Operations Management
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Lecture - 30
Capacity Planning Examples

[FL] friends welcome to session 30 in our course on Operations Management. So, today we are exactly midway of our course the course is a 12 week course and we are going to finish our discussion for the 6th week today and we will be finishing 30 sessions of approximately half an hour each. And as far as I have seen the data I have always exceeded the time limit of 30 minutes.

Persistently I have tried to explain that what are the various maybe aspects of the topics that we have covered and with passion when you speak you just forget all the time limits and I think last sessions were maybe 40-42 minutes each. But I feel that I have tried to explain the things in the most simplistic, most simpler as well as most clear manner, but still if there are few suggestions the suggestions are most welcome we are midway through the course and whatever feedback we get from the learners we try to incorporate that feedback in our next courses.

Already we have re recorded two courses under MOOCs scheme one of course, was run successfully on product design and development, and another course was run successfully or is currently running under processing of polymers and polymer composite. And this is the third course we are recorded and whatever feedback we have got for the previous courses we have tried to incorporate that feedback in the current course. So, exactly midway I think I am highlighting the passion behind recording this courses and today we are going to discuss the some examples some numerical problem maybe one or two related to capacity planning.

So, in the 6th week of our discussion our focus was on production planning and control and we are today in the 5th session of week 6 and in week 6 the very first session was focused on the objectives and functions of production planning and control. In week 6 the second session was on process planning and the third session was on aggregate production planning, and the 4th session was on capacity planning introduction and the basic objectives of capacity planning.

In the last session we finished at the economies of scale and diseconomies of scale and there are definitely many things which we must understand that what is economies of scale, what is the best operating level, what happens when we are operating below the best operating level or maybe prior to the best operating level, what happens when we use our capacity beyond the best operating level. So, that capacity can be utilized prior to the best operating level if you remember in the previous session we have seen an example of a hotel industry.

So, 500 rooms was found out to be the best operating level. So, if we are using only 200 rooms we are underutilizing our capacity. If we are using maybe 1000 maybe 500 rooms is the operating best operating level suppose we have 1000 rooms we may be over utilizing our additional facilities. For example, suppose we have maximum utilization may be beyond 500 rooms there can be a condition of chaos restaurant may not be able to service all the people staying in all the rooms, sometimes our hot water facility maybe may not be able to serve all the guests staying in the rooms there can be problems associated with the excessive utilization of the facility also.

Similarly, I have talked about an example in which on the speed indicator of any vehicle we have a optimal speed if we go beyond that speed, if suppose the overall the maximum speed marked on the speedo meter is 200 kilometres per hour, but we usually do not drive at 200 kilometres that is the maximum rated speed. But if you go towards 180 190 it may not be the best operating level the safety maybe one of the concerns, but if we stick to the best operating level we will get the maximum results, the fuel efficiency can be better safety can be better.

So, there are maybe the rated capacity is always different from the utilized capacity. So, the rated can be higher, but the actual utilization of the capacity may not be the maximum. As we have seen a term called utilization rate. So, we have calculated the utilization rate also in the previous session.

In today's session again I will focus slightly on what we where we left in the previous session on economies of scale and diseconomies of scale. Because I believed that I have not been able to explain the things properly so again I have taken an example today just we will try to have a overview of the best operating level because that is where the capacity is being utilized because we have understood what is capacity, what is capacity

planning and then we have tried to understand the best operating level. And there we have seen one or two diagrams, but today again we will try to understand the economies of scale and diseconomies of scale with the help of the diagram. So, you can see the economies of scale.

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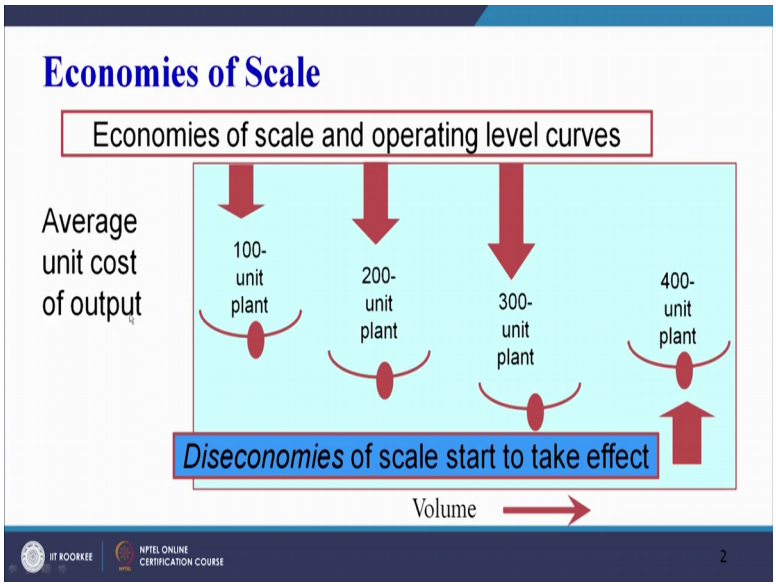

On your screen you can see the average unit cost of output or average unit cost 100 unit plant, 200 unit plant, 300 unit plant, 400 unit plant. So, you can see that beyond 300 unit plant for this particular manufacturing facility the average unit cost has started to increase beyond 300 unit plant.

So, the minimum average unit cost we are achieving at 300 unit plant only. So, why this happens we will try to understand. The diseconomies of scale have started to take effect after the 300 unit plant. So, why do these happens or why the rate there are two things to understand here. First is why the average unit cost is reducing till 300 unit plant question umber one. Question number two is why it has started to increase after the 300 unit plant. So, here the thing to understand is the economies of scale and the diseconomies of scale.

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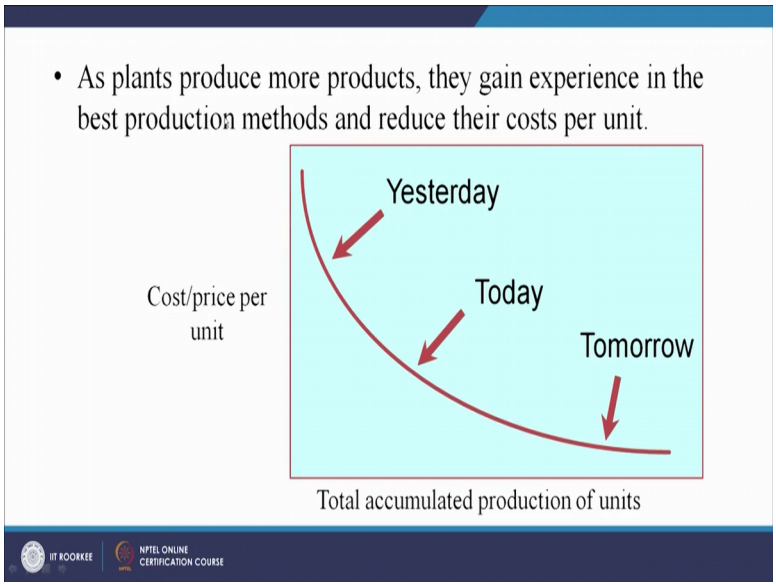

Now, from the graph that is shown on your screen, we can see that as the plant produces more products they gain experience in the best production methods and reduce their costs per unit. So, this is the cost per unit or the price per unit and this is the total accumulated production of units.

So, as an with time as and when you produce more number of units you learn more about the process, you learn more about optimization, you learn more about the skills required to make that product you develop the skills required to make that product. So, from manpower point of view, from experience point of view from, optimization point of view we become better as a teacher maybe let me share this example with you.

When you are checking the answer scripts for the students the first 10 to 15 answer scripts may take more time as compared to the same number of answer scripts when you are checking towards the end of the class. Maybe you have 100 copies to check the first 15 may take much more time as compared to the last 15 why because while checking the answer script you develop that skill of reading the answer script where to look in what type of answers the students have given also you memorize the maximum number of marks for ease each question.

So, you develop that kind of an experience for checking the answer sheet. So, that is the economies of scale that you derive that the average time spent on checking the answer scripts keep on reducing. Similarly the cost per unit also reduces.

Another point that I want to emphasize here is the concept of value engineering that we have covered in our week 2, in our topic of product design and development. So, over a period of time when you analyze the process, when you analyze materials, when you analyze the design of the product you always think or you always propose to come up with new materials, new processes, new designs in order to improve the product. So, with passage of time the things have to improve and therefore, we take advantage of the economies of scale because now we are using the best possible methods of production.

Now, economies of scale we have tried to again emphasize it cost less per unit to produce high levels of output one point must be taken into account high levels of output is not something which is linear. So, the cost per unit will not reduce linearly with high levels of output as we have seen as the volume is increasing, to some extent the cost per unit is reducing. So, cost per unit is reducing, but after the best operating level the cost per unit again starts to increase as we increase the volume of production. So, why do this happen? Why the cost per unit reduce with the increase in the level of output? So, it reduces because the fixed cost can be spread over a large number of units.

So, suppose you have setup a factory, you have procured the land, you have brought the machines, now this is related to the fixed cost required for setting up of the industry or the factory. Now, suppose you make only 100 components per month. So, the cost of setting up of the plant which includes the cost of the land and the cost of the machines that you have procured will only be spread over the 100 parts that you have made in a month. But suppose you make 1 lakh parts in a month. So, the fixed cost that you have spent on the machines and land will be spread now over 1 lakh parts that you have produced in that month.

So, therefore, when you increase the numbers of products that we are making the fixed cost are spread over a large number of product. So, it gets spread out. So, the cost comes down. So, production or operating cost do not increase linearly with output levels. So, production or operating cost do not increase linearly, so that there is the, this is an established phenomenon why because you take advantage of the maybe the discounts that are available you take advantage of purchasing the raw material in bulk and therefore, the production cost do not increase linearly.

The same thing has been highlighted; the quantity discounts are available for material purchases. So, if you buy suppose 10 parts you may have to pay rupees 2 per part, but suppose you buy 20 parts the price may come down to 2 rupee 8 paisa. So, that is the quantity discount. So, when you are buying more num more volume of raw material you get some discount on quantity. So, that can be taken care of when you are producing more number of products and in order to take the advantage of economies of scale. Operating efficiency increases as workers gain experience which I have already highlighted.

So, these are 4 important point which are responsible for reduction in the average input cost as the volume of production increases and thereby helping us in utilizing the economies of scale. But after a best operating level the diseconomies of scale start to set in. Now, why do these occurs this is given here, this occur above a certain level of output that we are terming as or that we are calling as the best operating level.

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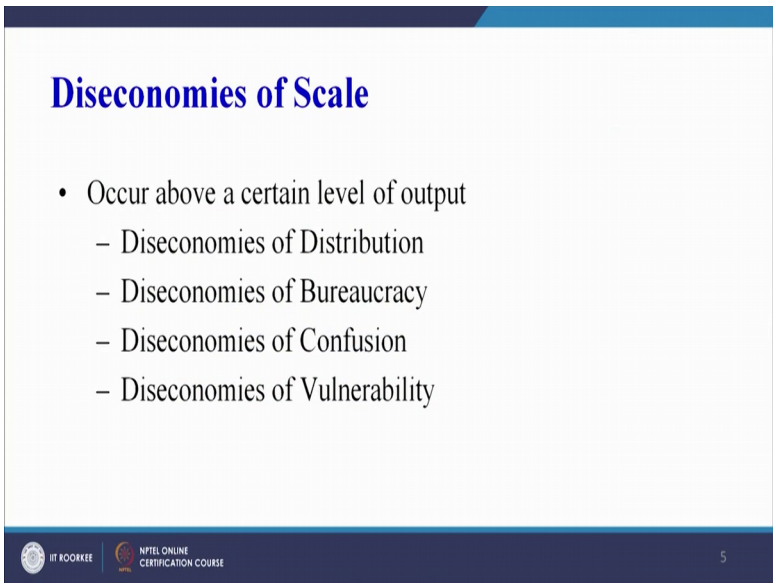

Now, why does this happen? This happens because of the diseconomies of distribution, diseconomies of beaurocracy, diseconomies of confusion, diseconomies of vulnerability.

So, if you see in totality I can say the chaos starts to set in we are not able to utilize our capacity properly, we are not able to plan the things properly, why because of the complexity in managing the operations.

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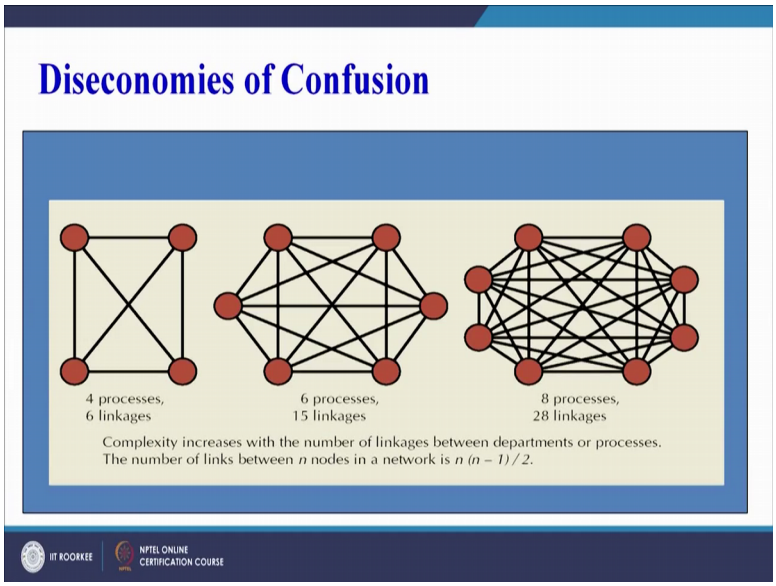

And I think we have one example here the diseconomies of confusion if we see 4 processes we have to manage 6 linkages, 6 processes, 15 linkages 8 processes, 28 linkages. So, the complexity increases with the number of linkages between departments or processes the number of links between n nodes is a network is n into n minus 1 by 2.

So, this is diseconomies of confusion. So, if you have to manage large variety of processes large variety of product or large variety of skilled manpower. So, it becomes a difficult operation or difficult process and therefore, we are not able to achieve our target of minimizing the average cost per unit. And therefore, beyond a particular operating level of capacity the things start to get out of hand and the average unit cost starts to increase.

So, I think the overall objective of understanding this capacity utilization or capacity planning is that we must identify that what is the optimal capacity utilization that we must target where the average unit cost of product or the process or the service that we are going to maybe study is minimized. So, we can see if we have a service that we are providing if we are a service sector industry, we have maybe 10 people working in for our company, we must identify that what is the exact number of this manpower that would help us to achieve the best operating level.

If we are doing the analysis of machines we must identify what is the exact number of machines that we must use in order to satisfy the demand and in order to operate at the

best operating level. So, basically the purpose is to finalize the capacity that we are going to use.

Now, let us see one example capacity utilization, this formula we have seen in the last class in the last session capacity utilization rate. So, the problem statement goes like this.

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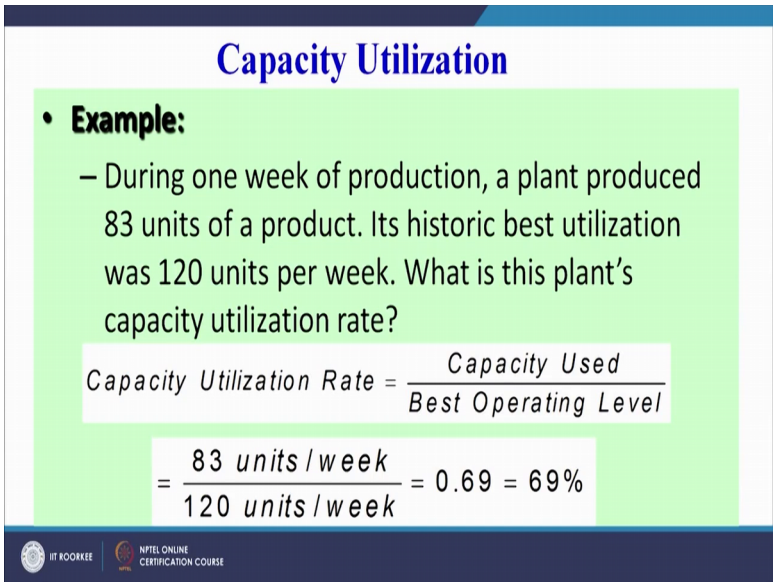

During one week of production a plant produced 83 units of a product its historic best utilization was 120 units per week. So, it has produced 83 units in the current week, but initially in when the plant was operating maybe to the best of its capacity it has also produced 120 units per week. Now, what is the plant's capacity utilization rate?

So, the capacity utilization rate as we have seen as for the formula is capacity used divided by the best operating level. So, the best operating level here we take as 120 units per week, so 83 units per week divided by the 120 units per week we get 0.69. So, approximately 70 percent is the capacity utilization rate, a very simple example simple mathematics only involved. But what information we can deduce from here the decision making information that we can infer from this is that we have the capacity to even produce 120 units, but we are not able to optimize or we are not able to achieve the best operating level that can be possible or that is possible in the plant.

So, we can try to see that how where we are lacking so that we can improve our efficiency effectiveness as well as the productivity. Now, when we are doing capacity planning what all we must focus on. So, determining the capacity requirements.

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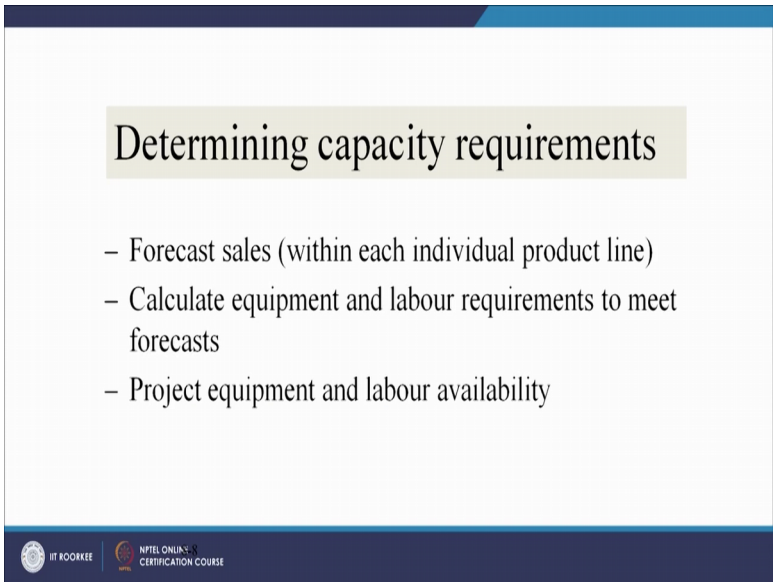

Now, if we see we are at the fagend of our discussion on production planning and control in the last session our focus was on capacity planning the introductory part only and prior to that we have seen aggregate production planning.

Now, suppose in aggregate production planning we see the regular time production is going to be this much units, the overtime production is going to be this much unit, now in overtime production suppose we are spending more money the cost of production is more because we have to pay more to the workers who are doing the overtime. So, we can see we can do a trade off that why not to install one or two more machines and employ one person more or one worker we can add. So, that the overtime we need not pay in the regular time only we are able to produce the products as so as to meet the demand. So, such type of decisions we have to take.

Now, adding two machines means that we are adding a capacity to our existing capacity as we have seen that capacity is usually added in chunks. So, we are adding a capacity to overcome the overtime production and to focus on the regular time production only. So, determining the capacity requirements is one thing. So, this will help us in planning our production in a more efficient manner. So, what is required? So, forecast of sales is

required within each individual product line suppose the company is a multi brand multi product company. So, it may be making 5 different types of products. So, for each product we must have a forecast.

Then calculate the equipment and labour requirements to meet the forecast if you go to the functions of production planning and control there is a term called esrouting and then estimating. Now, in estimating we have to estimate the machine requirement as per, as well as the labour requirement also to meet the forecast. So, first we need to forecast then we need to understand how many machines, how many people are required to make the product in order to satisfy the demand and then project equipment and labour availability so that must also be known to us that what is the equipment available or how many types of machines numbers of machines that are available and what is the availability of the labour.

Now, we have seen we have calculated machine requirement and labour requirement and we have exact labour and machine requirement as per the current status we can see what is the difference and that difference we will try to do with capacity planning. So, we will try to bridge that gap of difference by doing the capacity planning by utilizing our existing capacity as well as by adding the additional capacity. Now, capacity planning we can see 3 important considerations are there in capacity planning maintaining a system balance.

In the ideal case the output of one stage is the exact input requirement for the next stage. So, we have to maintain that particular, sequence or that particular balance otherwise what will happen if the output at one stage is much more than the input at the next stage the line will be slow. So, we have to plan our capacity in such a way that the system balance is maintained, the line balance is maintained, and the output of one stage is exactly equal to the input of the next stage. Then the frequency of capacity additions we have to see that thereby because there are costs involved in adding of the capacity too frequently as well as too infrequently. So, we have to see that when and where we have to add a capacity in order to meet demand.

Then the external sources of capacity also needs to be we can evaluate also needs to be explored I must say. So, it might be cheaper outsource some of our production and if you remember in the session on aggregate production planning we have seen that outsourcing

is also a very good production alternative to meet the demand. So, from capacity point of view we have to see that we have to manage our capacity in such a way that the system balance is maintained, the line balance is maintained. Secondly, we have to focus on the addition of the capacity wherever required and thirdly we have to ensure that how we can augment our capacity with the help of outsourcing some of the production to maybe our sister concerns or to the well established companies who are also in the same business.

Now, some of you may be wondering that why should we give a production our maybe demand to some other company or maybe that may not too well for the organization. But many times we see that whenever we go to buy a particular product from a grocery store and if that grocery shop owner does not have that product he will send his sales boy to some other shop to fetch that product for us we could have also gone there, but there can be maybe this branding involved that if maybe I am going to a particular grocery store he may not like me as a customer to go to some other vendor.

So, I will do it for that customer maybe I have to get it done from some other source also without revealing to the customer that what was my source of production because I will be putting my brand on that particular product also. But there can be many managerial or strategic decisions that the company have to take. So, there therefore, sometime outsourcing is also a very good production alternative.

So, we have to see what capacity we have to deliver to the demand and how we can augment our capacity internally as well as with the help of our outsourcing agents.

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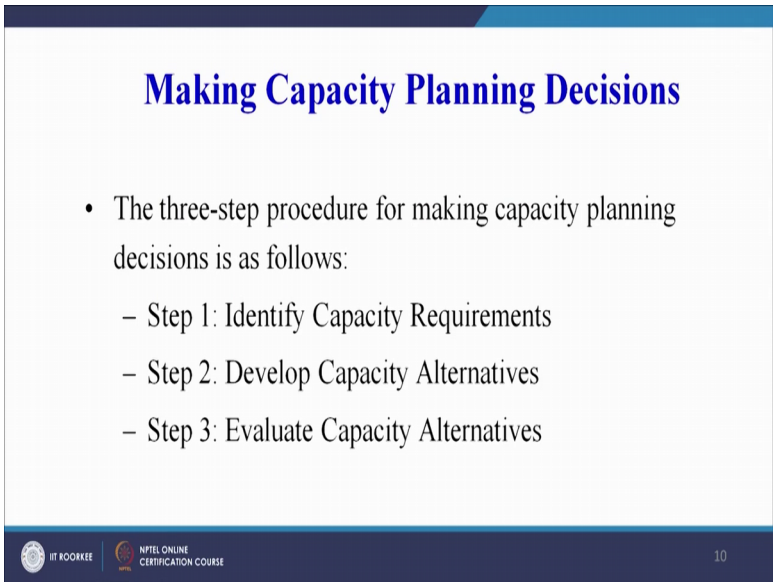

Now, making capacity planning decisions the 3 step procedure for making capacity planning decisions is as follows identify the capacity requirements already we have seen in the previous slide develop the capacity alternatives and I must address outsourcing is one important capacity alternative and then we have to evaluate the capacity alternatives.

So, this is a very simple procedure for developing a plan to change the capacity. First I will just read it for you determine project capacity requirements given a demand forecast. So, the input is a demand forecast that we have. So, as per the demand forecast we have to map that what capacity we have to meet that demand.

We may be having additional capacity also, but that does not make a difference because if we have additional capacity demand is less no problem, but in case where the demand is less, but we have sorry when the demand is more and our capacity is not able to meet that demand in that case we have to see that how to satisfy this demand. Formulate alternatives to meet future capacity requirement because we have the forecast of the demand. So, we have to formulate what alternatives we have at our disposal to satisfy this forecasted demand.

Then evaluate the alternatives. Now, we may have different alternatives, but we have to evaluate them. How we can evaluate them? They can be evaluated based on economic factors costs revenues risks competition flexibility quality of the products organizational

and managerial adjustment. So, there can be as I have told you that while going for outsourcing there can be number of factors that we have to take into account.

Similarly, these are the criterion as mentioned in point number 3 on your screen here which will help us to evaluate these alternatives and to find out the best alternative for changing our capacity.

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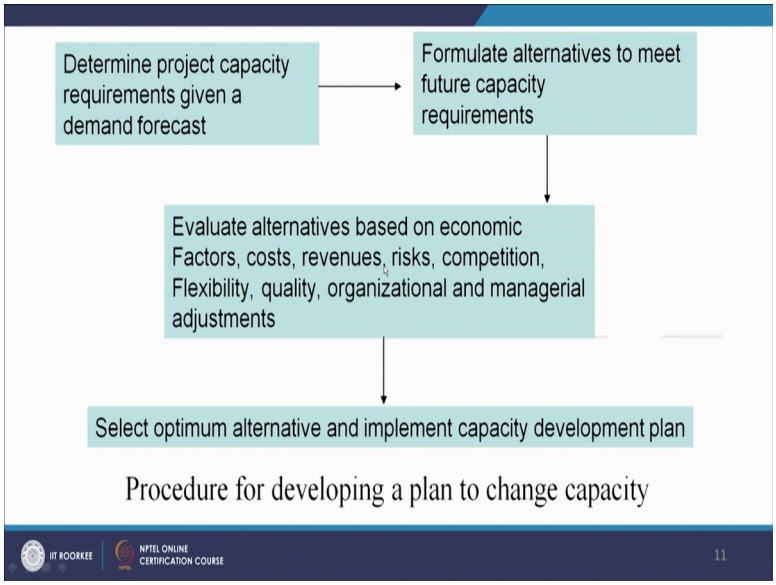

Select the optimum alternative and implement the capacity development plan. So, in summary we can see that when we have to change the capacity what we need to do. First we need to establish that what is the capacity requirement depending upon the demand forecast whether we have the capacity to meet the demand forecast, suppose the answer is no then we have to look for alternatives that what are the other alternatives that we can explore. Suppose we have 4 5 alternatives we have to evaluate those alternatives based on a number of factors or based on the number of criterion and then we have to finally, select the best alternative that goes well with the strategic policy or maybe the policies of the organization.

So, friends let us take an example on the capacity planning and this is the last part of our session today. So, the problem statement is given here, manufacturer produces mustard in small end family sized plastic bottles with the following demand forecast. So, the for the 4 years the demand forecast is given and the products are two products, one is small sized plastic bottle and another one is a family sized plastic bottle for the manufacturer.

So, the product is mustard. We can see here the 4 years demand forecast is available with us and in order to meet this demand forecast we have different types of machines available.

So, 3 machines of 1 lakh units per year with the capacity of 1 lakh units per year is available for small bottles and two machines of 1,20,000 units per year capacity are available for family sized bottles.

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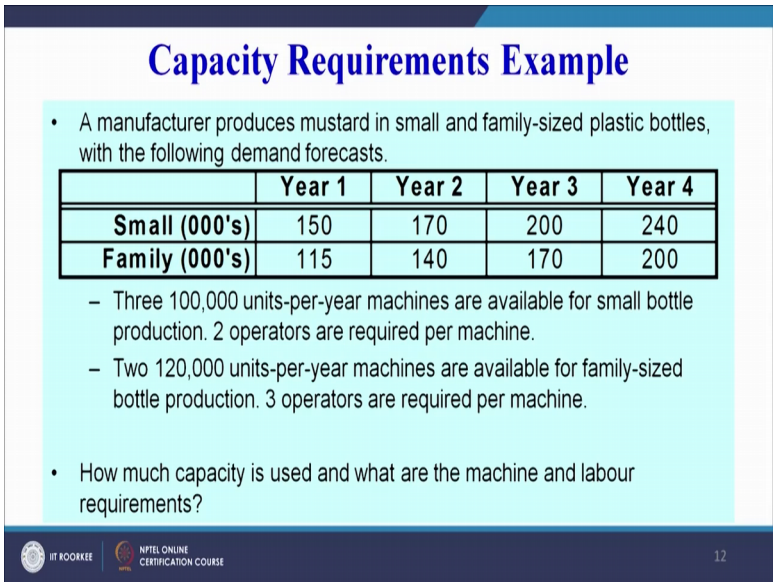

So, maybe we can say two types of machines are available for small size we have 3 machines, for large size bottles we have 2 machines and the individual capacity is also mentioned.

So, one resource is machine the other resource is manpower that is also mentioned here for small for operating the machines for making small size bottles or we can say 2 operators are required per machine. So, total 6 operators are required and for running or for managing the machines used for making family sized bottles 3 operators per machine is required, per machine are required and there are two machines. So, we can say that we have 6 people required to run the machines for making the family sized bottle.

So, we have in nutshell 3 machines for making small sized bottle and 2 machines for making large sized bottle 6 people are required to run the small sized the machines for small sized bottle and 6 people are required to run the machines used for making family

sized bottle. So, that is the problem statement now. Demand is given to us. So, we have to map this demand with our capacity. Capacity is in terms of machines and the manpower available at our disposal. So, we can say calculate now that how much capacity is used and what are the machine and labour requirements.

So, labour is available 6 people are available to run both types of machines, but whether their utilization is happening properly, whether their services are being utilized properly that we can calculate mathematically. So, the problem whatever was given in the form of sentences is summarized here.

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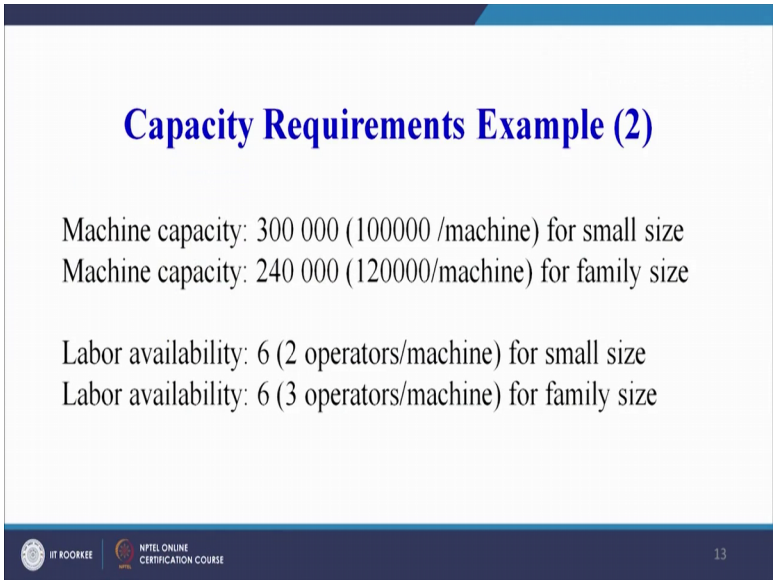

Machine capacity overall capacity is to make 3, 00,000 small sized bottles per year. Similarly, 2, 40,000 bottles for family sized bottles. So, maybe we have a capacity of 2, 40,000 for family sized bottles 3, 00,000 for small sized bottles. Similarly labour availability is 6 each for small sized bottles also or for family sized bottles also. Why? Because for small sized bottles two operators per machine are required and for large size bottles or family size bottles 3 operators are required to operate the 2 machine. So, we have a labour availability of 6.

Now, we can do these calculations on your screen. You can see we have taken an example of family size only.

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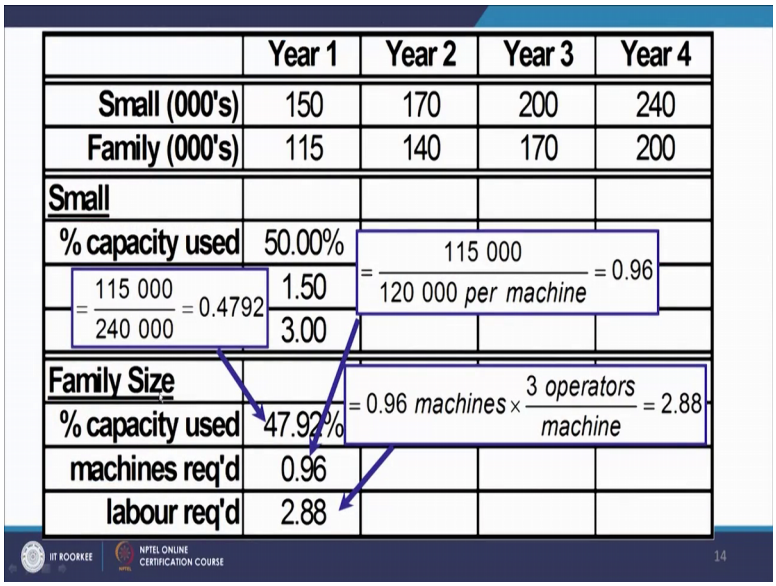

So, the percentage capacity used is 47.92 percent. Why? Because we can see the demand for year one is 1, 15,000. So, we can say 1, 15,000 is the demand forecast and we have a capacity of 2,40,000 because there are two machines available with us with the capacity of 1,20,000 each. So, 2, 40,000 is the overall capacity for making family sized bottles and the demand is less it is 1, 50,000 only. So, the percentage capacity used is 47.92 percent.

The second is how many machines are required? So, if we can see just without calculation also our just by looking using common sense 1, 15,000 is the demand forecast and each machine can produce 1,20,000. So, and the percentage capacity utilization is also less than 50 percent. So, we can say that 0.96 machines or approximately one machine can do the work for year 1, when we are making family sized bottles as per the demand. So, how much is the labour required. So, for operating one machine 3 people are required. So, mathematically we can calculate the number of machines into the number of operators required per machine. So, we can see 2.88 is the number. So, 3 people are required to run the machine.

So, if we see we are not properly utilizing the capacity that is available with us and then we can think that how this additional capacity the gap between the available capacity and the utilized capacity how we can make use of this gap, so that we are able to map up the

two things together as operations manager, as a production manager our target is always to ensure the most optimal utilization of the resources at our disposal.

So, that is only possible if we do these types of calculation and statistically or mathematically analyze that how much of our capacity we are utilizing. So, this type of analysis can be done this is just a representative analysis shown for 1 year only, if we do these calculations we can calculate for the all the 4 years that what is the percentage capacity used, how many machines are required and how much labour force is required.

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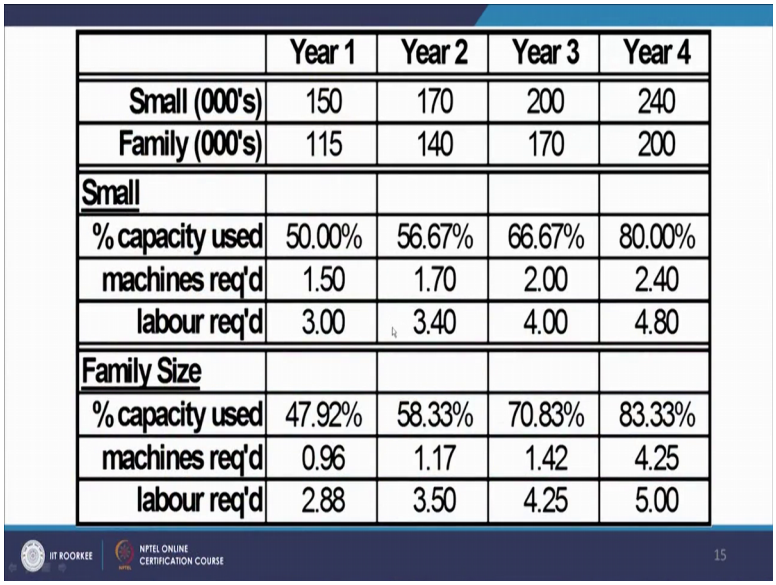

So, if we see that most of the time our capacity percentage capacity used is less or approximately equal to the maximum utilization 80 and 83 percentage here because the demand is maximum 240 and 200 here in the 4th year. So, prior to that for the first 3 years we are not able to utilize the capacity available with us and therefore, we can just use some creative thinking your innovative thinking to find out other uses other usage of this capacity that is available with us.

So, with this we conclude this week's discussion on production planning and control with an understanding that we have understood that, what are the roles responsibilities of a production manager, and what are the important tools and techniques that he can use for ensuring a smooth production, meeting the overall objectives of quantity, quality, time and cost.

In next week we will start our discussion on the next topic in our overall objective of understanding the fundamentals of operations management.

Thank you.