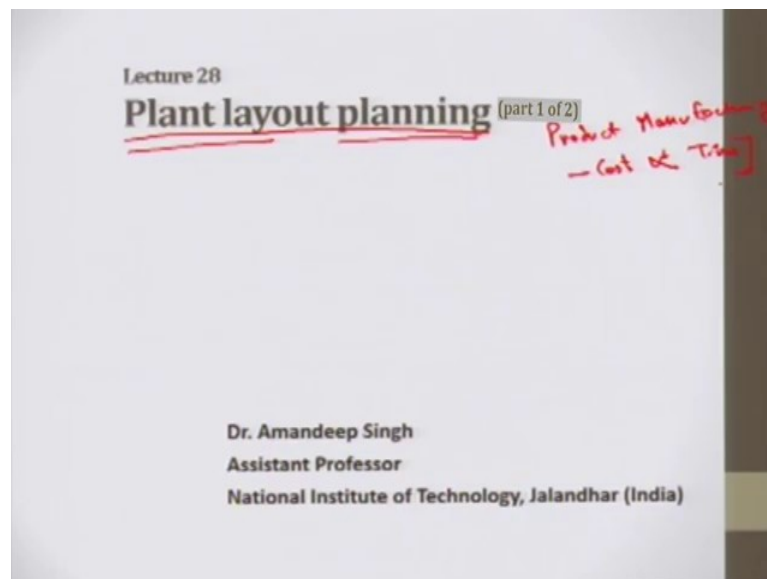


Product Design and Manufacturing
Prof. J. Ramkumar
Dr. Amandeep Singh Oberoi
Department of Mechanical & Design Program
Department of Industrial and Production Engineering
Indian Institute of Technology, Kanpur
National Institute of Technology, Jalandhar

Lecture – 28
Plant Layout Planning (Part 1 of 2)

Good morning, welcome back to the course Product Design and Manufacturing. So, herein we are discussing how to design a product? How to develop a product? And how to manufacture a product starting from the very basic idea to have the final prototype and then testing and further we will also discuss, how to market the product? What is the how to manage the competitiveness market competitiveness benchmarking and these things and in this specific lecture I am trying to focus on the plant layout planning.

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Plant layout is an important factor in product manufacturing; because the cost of the product is very much dependent upon the time cost is proportional to the time that is taken by that product to get manufactured.

So, this time is very important factor in a factory, in a factory material handling is there the product has certain complex characteristics certain products are very complex certain products are simple to manufacture. So, there needs to be some specific arrangement of

the equipments and tools and the movement of workers, material handling. So, that the product time is minimum and the cost is also very much optimal.

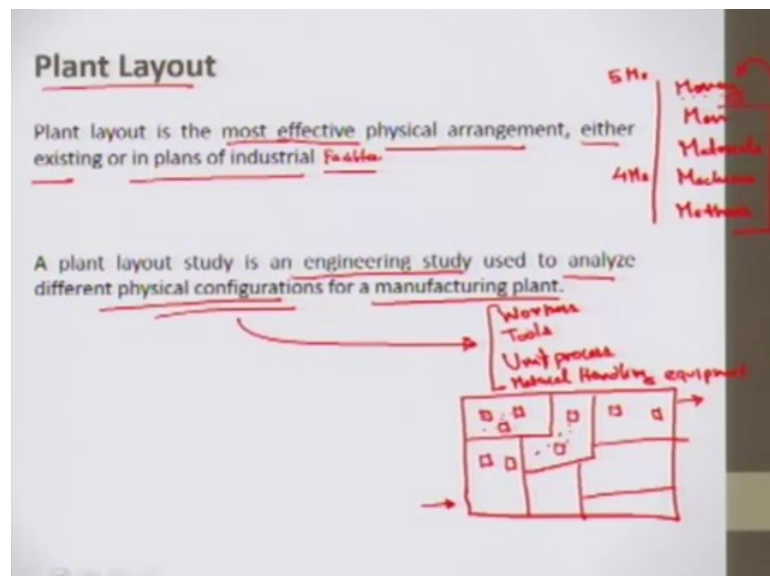
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So, I will try to cover an introduction to plant layout. So, why plant layout study is important, then we will discuss certain factors those affect the plant layout. Then the types of plant layout, and we will see the advantages, and disadvantages of all these process layout, product layout, fixed position layout, combination layout, cellular layout, and some other miscellaneous layouts.

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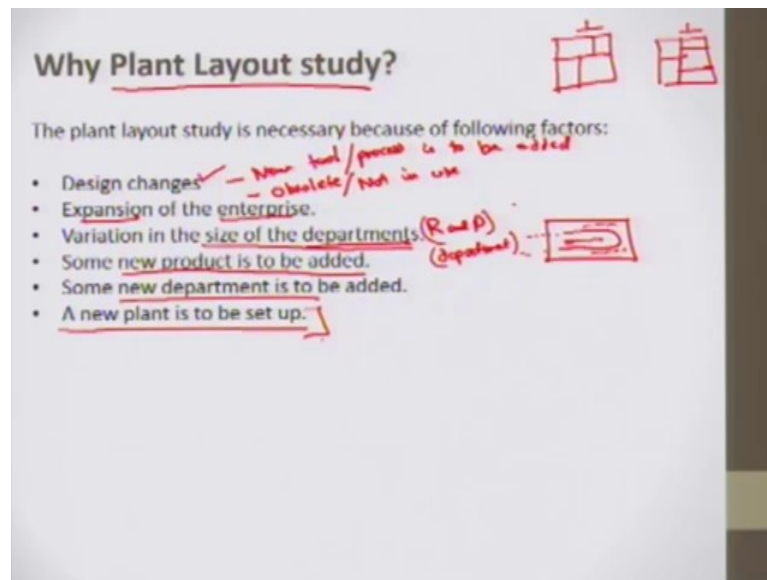
So, how do we define a plant layout plant layout is the most effective physical arrangement either existing or in plans of industrial facilities industrial facilities. So, it has to be most effective how it can be most effective we will see. Now it is arrangement of machines and equipment and it considers certain all the MS of management there are 5 Ms in management, 5 Ms of management are 5 Ms of management are money, men, materials, machines, and methods.

So, the plant layout is an arrangement of machines or the processing equipments and service departments to achieve the greatest coordination between the 4 Ms these 4 Ms. So, as we could have lesser investment lesser money is used here. So, these 4 Ms are more of focus in plant layout study.

So, layout problems are fundamental to every type of organization or enterprise and all kind of undertakings the adequacy of layout effects the efficiency of sub subsequent operations, the layout study is an engineering study used to analyze different physical configuration of a manufacturing plant here. By physical configuration I mean the plant setup for example, this is the area where my factor is to be set I need to divide into 2 certain sections, I need to see where we have the entry where we have the exit and we need to put certain machines in here.

So, this is a kind of a layout. Now these are the fixed equipment, then we have material handling the workers would keep moving between these machines. So, this one unit is called unit process or a unit manufacturing process. So, these are physical configurations unit process, material handling equipment, then consumable tools, also I can put workers here. So, these are all physical configurations.

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Now, next is why do we need a plant layout study? Many situations give rise to the problem of plant layout 2 plants having similar operations may not have identical layout here. For example, both of the plants are producing similar kind of product, but the layout might be different and because the nature of the process and management caliber how well is management able to take the decision about the plant layout here is also a factor here.

So, the plant layout study is necessary, because of following factors there are design changes sometimes in the product and because of the design changes, sometimes some new equipment a new tool some new tool or new process is to be added or some obsolete better to use not obsolete or not in use process is might also be there. Then sometimes the enterprise thinks of expansion every company every industry as we seen in the physical world is trying to expand.

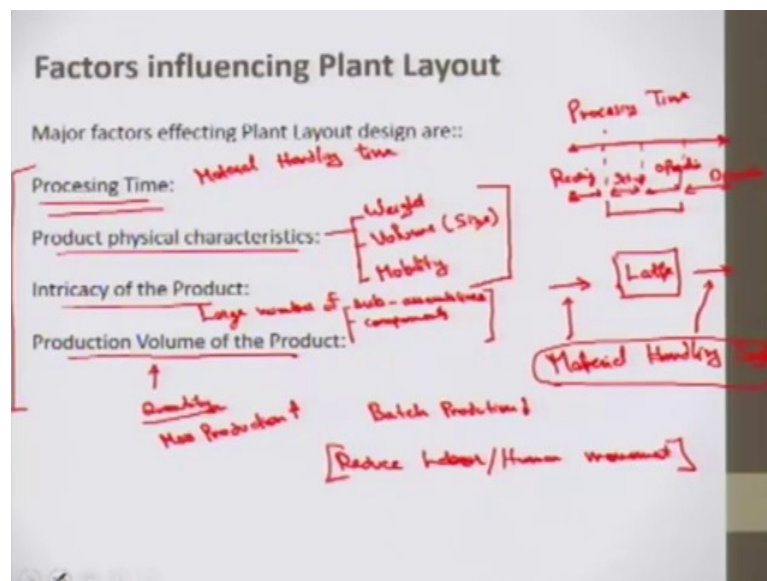
A automobile industry is trying to expand the competitiveness in the market is too high these days a product segment for a software a if I say, the life of a software is not more than 6 months for the mobiles that is lifespan of the mobile phone a new segment of the mobile phone or a new class of the mobile phone would get obsolete or a would get outdated because of the new products coming in the market in maybe 6 months.

So, there are now numerous competitors China is coming into play is a taking the market share very fast. So, new products are there and enterprises are trying to expand. So, a

plant layout has to be made in such a way that the expansion is also possible, if there is some layout will discuss about the layout for example, this is u kind of layout, it could be expanded or we could be able to put some more machines in there. So, this is one of the factors here, then there is variation in the size of the departments sometimes the department size varies.

For example, in recent years the R and D is taking place very fast in automobile manufacturing in mobile manufacturing and I would rather say in almost all the products R and D department is playing very big role. So, that is why the variation of the size of the department R and D department would become bigger R and D department. And if some new product is to be added into the line that might also need the change in the plant layout some new department is to be added sometimes and even we if a new plant is to be set up the plant layout has to be studied.

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So, next I like to discuss a few factors that influence the plant layout, the major factors those influence the plant layout are processing time of the product, product physical characteristics intricacy of the product, production volume of the product.

So, what is processing time? It is actually the material handling time, material handling time. So, when I say a processing time or a product manufacturing time, if this is the time span. If I divided into wave spars this is setup, this is actual operation, and this is dispatch and here we have the receiving from the previous unit. Now here setup and

operation are the attributes of my unit process for example, if there is a milling machine or if I put it is there is the lathe machine setup would be made here or operation or a processing would be done here only and this receiving and delivering out is done by material handling systems.

These are done by material handling systems. So, this is very much dependent upon this time material handling time is very much dependent upon the kind of plant layout that design of our plant. So, it has a significant proportion of total time of manufacturing and any reduction in handling time of the product may result in great productivity improvement. So, that is why processing time is one of the important factor that influence the plant layout.

Product physical characteristics, but physical product characteristics I would say weight of the product, volume of the product, hereby volume I do not mean the production volume, volume means the physical size of the product. And the mobility of the product, that how well a how what is the ease of the product movement could we move the product of the does it have to be made in a fixed position.

So, if the per final product is quite heavy or difficult to handle involving costly material handling equipment and a large amount of labor important consideration will be to amount the product minimum possible, to give minimum movement to the product.

For example, in aircraft manufacturing we will use fixed position layout, the product handing the product, moving the aircraft through a conveyor line would be very much expensive and even the space that is required would be very large the movement energy that would be consumed in moving the conveyor belt would be very high, for in that case the mobility of the product suggests that it has to be fixed position layout here.

Now, next is the intricacy of the product. Now if the product is made of very large number of components, then large number of people may be implied for the handling the movement of these parts, from shop to shop or from machine to machine, or one assembly point to another, then the product layout has to be accordingly by intricacy I would means large number of sub-assemblies or components.

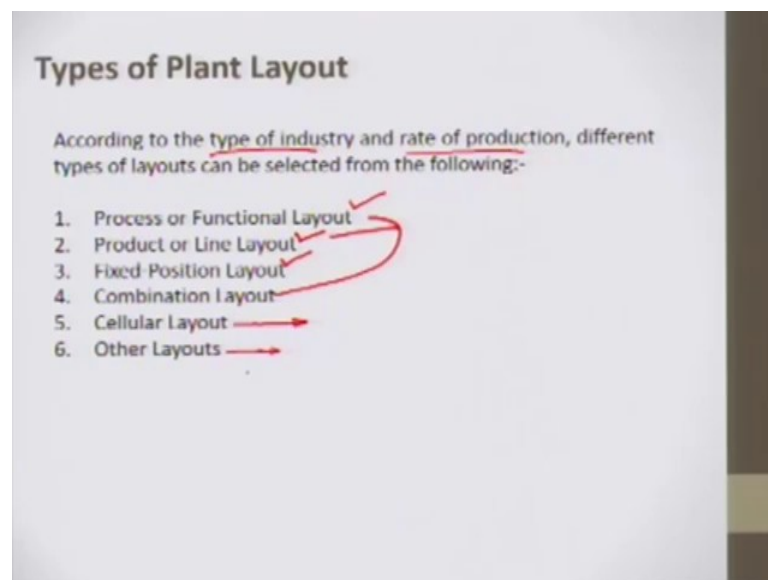
So, in this case I can say in automobile manufacturing. The car manufacturing is being carried out on conveyor belts and the, it has large number of parts involved the large

labor is involving there, the labor what do they do? Their labor is there in fixed position, they just do their job for example, one guy is doing just fixing this side mirrors he will keep on fixing the side mirrors and do the same things on the same side. If he is putting the right side mirror on he also putting the right side may be lid or maybe the wheel cover kind of things on into my automobile.

Next is production volume of the product. The production volume here I mean the quantity of the product. The extent to which process tends towards mass production, that is mass production. If it is volume is very high it will be mass production, but the volume is low we can call it batch production. Now with the use of automatic machines in industry for adopting mass production system of manufacturing the volume of production will increase, in view of high production output larger percentage of manual labor would be engaged in transporting the output unless the layout is good.

So, in this case mass production to reduce labor or human movement the layout has to be designed accordingly what layout can be used for this we will see in the forthcoming slides of this lecture.

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Now, let us come to the types of plant layout. According to the type of industry and rate of production, different types of layouts can be selected from the following number one is process or functional layout, number 2 is product or line layout, number 3 is fixed position layout, then we have combination of these 2 process and product it is known as

combination layout, then we have cellular layout that has also certain advantages we will see here, then some other kinds of miscellaneous layout we will see.

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Process or Functional Layout *Batch Production*

- Process Layout are discovered essentially in work shops, or firms that deliver altered, low-volume items that may require distinctive preparing necessities and arrangements of operations.
- Process layouts are office arrangements in which operations of a comparative sort or capacity are assembled together. In that capacity, they once in a while are alluded to as utilitarian formats.
- Their objective is to process products or give benefits that include an assortment of handling prerequisites. The example would be a machine shop.

Figure 10.1

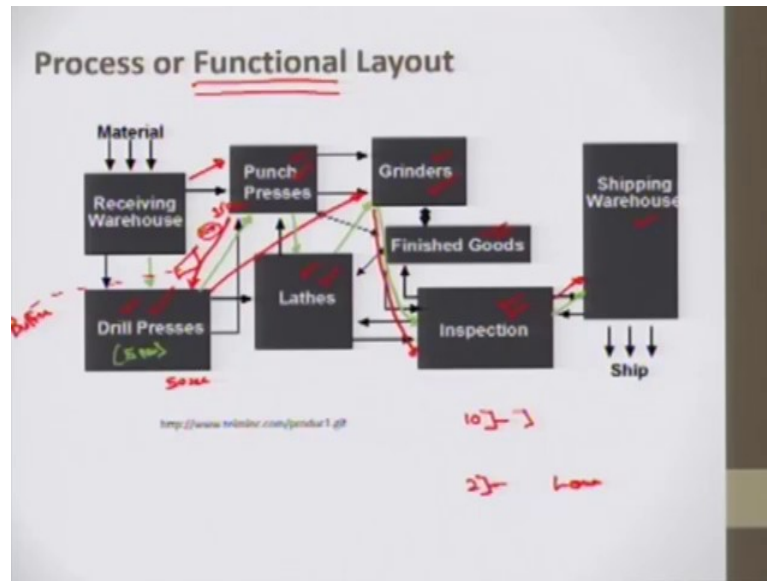
II	Can I
1. Drilling	1. Milling (Planing)
2. Planing (Milling)	2. Drilling
3. Grinding (Milling)	3. Grinding
4. Inspection	4. Inspection

So, let us come to the process or functional layout. First process layout are discovered essentially in workshops, firms that deliver altered, low volume items, that may require distinctive preparing necessities an arrangement of operations. By low volume items if I say low volume as just I just mentioned; that means, it is a batch production.

So, what is process layout it means the similar kind of processes are arranged in one section of a factory the similar kind of operations are carried out in one section for example, one section can do all the lathe of one section can have all the mate machines and other section can have all the milling machines, and the certain other section can have all the drilling machines and finally, grinding machines and inspection final one section would be of inspection.

In this case the product it is a certain sequence of operations the product with that is to be carried out on a product. What is has to be done for example; the first operation is milling, second is drilling, third is grinding, and then is inspection. So, what happens this milling operation would be carried out in the milling section only we will see the kind of layout here?

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So, this is a material that is receiving by warehouse. So, there we have only drilling presses, here we have punch presses, here we have lathes, here we have grinders, here we have finished goods, here we have inspection, here we have shipping warehouse.

So, let me say in place of milling let me say punch. First, I receive my product here in case of the specific batch, which I have this I am trying to put here I will say punching. So, my product would first be received here, then second operation is drilling, third operation here is grinding, fourth operation is inspection and the final shipping. So, this red arrow path is for my one product here. For another batch I could have this is case 1, I can either have second product or product 2 I would say in that case let me say I have first process has drilling, second process has punching, third process has some turning or some step turning, that is lathe operation is required lathe machine is required here, then grinding and inspection.

So, in this case it will follow a different path. Once this batch is over the second batch would come into play and letting follows this path. From the receiving end we will first receive the parts to the drilling presses section and this will go to punching, then step turning would be carried on all lathe machines then grinding, then inspection and again and then final shipment.

So, this is my green path shows second batch here. What do you think? If we have mass production, is it good to have this kind of layout would this be beneficial or if we have

some very big equipment very big product I would say manufacturing of a ship, manufacturing of aircraft, could we move in this way could we move that no.

So, this kind of layout is not fit for mass production. Now, process layouts are office arrangements in which operations of a comparative sort of or capacity are assembled together. In that capacity once in a while are alluded utilitarian formats once in a while only. So, here the objective is to process products or give benefits that include an assortment of handling prerequisites that is higher requirements here, the example would be a machine shop.

As we have seen this is an example of a machine shop here. So, a machine shop has could have various other machines like we have punch press, drill press, lathe, grinders, finish good, inspection, shipping where we keep that is the warehouse only we cannot have hydraulic presses, we can have CNC machines NC section CNC section and certain similar kind of sections here.

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Process or Functional Layout

- Along these lines, offices that are designed by singular capacities or procedures have a process format.
- This kind of format gives the firm the flexibility expected to deal with an assortment of routes and process prerequisites.

↑ product

Material Handling Minimization

Minimum distance
↓
Less time
↓
Less cost (Transportation)

- Clinics
- Banks
- Auto repair shop
- Libraries
- Institutes/Universities

Now, along these line offices that are designed by a singular capacity or procedures have a process format, this kind of format gives the firm the flexibility expected to deal with an assortment of routes and process requirements. Administrations that use process layout incorporate for example, other than the mesh manufacturing in clinics, in banks, you would say the in banks cash receiving section is there manager is on one side, and inquiries in other side all these sections are divided. In clinics also we have the different

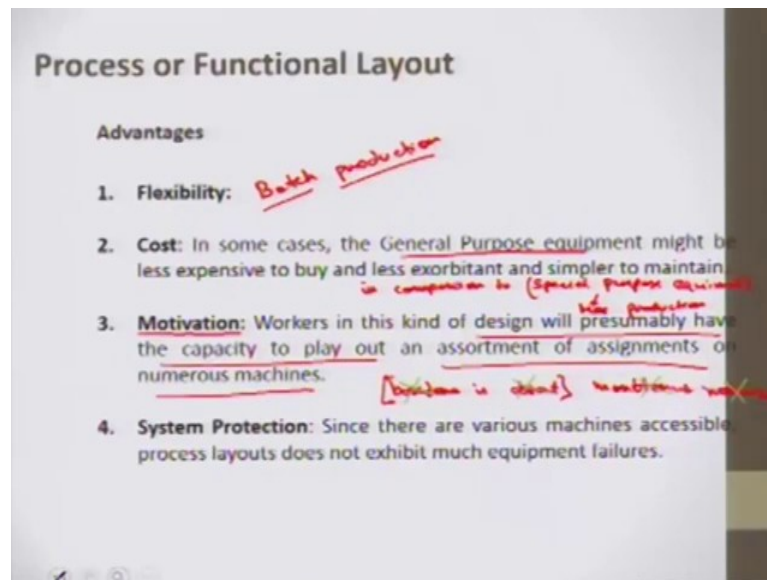
labs set into different sections, we have all the laboratory testing into one section only that is the testing area only.

On one section we have OPD on one section we have surgery. So, that is the way these systems are designed. So, similarly when we go to an auto repair shop or in libraries also the books are arranged according to the sections here ok. I can even put the institutes or universities, you have mechanical department chemical department all engineering departments have different sections and in that is a kind of an institute is a kind of a systems or system of systems.

So, here the full system is an institute the smaller systems are it is department it is respective departments and it is smaller system even has certain subsystems included. So, subsystems are in mechanical engineering department, we have design department, we have manufacturing department, we have thermal department, we have solid mechanics thing and all those are divided accordingly. So, improving process layout involves minimization of transportation that is I am again putting material in handling minimization.

So, how this could be done to have minimum distance between the frequent moving and this; obviously, lead to lesser time. So, in this case because the distance is minimum the time is less the transportation cost would be less, specifically transportation or process or functional layout here we have put a functional word as well here as we have a very well-known now in value engineering concept what is function. So, this is one function drilling this is a second function punching, third function is turning here, fourth function is grinding, fifth function is just finishing the goods, this is another function.

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So, it is divided accordingly to the function groups. Now there are certain advantages of process layout number one is flexibility, flexibility is because it is a batch production. So, any product most of the product can be put into this. So, as I have just discussed in why plants layout studies required the variation in size of department in product design changes or some new product is to be added this process layout offers best flexibility, because we will see in product layout or a line layout that putting even one machine into the line would demand for relocation of all other machines.

So, if the flexibility is very higher, then is the cost in some cases a general-purpose equipment might be less expensive to buy and less exorbitant and simpler to maintain, this is in comparison to the special purpose equipment the special purpose equipment is used generally for mass production. For example, general purpose equipments are these only the lathe milling, drilling, grinding, all these machines and for the special purpose machine is one machine is known as bolt maker.

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It will just take the round rod as it is input it will first form the rod into a hexagonal shape after passing it to certain passes and after that it will cut that rod so, this rod which is now a transform into a hexagonal bar.

Now, this bar would be cut according to the size of the bolt required, then the machining would be carried out turning would be carried out and after turning the threading would be carried out the mechanical people would more appreciate this process.

So, these are known as special purpose equipment now next advantage is motivation. Here, the motivation is the worker motivation. To work here the workers in this kind of design, this kind of real design will presumably have the capacity to play out and the assortment of assignments to on numerous machines.

So, the boredom is absent. So, they because they have they would have to keep on moving the monotonous kind of job is not absent here, this monotonous job or monotonous nature of job is not present here. So, this brings some interest into work. Next is system protection, since there various machines accessible, process layouts does not exhibit much equipment failure, because even if one machine fails here in this for example, I have here 5 number of beam processes and if one is not working other 4 can do the purpose.

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Process or Functional Layout - Capacity Utilization

Disadvantages

- 1. Availability:** Hardware use rates in process layout are as often as possible low, machine usage is dependent upon a variety of output requirements.
- 2. Cost:** In the event that batch processing is utilized, in-process inventory expenses could be high. Setups are more frequent. Material handling is slower and more wasteful. The span of supervision is small because of occupation complexities (routing, setups, and so forth). Moreover, in this sort of design bookkeeping, stock control, and buying for the most part are exceedingly included. Management work.
- 3. Perplexity:** Always showing signs of change plans and routings make rearranging process necessities more troublesome. Complexity.

Eoq: - Setup

There are certain disadvantages also associated with process layout number one is availability, the hardware huge rates in process layout are often as possible low machines user is dependent upon a variety of output requirement. So, hereby availability I could even say the capacity utilization. For example, at certain point of time we have 10 batches or 10 kind of production line and some at some other point of time we have only 2 batches, in this case the capacity utilization would be low in this case the factor would be running out of capacity here sometimes.

So, the capacity utilization is a factor here, next is cost in the event that batch processing is utilized in process inventory expenses could be high and setups are more frequent in process inventory here what we have for example, a drill presses taking 50 seconds for processing for doing one job. Now this one is taking for example, 100 and 50 seconds. So, what is happening $100 - 150$; $50 - 100$ seconds is the waiting time for one yard job here and here will we have stacking here will we have to locate a buffer to store.

So, in process inventory here is high and inventory carrying cost when we talk about E or Q, that is economic order quantity we have 2 factors here, 2 major factors here inventory carrying cost or also it is known as holding cost and this set up cost that is making an order.

So, in this case the inventory carrying cost is high. In this case setups are more frequent this setup is not the order setup of inventory not this setup this setup is the machine setup 2 for example, in a single lathe if I am doing or if I am trying to do step tending first.

Then next process I on a second job I have to do taper turning, I have to then fix the job and then do setting of my tool post accordingly that the taper cutting is carried out. So, that setup is very much frequent here that it also involves some time. So, material handling is slower and more wasteful here, the span of supervision is small because of occupation complexities routing setup and so on. These complexities these occupations all are carried out, moreover in the sort of design bookkeeping stock control and buying for the most of the part are exceedingly included.

So, this is all a control this is all managements work. Next is perplexity always showing signs of change plans and routing make rearranging of process necessities more troublesome. So, that is why some complexity comes into play. So, next is product or line layout it is also known as flow line.

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Product or Line Layout *F low line* - High volume
- High quantity

- Product Layouts are found in flow shops (monotonous get together and process or ceaseless stream ventures). *repetitive*
- In a product layout, assets are organized consecutively, in view of the directing of the items. *Machines*
- In principle, this consecutive layout enables the whole procedure to be laid out in a straight line, which now and again might be completely devoted to the creation of just a single item or item form.
- The stream of the line would then be able to be subdivided with the goal that work and gear are used easily all through the operation.

Product layouts are found in flow shops, that is monotonous get together and process or ceaseless stream ventures in a product layout asset are organized consecutively in view of the directing of items hereby assets I mean the machines or equipment.

So, flow shops produce high volume, high standardized products, high standardized products. So, these are the processes here are monotonous or repetitive. So, in principle this consecutive layout enables the whole procedure to be laid out in a straight line, which now and again might be completely devoted to the creation of just a single item or item form.

So, in one line this is also known as flow line the machines are set according to the requirement of the product for example, this is product 1. So, this is operation 1, operation 2, operation 3, whatever would be the sequence of operation for this product this arrangement would be made.

What we can see here is because it is made according to the product this product would be manufactured fast, that time material handling would be less in comparison to the process layout, but this is good only if mass production is carried out with only if the product one is having very large quantity to be manufactured large quantity. Because you see these machines 5 machines are dedicated to only 1 product.

So, it has to be done wisely the stream of line would be then able to be subdivided with the goal that work and gear are used easily all through the operation.

So, here work and gear mean the workers and equipment or machines now there are 2 kinds of lines that are utilized as a part of item formats paced and unpaced.

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Product or Line Layout

- Two kinds of lines are utilized as a part of item formats:
 - paced and
 - unpaced.
- Paced lines:
 - These can utilize a type of transport that moves yield along at a persistent rate with the goal that workers can perform operations on the item as it passes by.
 - For longer working circumstances, the workers may need to stroll close by the work as it moves until the point that he or she is done and can stroll back to the workstation to start dealing with another part.

Handwritten annotations in red:
- "Product (Work)" with an arrow pointing to a box on a line.
- "Work piece" with an arrow pointing to a small square on a line.
- "Paced" with an arrow pointing to the first bullet point.
- "Unpaced" with an arrow pointing to the second bullet point.

So, what is there in paced lines the product is attached product is fixed to the conveyor belt the product is fixed here. And the machines or the workers who have whoever has to carry this operation would do it is operation, whenever the product is flowing in this path. So, this can utilize the type of transport that moves yield along at a persistent rate with a goal that workers can perform operations on the item as it passes by.

For longer working circumstances the worker may need to stroll close to a work as it moves until that point he or she is done. So, what happens the as the work is fixed here we cannot take off this product from the conveyor belt. So, what if some operation has to be done here that is to be done by worker one only, if their worker one has to do this operation he has to move here or stroll here to do this operation with worker 5 and then again come back to it is position.

So, then he can stroll back to his own position own workstation to start dealing with another part here oh this is paced flow line.

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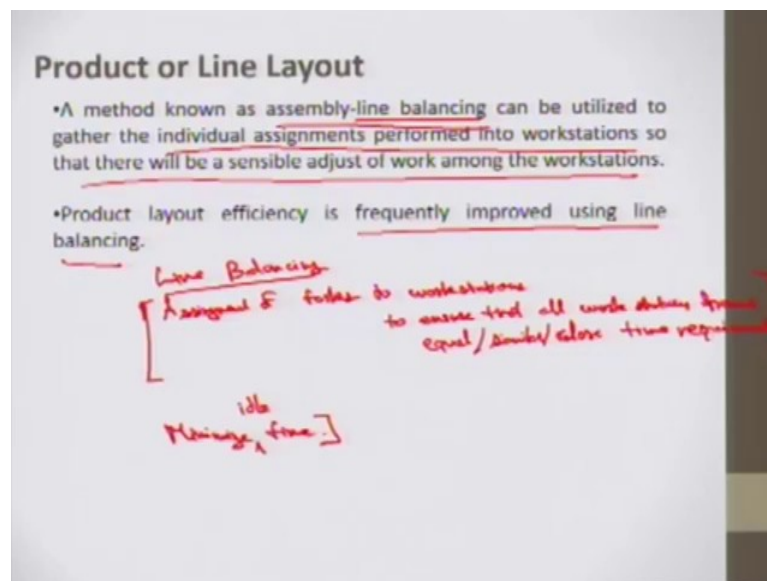
The slide is titled "Product or Line Layout". It features a diagram in the top right corner showing a series of parallel lines representing a production line. A red box is drawn around a section of the line, with the handwritten text "Not Fixed" above it and "Storage" to its left. Below the diagram, the text "Unpaced line:" is followed by three bullet points, each with underlined key phrases:

- On an unpaced line, labourers develop lines between workstations to permit a variable work pace.
- This kind of line does not function admirably with expansive, cumbersome items in light of the fact that an excess of storage room might be required.
- It is hard to adjust an outrageous assortment of yield rates without critical sit out of gear time.

Next is unpaced line in an Unpaced line; the laborers develop lines between workstations to permit variable workplace. So, what happens in unpaced line the product is not fixed on a conveyor it is not fixed, when I use word product here by product I would say my work or my work piece it is not the end product here would have end product or final product.

So, what is happening here he can take off this piece he can take off this work piece and take it to another line to do this operation he can take it off. So, this kind of line does not function admirably with an expensive, cumbersome, items in light of the fact that an excess of storage room might be required, which in this case some storage might be required here storage, it is hard to adjust an outrageous assortment of yield rates without critical sit out of gear time.

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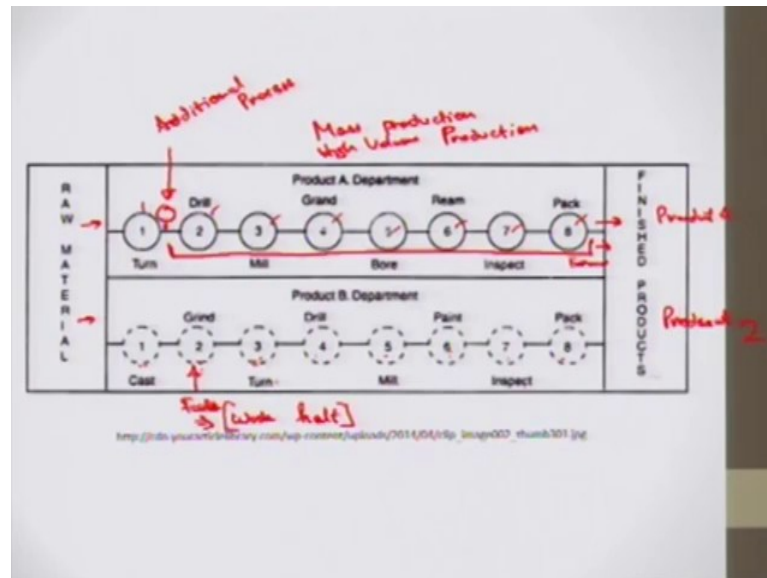
Now, there is a method known as line balancing or assembly line balancing that can be utilized to gather the individual assignments performed into the workstation. So, that there will be a sensible adjust of work among the workstations.

So, what is actually a line balancing line balancing is the assignment of tasks, it is assignment of tasks to workstations in a way that all workstations have approximately equal time requirements. Assignment of tasks to workstations, to ensure that all workstations have equal or similar or close time requirements what will this do this will reduce the ideal time of the machines. So, this is line balancing.

So, line balancing the product layout efficiency is frequently improved using line balancing this minimize the amount of time that some work stations are idle. So, this minimize time, better to say minimize idle time. So, this idle time is due to the work pieces which are waiting on parts from an upstream process and to avoid building up an

inventory queue in front of downstream process the line balancing is done in product layer this is the kind of a product.

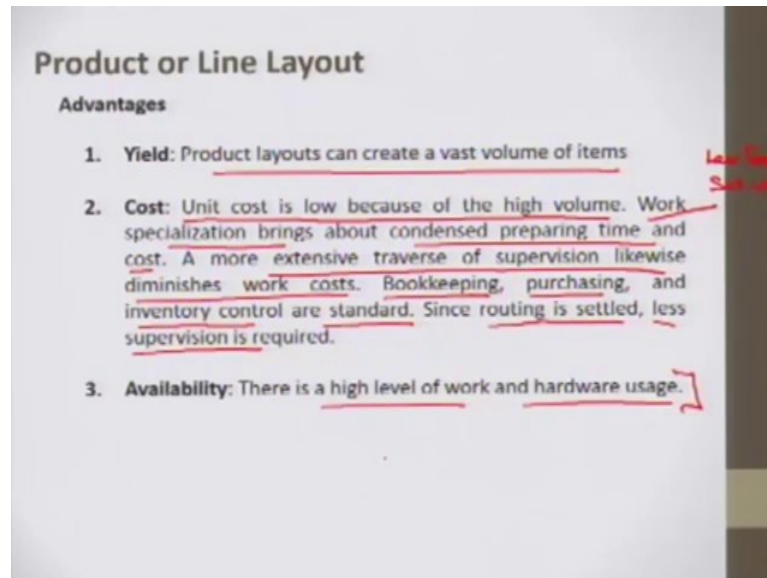
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Layout here the raw material is coming in we have one process turning, drilling, milling, then grinding, boring, rimming, inspection and packaging.

And the product one is out and the second process is second product is the raw material is coming in certain processes are being carried out casting, grinding, turning, drilling, milling, printing, inspection packaging, and then product 2 is out again recalling this is mass production or higher volume production.

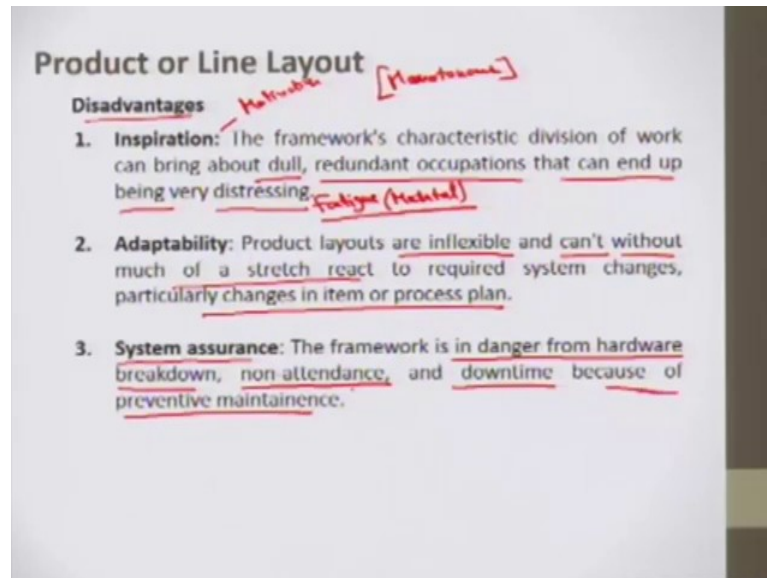
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So, say certain advantages of product or line layout the yield or the output the product layouts can create vast volumes of items the yield is too high. The cost the unit cost is low because of the high volume, unit cost is the cost of the product work specializes brings about condensed preparing time and cost preparing time is reduced because there are less setups less frequent setups in here I will put it here.

Less frequent setups and more extensive traverse of supervision likewise diminishes work costs, extensive supervision is carried out by the worker here. Now bookkeeping or accounting purchasing and inventory control are all standard, because of mass production since routing is all settled here less supervision is required. Then is availability, there is a high level of work and hardware usage the capacity utilization is high here disadvantages.

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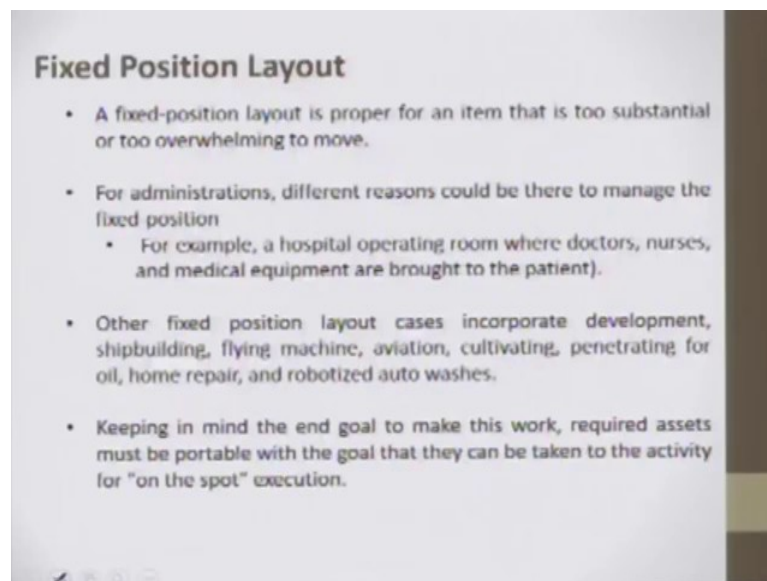
The inspiration or motivation, because of monotonous kind of job nature the frameworks characteristic framework is the layout characteristic division of work can bring about dull or bore rendered occupations that can end up being very distressing. So, some fatigue can come in this case I am not talking about physical fatigue that is different mental fatigue. So, for this, certain breaks, that is when we talk about the work study and we talk about the method study, when we talk about the efficiency of the worker it is the skill worker is compared with a standard worker and certain breaks are given in between for example, if there is a 8 hour work shift certain breaks after every 3 hours or every 2.5 hours is given.

So, that is why the fatigue can be reduced next is adaptability product layouts are inflexible and cannot work without much of a stretch react to required system changes, particularly changes in item or process plan as I have discussed before also if I need to put one more machine and additional process, additional process here. What I have to do? I have to shift all these machine forward to provide a space for another process here. So, this flexibility is lesser here.

So, this is also disadvantage here then system assurance the framework or the product or line layout is in danger from the equipment breakdown or hardware breakdown or non-attendance. Non-attendance means absent of the workers and downtime, because of preventive maintenance, preventive maintenance whenever because this is a kind of a

series connection if one equipment fails this fails employees work is halted, whole process is halted. To make sure that the need of corrective maintenance of breakdown maintenance is not there, preventive maintenance is carried out, but that also consume time preventive maintenance carried out for preventive maintenance this machine has to spare sometime for maintenance as well and that or during that time operation would not be carried out.

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So, next is fixed position layout let me take a break here and in the second part of this lecture I will discuss the fixed position layout then we will discuss (Refer Time: 46:13) combination layout combination layout is the combination of process and product layout, where is it beneficial we will see. And why do we need combination layout, then is cellular layout cellular layout is very prominent very widely used in industry these days. We will see about what is group technologies, what is flexible manufacturing system certain introduction to this one? So, let us meet back in the next part of this lecture.

Thank you.