Principles of Industrial Engineering
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Plant Layout: Product Layout Design
Lecture No. 23

Hello, I welcome you all in this presentation, related with the subject Principles of Industrial Engineering and you know we are talking about the Plant Layouts. We have seen that there are 5 types of the plant layouts like the, process layout, product layout, combination layout, cellular layout; which is also called group technology layout and the fixed layout. We have talked about the way by which we can design the process layout. In this presentation, we will be talking about the procedures which are used for designing the product layout.

In the product layout, we know that the facilities and the work centers are arranged according the sequence in which the operations will be performed on a product, and here there is no clustering based on the nature of the operations being performed, like in the process layout.

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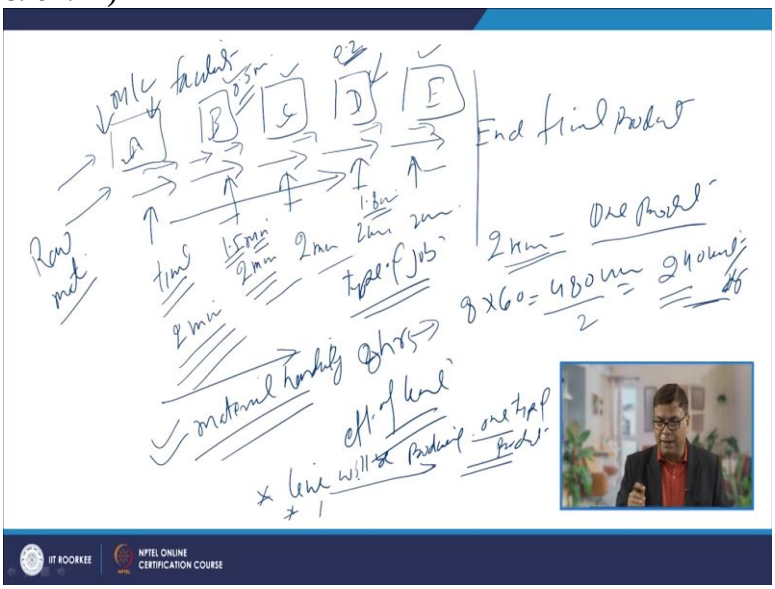

So, the typical arrangement which is used here is like there is a set of the facilities. Like say there is station A, Station B, station C, Station D, Station E. So here what do, basically the raw material is fed in. And after getting processed through the different stations; at the end we get the final product.

So here, these various facilities at different stations A, B, C, D to E, the machines, the nature of the machines and the facilities can vary significantly. Here, what we do basically, the each station is designed or developed in such a way that it takes the time to complete the operations at each station of equal magnitude. Let us say, the time required to complete the

work at Station A by the different machines whatever are working, let us say it is 2 minute. Then after the completion of the work on the raw material, partially processed component is moved forward and then further work is done on the station 2 by the another set of the machines.

Technically or theoretically it should take also approximately the 2 minutes only to complete the job. So, the distribution of the work at these centers is done in such a way that the time require to complete the assigned activities at each station is almost equal. So, if it is 2 minute at each station, then in that case all the machines will be working continuously and there would not be any idle time and at the end of the each 2 minutes we will be getting the 1 product.

So, if we have a shift of 8 hours, shift of 8 hours, leading to the 460, 8 into 60, 480 minutes. And if the 1 job is completed in 2 minutes, then the output, daily output will be like say 240 units per day. So, this is the basically the logic behind. So, what we have to do here, in this particular scenario, irrespective of the number, here since the line is designed in such a way that the job is done in 2 minutes at each station, giving the daily output of the 240 units.

If, let us say here the time consumed is 150 minutes, 1.5 minutes only and here it is 1.8 minutes only, in that case the station D will be idle for the 0.2 minutes and the station B will be idle for 0.5 minutes. So, this idle time will be reducing the efficiency of the line which has been developed. What we have seen that work is done at each of these stations and after completion of the work at each station the job is moved. So, for this movement the material handling device forms the integral part. Material handling device becomes very crucial.

Depending upon the type of the job to be done, the different types of the material handling devices are used. So, whenever we will be considering the development of the product layout, at the same time we have to see that we have to consider the kind of the material handling facility will also be used. In this case mostly, what we will see that the each line will be producing, whatever the product line or the assembly line has been developed, that each line will be producing either one type of the product or multiple products also.

So, multiple products if there is little bit variation in design with regard to the kind of operations which are to be done. And in this case, so each line will have the dedicated facility for each type of product in case of the product layout, that is very important.

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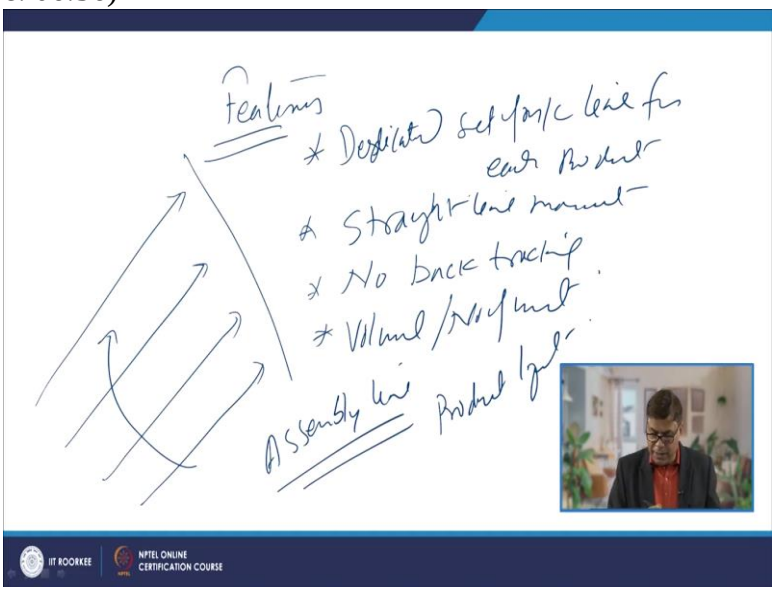

So, as far as the features of the product layout are there which will be affecting the design, like dedicated set of the machines, which means dedicated line for each product. Then there is the straight line movement, straight line movement, always movement, straight line movement so there is a clarity in the direction in which, regarding the direction in which the movement of the material during the processing will be taking place.

Third is, because of this straight line movement there is no backtracking. So, there is no clumsiness as far as the movement is concerned. And since, the each product line is for one type of the product, so we can have the limited number of lines because it requires huge investment. And that is why what we say, and these lines will be working continuously for producing same type of the product. So, the volume or the number of units to be produced, they must be sufficient so that these kind of product lines can be justified.

Assembly line, assembly line is a typical example of the product layout, like the assembly of car, assembly of toys, assembly of electronic goods, assembly of, like the mobile phones, and so many types of the components which are manufactured through the assembly lines. Wherein there is a smooth flow of the, the raw materials and the operators will be working on the components and after processing it will be moved to the next stations, so that there is a smooth and uniform flow. And the maximum production is generated in the minimum possible time. So, there is no cluttering, there is no wastage of the, there is no delays.

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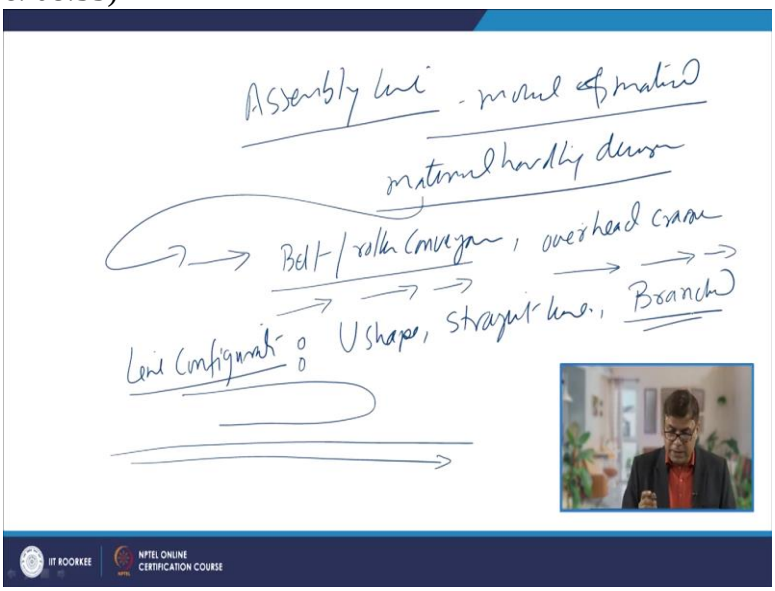

So, if we consider that like say, in case of the assembly line, we have to move the, movement, move the material. For the movement of the material, we have to use the material handling device. So, depending upon the type of the material handling device is used, the product lines are termed, grouped, classified in different ways. Say, if there is assembly line and the material handling devices are used in the assembly line to move the material, so these can be in form of, like say the belt, material handling devices can be in form of belt or roller conveyors. It can be like overhead cranes.

So here, the belt conveyors will be used when there is very straight line continuous movement. But overhead cranes will be used when the movement is intermittent between the different stations. Here now, the another one, the way by which the line is arranged, so what we will say, the line configuration. The material handling device may be arranged like in a straight manner, like the belt conveyor is moving the things in straight line. Or the belt conveyors are moving the materials in U shape.

So, as per the configuration of the line it may be of the U shape, the straight line or it may be branched also, it may be the branched also.

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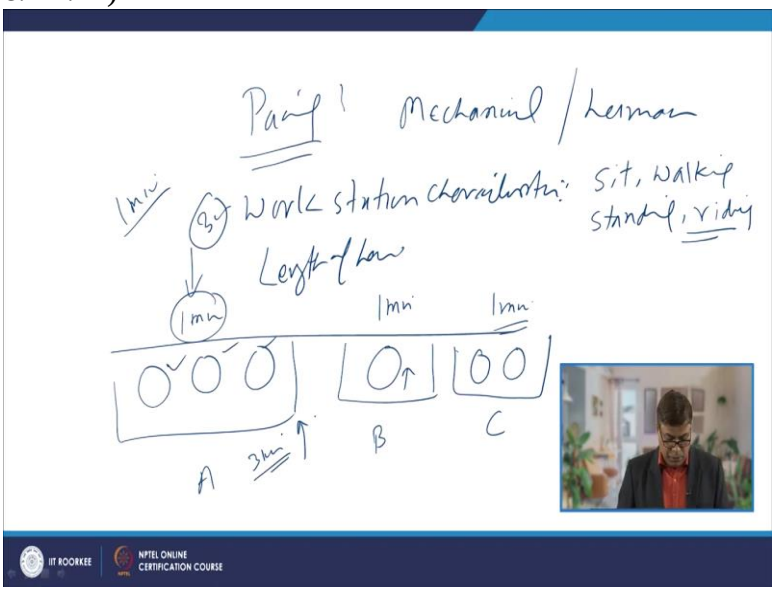

So, then we have the how the material is moved. So, how the pacing is done or the material is moved, so it can be mechanical or through the human effort. Then the work station characteristics. Like the worker will be sitting while work is being done, or worker will be walking during the operations, or he will be standing during the operations, or he will be riding on the belt during the, belt or the material handling device during the work.

Then the length of line, so like if the, if the, at a particular station A, the job is very complicated and if it is to achieve the desired production rate, if the maximum cycle time is say, 1 minute and a particular operation needs longer time, say 3 minutes. Then we will be deploying the 3 workers to complete the operations at particular stations, so that roughly it takes just 1 minute to complete the job.

At another station B, if the smaller step is involved and 1 operation is sufficient to complete the job then in 1 minute, then 1 operator only. Say station 3, if it takes 2 minutes to complete then the 2 operators will be deployed, so that they are able to complete the job in 1 minute. So here, at station A, the job needs 3 minutes for completion. So, we are deploying 3 persons, so that the entire job is completed in 1 minute.

At the station B, the operation takes just 1 minute so the 1 person is deployed. So, the different stations can have the different number of the operators and the different types of the facilities, so that each station the job is done in almost the same time or the cycle time which is desired for achieving the given production or the given output.

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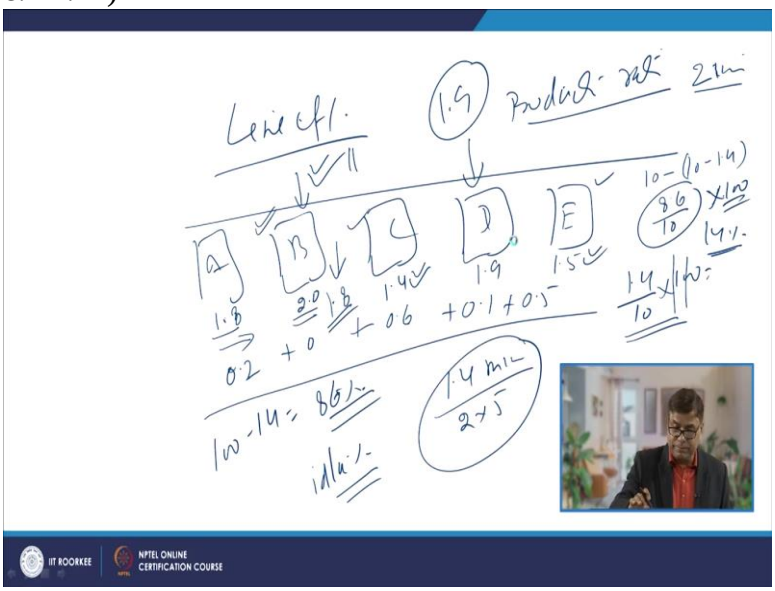

So here, if we see the line efficiency is the another thing, line efficiency. Say, in a line there are 5 stations, A, B, C, D and E. And for a given production rate, let us say cycle time is 2 minute, and what we see that the job at station A is completed in 1.8 minute, job B, at station B job is completed in 2 minutes, at C it is completed in 1.4 minutes, at D it is completed in 1.9 minutes, and at E say it is completed in 1.5 minutes.

So, the left out time, since the cycle is design, maximum time is taken here at station B. So, after the completion of the job at station A, the worker will be idle for 0.2 minutes here, here, here he will be idle for 0 minutes, here he will be idle for the 0.6 minutes, here he will be idle for 0.1 minute, and here he will be idle for the 0.5 minutes.

So, if we calculate the total time it is coming out 0.2, 0.6, 0.8, 0.9 and 1.4 minute is the total idle time of the workers in the line. Out of how much time, like say 2 into the 5 stations, so that will be giving us the kind of the percentage of the idle time which is being wasted. So here, what we will be getting, like 1.4 divided by 1. So here, what we will be having like the kind of the time which is being wasted, say 14 percentage is the wastage time.

And the time for which it is, the time which is effectively utilized is the balance time which is effectively utilized, that is equal to 10 minutes minus, 10 minutes minus 1.4 minutes, so that is equal to how much, 8.6 minutes divided by 10, so this is the percentage, this will be giving us the efficiency of the line.

So, that we can simply determine, like 100 minus 14 is equal to 86 percent. 86 percent is the time which is effectively utilized, will be giving us the efficiency of the line. So here, if we

see the station E is idle for most of the time and station C also, station C is having the maximum idleness than station E. And the idleness is 0 at the station B. So here, this is the station which is acting as a bottleneck. This is the station that takes maximum time. So, this station will be dictating the kind of the production rate. If the time of this station can be reduced to 1.8, then our production cycle time, 1.8 then our production rate will be dictated by the station D, where the time required to complete the job is 1.9.

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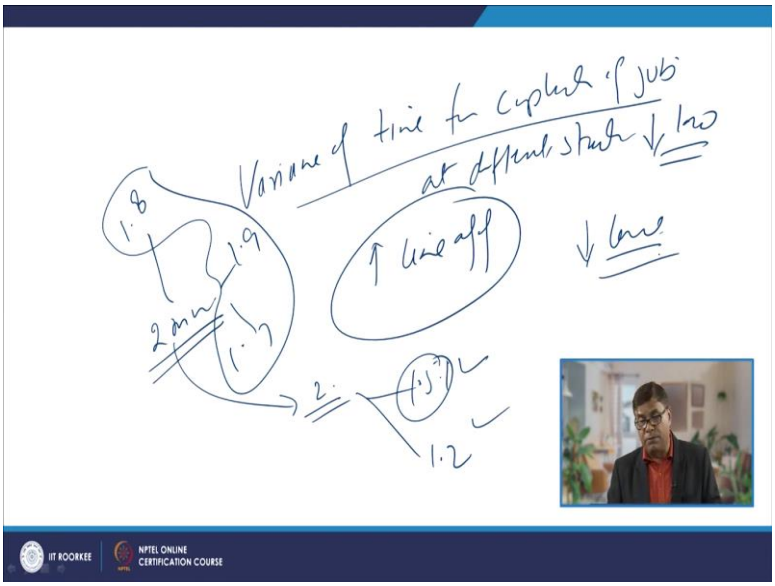

So here the important thing is that, if the variance of the time for completion of jobs at different stations is low, if this variance is low then the efficiency of the line, line efficiency will be high. And if the, like, say what we said the, let us say on an average time to complete is 1. So, if here it is in the range of like say, 1.9, 1.7, 1.9 like this, then the variation is somewhat less. But if out of the 2 minute the time, if the variation is like say 1.2, 1.5 having the larger variation. So, this will be leading to the greater variance in the time to complete the job, which will be leading to the reduced line efficiency.

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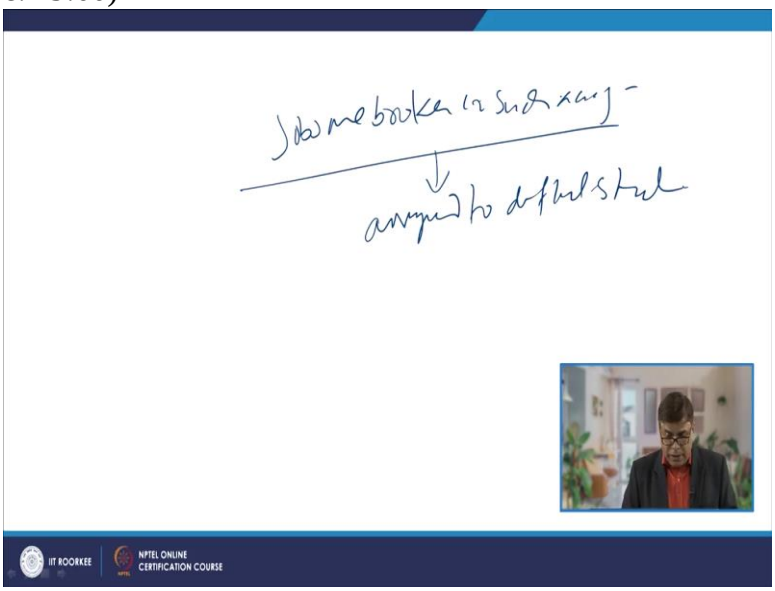

Therefore, in designing of the product layout it is important that, the jobs are assigned to different stations in such a way that almost they take equal time to complete the job, so that the efficiency of the line can be improved.

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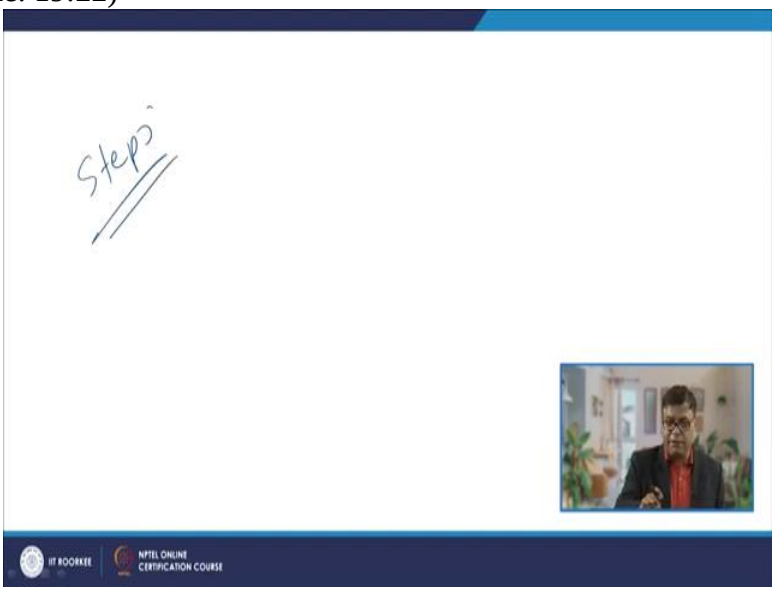

As far as, the steps and the procedures for the line balancing is concerned, those I will elaborate little bit later.

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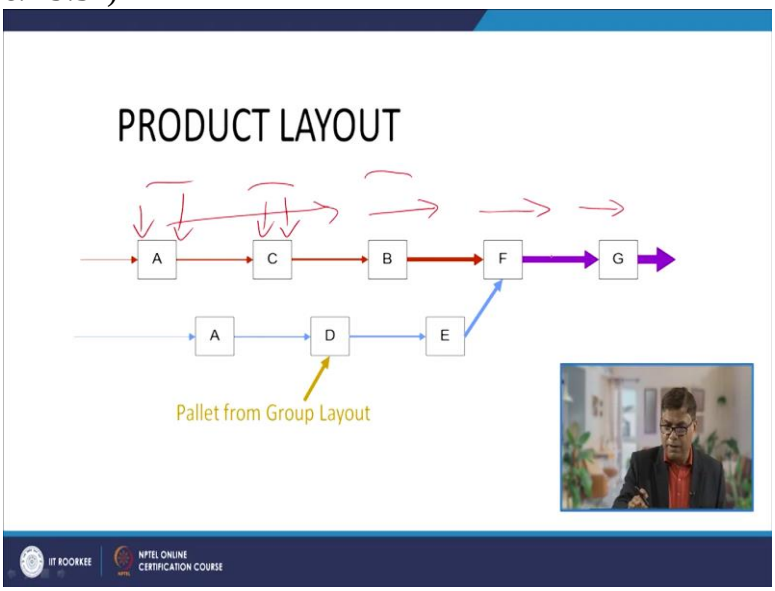

Let us see, the little bit details of, in the typical product layout what we have? Like say, the equipments are arranged in the sequence of the operations to be done. And the, these are designed in such a way, the activities to each station is assigned in such a way that they take almost equal time to complete, so that the wastage of the time at each station is minimized. And there is no backtracking and streamline movement.

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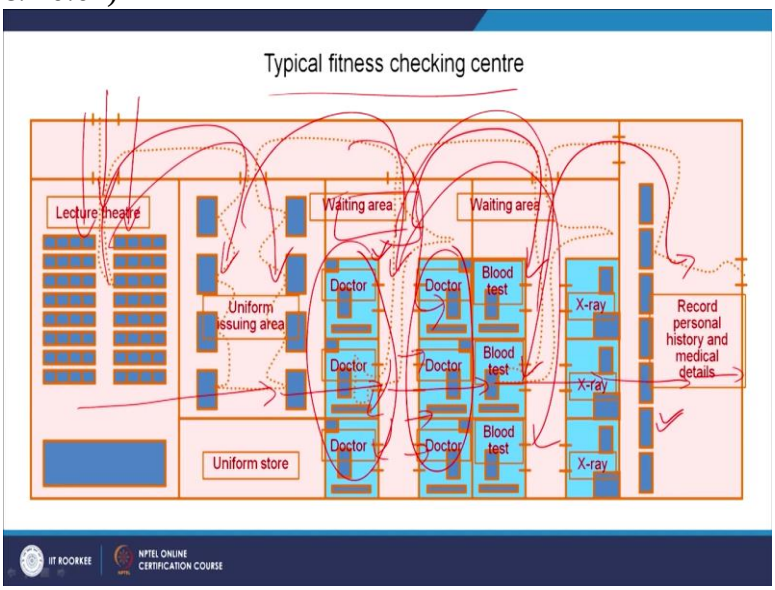

A typical example of the product layout which is used is, like say, the things will be moved in a particular fashion. Like say, in the typical fitness checking center, initially as soon as the candidates enter, they are informed about the various things which will be done. Then candidates will be moved and they will be giving the uniforms. After wearing the uniforms, the candidates are asked to wait here and then to consult the doctors for fitness checking. And then, here they will be giving the blood for the further test.

So basically, the fitness checking is done after consulting the doctors, they will be going to the, giving the blood for the testing purpose. And then they will be sent out after maintaining the record like what, who are the persons who have been subjected to this kind of checking.

So here, the facilities if we see, there is a particular way in which the facilities have been arranged and the candidates or the customers will be moving in a particular direction. This is the case where the things have been done, in a particular sequence with regard to the movement of the candidates. Although here we can see, all the doctors are sitting so this is also kind of the product layout kind of thing, where the similar kind of the facilities are arranged at one place, so it is combination of both.

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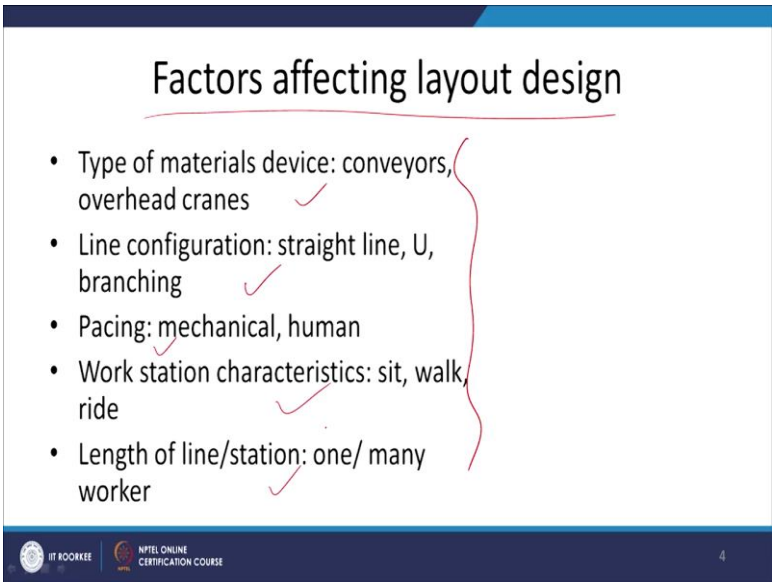

About this I have already talked like, how can we understand the different kind of the product layout designs, depending upon the kind of the facilities which are being used to move the material as per kind of the material handling device, kind of the configuration of the line which exists, the way by which the material is moved, the station characteristics and the kind of the length of the line, or the station where we are deploying either one or the number of persons.

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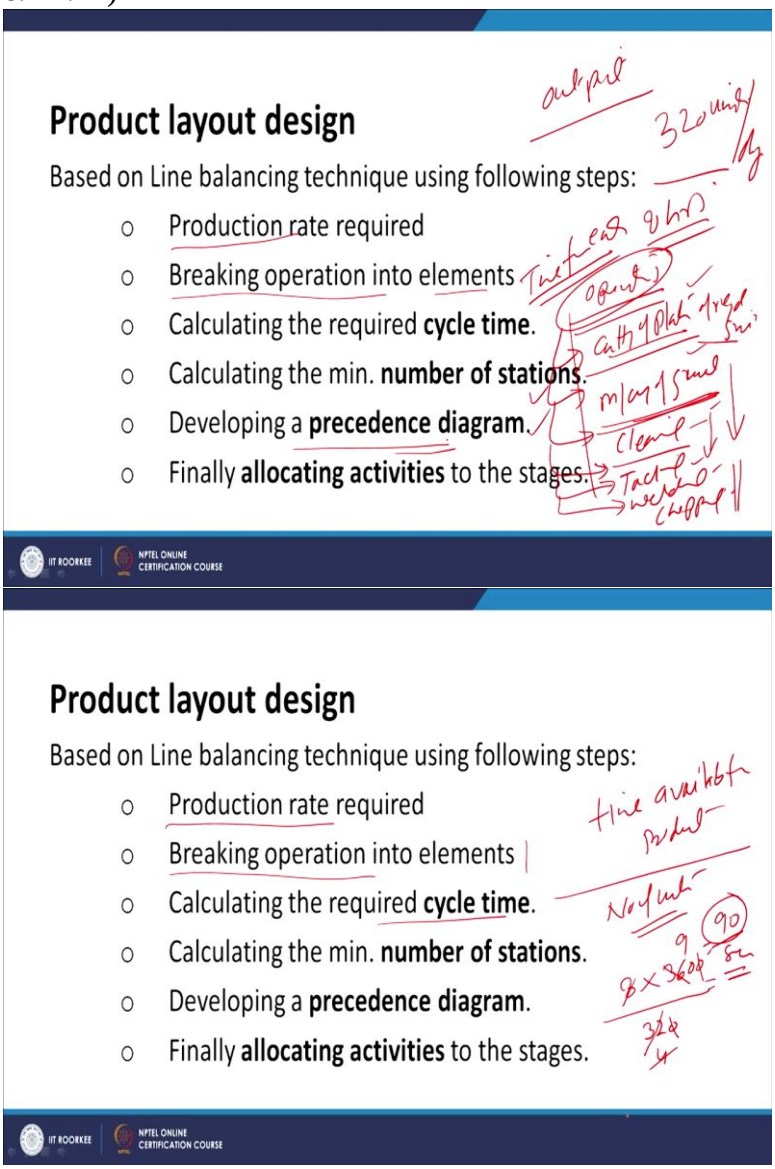

What we have to consider here, for designing the product layout, the basic method in designing the product layout is the balancing of the line. Which means the different stations are designed in such way, that all will be having the almost equal time required to complete the job at each station, so that the wastage of the time at each station is avoided or minimized.

The typical steps which are involved in design of the product layout includes like, what we are looking for from the particular product layout. Like if there is any target which we want to realize, what is the target. Because the product layout will be giving, will be running, the facilities will be running continuously to give the output. So, what is that output we are looking for, for which a particular layout is to be designed.

For example, it may be in form of, like say 100 units to be produced per day or 500 units are to be produced per day. As per the target, the lines, the layout is designed and the line is

developed. So, the first thing here is to identify the target output, what we are looking for. Output, say for a particular item, output is say, 320 number of units to be produced per day, considering the 8 hours of the working time per day.

Then, after we have identified the output we need to see what are the different operations to be performed. These operations are now broken down into the finer elements, so that each has its own identity. Let us say some (())(24:41) joint is to be developed then, it will start first of all cutting of the plates. So, this is one, of required size. Then it will involve like, the machining of grooves, then it will involve cleaning, then it will involve like say the tacking operation, then it will involve welding, then it will involve like say chipping process.

So, say these, for developing a weld joint these are the different steps which are to be performed. So, once these steps are identified; we have to estimate from the work measurement techniques, we can estimate the time to complete the each job. So, time for each element is identified. The operation is broken down into the different elements having the individual identity and the time for completion of the each element is identified. That is the second thing, so the breaking of the operation into the elements.

Another important thing here is, like what will be the sequence in which these, the different elements of the job will be done. In any case, say first of all we have to perform the cutting. Thereafter, after cutting the plates we can do the machining. During, after the machining we can clean. There is no point in cleaning before machining or the cutting. Then after the cleaning it will be done, tacking will be done. So, there is a particular order in which only the jobs can be, these different elements or different sequential steps related to the job can be performed.

So, once this is identified we will be able to develop the kind of the sequence in which or the steps in which the job should be done. This will come later, this is known as basically the precedence requirement. Which are the steps to be done first before taking up the particular operation.

Then the next step here is the, after identification of the output desired breaking the given job into the finer elements and then identification of the time required to complete those elements. Next is the cycle time required, so how to calculate the cycle time, to calculate the cycle time we have to see what is the time available for production and divided by the number of units to be produced.

So, if we consider like the number of units to be produced are 320 per day, and in a day, we have a shift of 8 hours into the, like say we have 3600 seconds each hour. So, on division what we get basically the like say, this 0 cancel, this 9 and so here what we are having 3, 80 into 60, 90 seconds. So here, the available time to produce divided by number of units, this will give us the kind of the cycle time or the time that can be allowed, maximum time that can be allowed for production.

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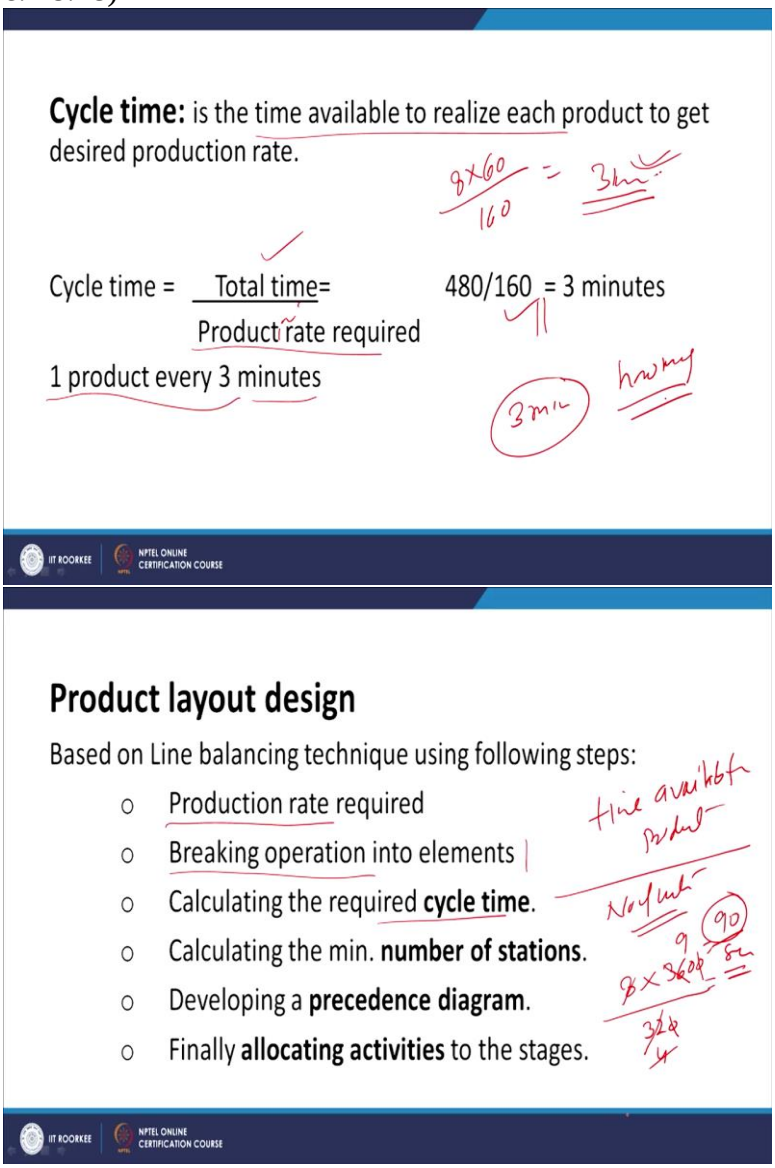

So here, if we see just for clarity. Cycle time is the time available to realize the each product to get the desired production rate. So, the total time available and the kind of the production rate which is required, the production rate which is required. So here in this case, say the total time available in 8 hours, 60 minutes and if the desired production rate is 60, so the 3 minutes becomes the cycle time. We cannot allow the time to complete the job at each station more than 3 minutes.

If that happens in case of the product layout, then we will not be able to realize the target production rate of the 160 units. So, in this case 1 product will be produced in every 3 minutes. So, this cycle time is helpful, like say 3 minute will be helpful in identification how many stations we should have in a particular line or in a particular layout, in a particular product layout. Say to complete, then another, another step related with the product layout design is the number of stations that we should have in a product layout. This is primarily based on the kind of, number of the steps required to produce a component.

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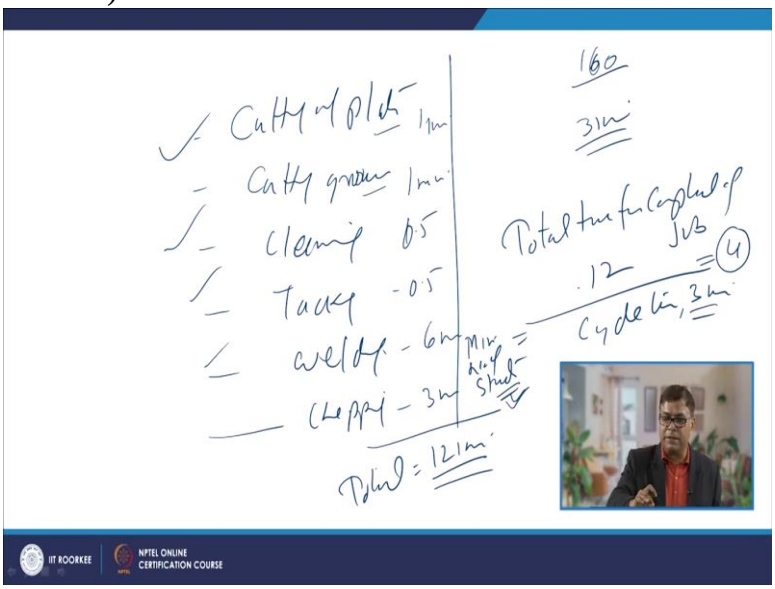

As I have said in earlier example of the weld joint design, which involves cutting of the plates then after the cutting of the plates say, then cutting groove, then cleaning, then tacking, then welding, and then let us say, chipping. As per our earlier example, if the 160 weld joints is the desired production rate, for which we were having the 3 minute cycle time. Say in this case, if the cutting takes 1 minute, cutting of the plates take 1 minute, cutting of the groove also takes 1 minute, cleaning takes half minute, tacking takes half minute. Welding takes 6 minutes and chipping takes, let us say 3 minutes.

So, the actually, if the, all these things are, all the, in any case to produce a weld joint will be required to, it will be required to complete all these steps to produce a weld joint. But these are taking the different times. And total time required to complete all these activities are like, 6, 3, 9 and 3, 12. So here, it is 12 minutes. So, time to complete, total time for completion of job is 12 minutes, divided by the cycle time which we have, that is the maximum allowed time for achieving the required production. This will be giving us the minimum number of the stations that we should have.

We can have more stations if the clubbing of the activities is not allowed. This will be the case of the minimum stations. We can always have more stations, if the precedence requirement is not justified. So, in this case if we see it will be coming 4. So, the 4 number of, we should have the minimum 4 number of stations in development of the product layout.

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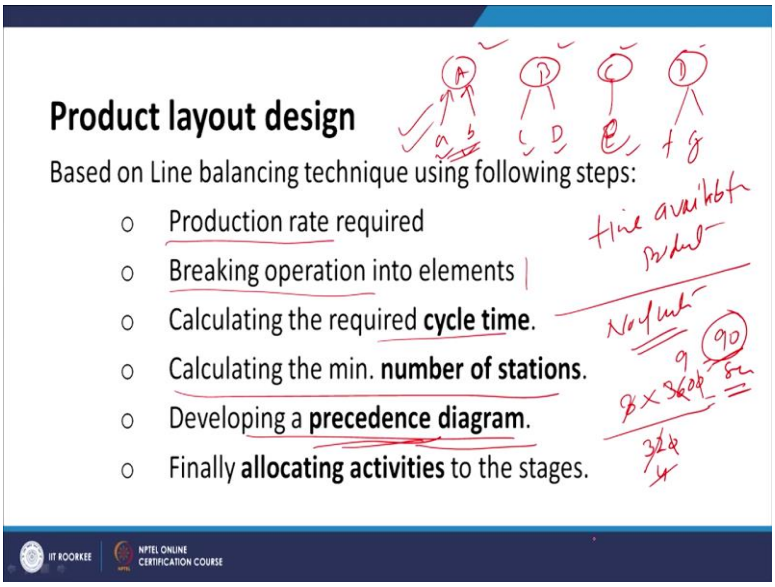

The precedence requirement as I have explained, it is the kind of the steps which should be completed first before taking up the next activity. And once we have identified the kind of stations say, we have identified 4 number of stations like this. What are the stations, like say A, B, C, D. So, for these stations what will be the activities which will be allocated so that the precedence requirement is also satisfied. Like say the job a and b, job c and d allocated to B, and the job e is allocated to the C station, and the job f and g are allocated to the D station.

So, these allocation or allotment of the activities to be performed at these stations; that will be based on the precedence requirement. Like it should be possible to do the activities a and b, first like say, in this case there is no precedence requirement. If there is no precedence requirement, they can always be started with and we will have, once the a and b are completed then we can say, if we can initiate, if we can initiate c and d activities only after the completion of a and b, so we have to assign a and b activities first to the station A.

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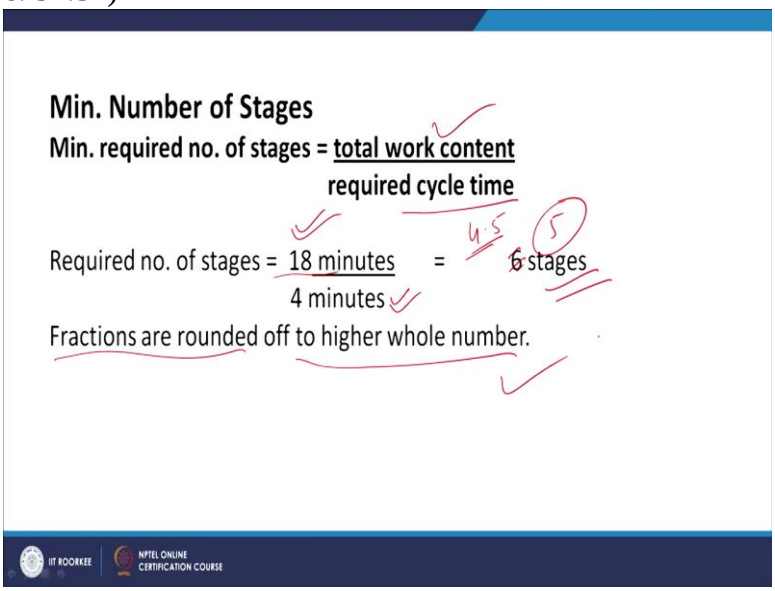

It means in precedence requirement, precedence diagrams just shows the kind of activities that are completed first before taking up the next activity. There is another example related to the minimum number of stations or stages required. Total work content in terms of the time required to complete the job, for completing the different works and processes which are related with the completion of job, and the cycle time.

So, let us say 18 minutes is the time required to complete various steps related to the job and 4 minutes is the allowed cycle time. Then here what we will be having, like ratio will be coming up like 4.5, so we will be rounding off and doing to the 5 stages, so 5 stations. We will have the 5 stations, in this case for minimum number of stages required. So, if you are getting the fractions, then rounding off is done to the higher whole number.

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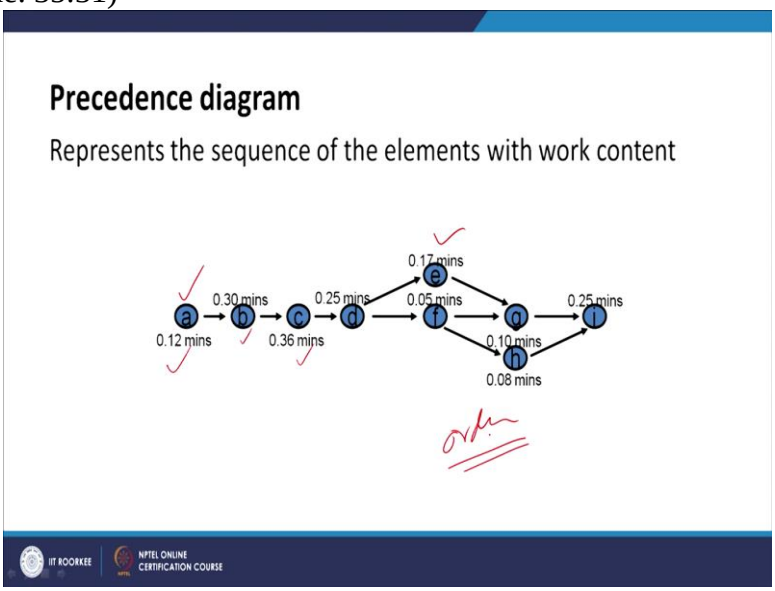

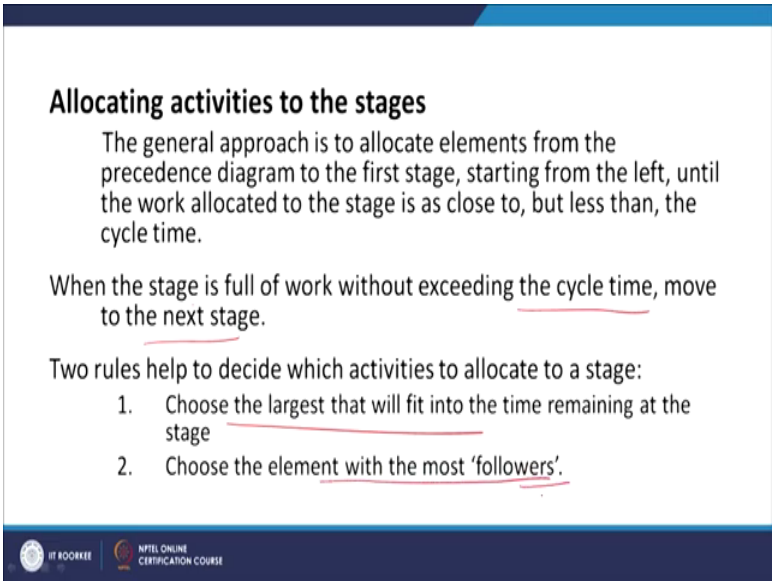

I was talking about the precedence diagram. It simply shows the kind of the activities to be done, along with the time required to those activities. What it shows that a should be done taking up the b, b should be completed before taking up the c, and all these things like a, b, c should be done before taking up the d, e and f. So likewise, what is shows, the order or the sequence in which the jobs should be completed and the kind of the time which will be related with the various activities.

As far as, the allocation of the activities to the different stations is concerned. In general, the general approach to allocate the elements from the precedence diagram, to the first stage starting from the left side activities. Until the work allocated to the stage is as close to, but not less than the cycle time.

So what we do, we will be starting with the allocation of this activity. And this activity whatever we can, like say first a is completed, then we will be allocating the b. And this allocation will continue until it is equal to, until it is equal to the cycle time and while satisfying the precedence requirement.

So, when the stage is full of the work without exceeding the cycle time, we move to the next stage. So, while allocating the activities to the particular station, we follow a particular criteria. Like choose the activity that will take the largest time, that will take the largest time and still if there is the clash between the 2 in terms of the largest time then, means if there is a tie, then we will be choosing the element which will have the most followers.

The example related with the product layout design; I will be taking up the next presentation. I will summarize this presentation. In this presentation basically, I have talked about the features of the product layout and what points we should keep in mind while designing the

product layout. The procedural steps, with the example of the product layout will be taken up later. Thank you, for your attention.