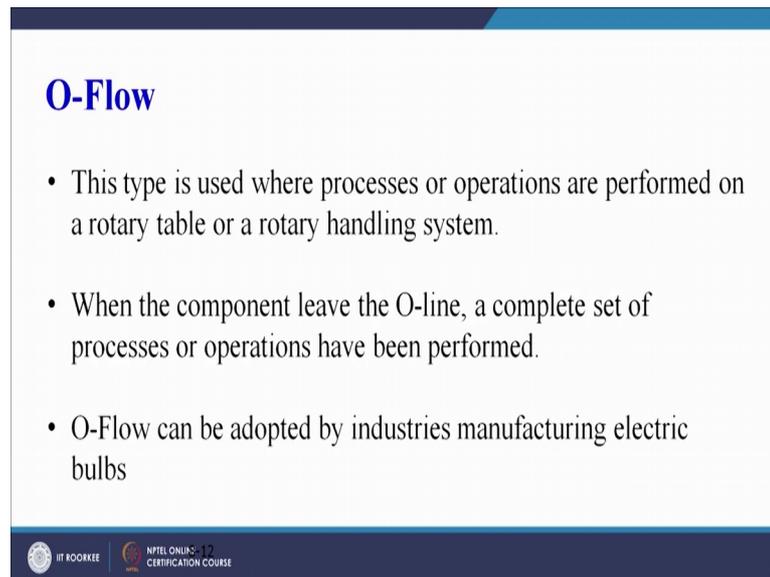
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This is S-Flow and combination of S-Flows here. So, if the production line is so long that zigzagging on the plant floor is necessary, than S-Flow is adopted.

Now, this types provides efficient utilization of space and is compact enough to allow the effective supervision. So, we will see wherever we are cramped for a space, we will try to go for a s type of layout. But with a condition that we have to ensure proper circulation space also, the workers or the working personnel who are working may not feel too cramped in cramped for space.

So, all those parameters have also to be taken into account and then, we arrange our machines and equipment in S pattern. So, that the material moves in S pattern and finally, gets converted into the final product. So, we have seen I-type, we have seen U-type, we have seen S-type combination of S also can be used.

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**O-Flow**

- This type is used where processes or operations are performed on a rotary table or a rotary handling system.
- When the component leave the O-line, a complete set of processes or operations have been performed.
- O-Flow can be adopted by industries manufacturing electric bulbs

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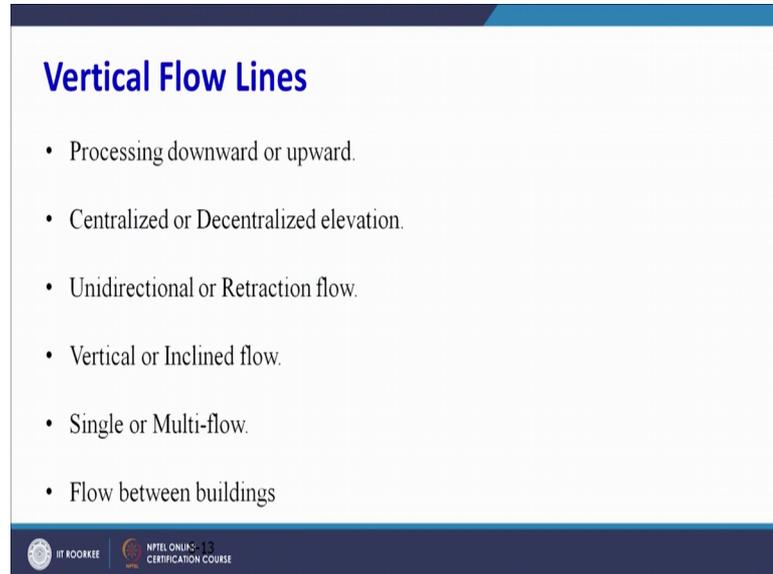
Then, O-Flow is another type of flow pattern. This type is used where processes or operations are performed on a rotary table or a rotary handling system. So, this can be may be 1 example where again, we want to emphasize on effective utilization of space, better supervision and control.

So, we can also the type of land or the type of floor space available with us; we can even go for O-type of arrangement of machines. When the component leaves the O-line, a complete set of process or operations have already been performed. O-Flow can be adopted by industries manufacturing electrical bulbs or it is not a specific for electric bulbs only. It can be used for different types or different variety of products, but the arrangement of the facilities will be in the shape of a O.

Then, may be all these flow lines that we have covered starting from I; then, U and then, we have seen S; then, we have seen O are coming under the horizontal movement of the materials only; that we have one floor and on that floor the sequence of machines is arranged either in the shape of 'I' or in the shape of 'S' or in the shape of 'U', but then I has, as I have already told you that land is the most precious commodity. In spite instead of using x and y coordinates many companies usually go for the z coordinate also. They do not they do not use only the floor space; they also try to raise the different floors and make use of the z coordinate also.

So, we can have a vertical flow lines also and different types of vertical flow lines are there. I will read it for you.

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**Vertical Flow Lines**

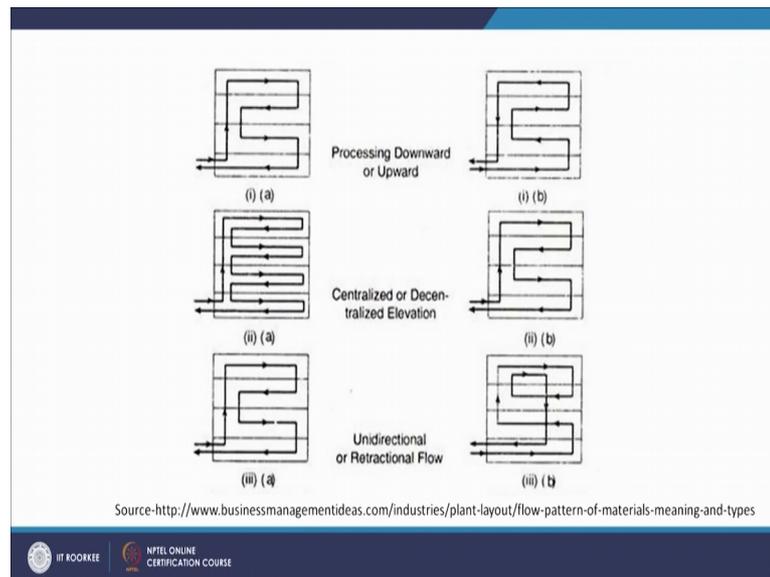
- Processing downward or upward.
- Centralized or Decentralized elevation.
- Unidirectional or Retraction flow.
- Vertical or Inclined flow.
- Single or Multi-flow.
- Flow between buildings

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Processing downward or upward, Centralized or Decentralized elevation, Unidirectional or Retractional flow, Vertical or inclined flow, Single or Multi flow. And then, Flow between the different buildings also. Because last one let me explain, each one can be explained in detail, but this is just to give an idea that the material flow usually we take it in a horizontal direction also only. But many times we many Industries, you will have a material flow in the vertical direction across the various floors of the organization or the factory or the building.

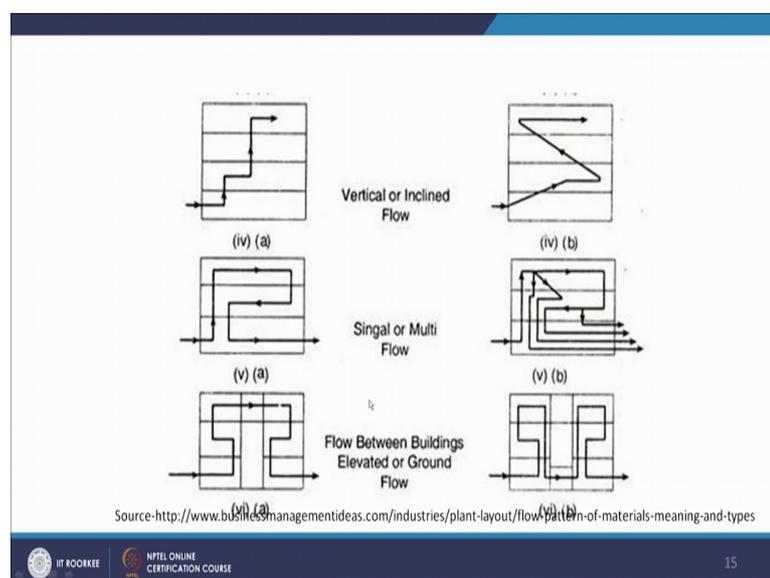
So, the last one like floor flows between buildings. Suppose the company has 2 buildings. So, the flow can be either at the top you can have a bridge in which the material can flow from 1 building to the other building on the top floor or the material can be at the ground. So, you bring the material down and at the ground floor only, you are doing the flow of material from 1, 1 building to the other building may be 1 explanation of flow between buildings.

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So, 1 examples with the help of photographs, you can see or with the help of picture processing upward or downward. So, these are the different floor. This is the vertical direction. So, in vertical direction we can have upward or downward movement, we can have centralized or decentralized elevation; unidirectional or retrational, we can see. Unidirectional, the material is entering here moving in a specific direction top floor and then, may be moving downwards and then finally, being produced here. But here we see there is no the material is entering; then, it is moving here. Again, moving here. It is gear again retracting again going back to the top and then coming down.

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So, we can have a unidirectional or retractional flow. Then, we can have Vertical or Inclined Flow very easily you can see the material is moving vertically, whereas here it is moving in an inclined fashion. Single or Multi flow material is entering here, it is being subjected to different operations in a sequence and then finally, it is getting out and then, there is multi flow also possible. So, we can see that the material may not flow on horizontal floor only; material may flow in the vertical directional also across the various floors of the building of an organization.

So, with this we come to the end of today's session. I think we have tried and we have been able to understand that within a factory layout, the material takes up a particular flow line and we to select the flow of material, we have to arrange our machines and equipment under the facilities in an specific flow line only in order to ensure the effective and efficient utilization of the various resources that we are using for converting our raw material into the final product.

So, with this, I conclude the today's session and in next session, we will discuss our final aspects related to the topic of factory layout.

Thank you.