Operations Management
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Lecture - 28
Aggregate Production Planning

[FL] friends. Welcome to session 28 in our course on operations management. As you are aware, we are discussing the production planning and control and we have already finished the discussion for the previous 5 weeks in this course. In the last session, if you remember, we discussed the process planning part which is an important aspect of production planning and control and we have seen that what are the factors that we need to be considered for process planning and one aspect that is how to select the number of machines required that we have covered with the help of a numerical problem.

So, this topic is more or less based on certain mathematical calculations and today also, we will try to understand the concept of aggregate production planning with the help of a numerical problem, but first we go to the numerical; first of all let us see that; what do we mean by production planning or aggregate production planning.

As we have seen in session one of this week that was related to production planning and control; basic fundamentals, we have seen that usually, we do planning activity at different time horizons. We make a long term plans which we call as the strategic plans, then we do the intermediate planning and then finally, we do the operational or the short time planning or the short term planning.

So, our aggregate production plans usually fall in between. So, it is intermediate planning where we plan our production for the next maybe a year or maybe 2 years. So, our plan which is intermediate production plan falls under the aggregate production planning horizon.

So, basically we are going to see today that how we are going to optimally utilize our resources in order to meet the demand. Now basically in production planning if you remember, if we have to sum up the definition of production planning in 2-3 sentences, we will definitely use the same words again that it establishes a planning activity to

ensure the maximum possible utilization of the resources available at our disposal in order to achieve the targets of quantity quality time and cost.

So, basically we are focusing on optimal utilization of our resources to meet our intended targets in terms of quantity, quality, time and cost. So, that is the overall summary of production planning activity and today, we are going to see that once we have to meet a target of a particular volume of production, how we are going to use the resources available at our disposal in order to meet that demand which we have already forecasted in our week 3 of discussion.

If you remember, in week 1, we have covered the basic aspects of operations management. In week 2, we have covered product design and development. In week 3, we have covered sales or demand forecasting. In week 4, we have covered plant location. In week 5, we have covered plant layout and week 6, we are covering production planning and control.

And in week 6, today is our third session; in first session, we have covered the basic aspects of production planning and control; in the second session, we have covered process planning, we have seen; what are the factors influencing the process selection and equipment selection and finally, today we are going to cover the aggregate production planning and I have told you that aggregate production planning is a planning horizon of maybe a year or 2 years and we see that what are our production alternatives, how we can make use of this production alternatives in order to satisfy the demand in terms of number of products required in a particular quarter or in a particular month or in a particular year.

So, let us start our discussion related to this very important part of production planning and control that we call as the aggregate production planning. Now aggregate planning determines the resource capacity needed to meet the demand over an intermediate time horizon.

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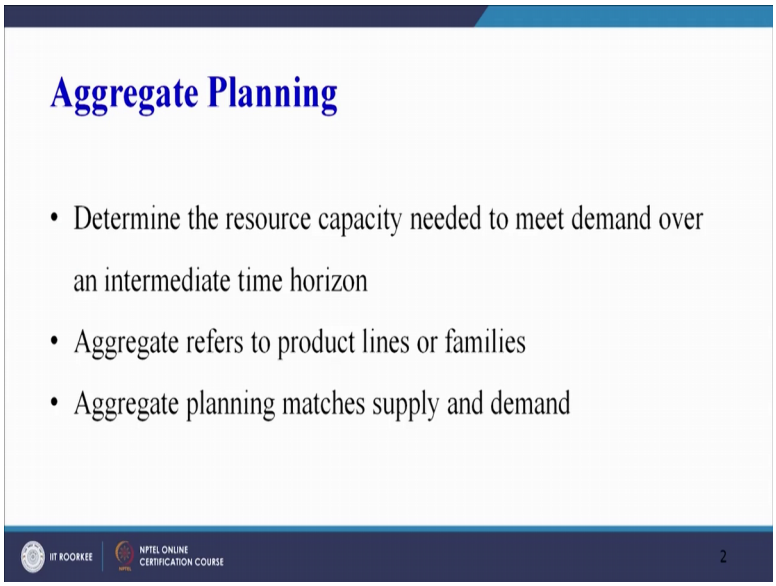

So, intermediate time horizon means as I have already explained, there is a strategic time horizon or maybe a long term planning activity may be focussing on next 5 or 10 years of the organisation, then the intermediate activity or planning activity focussing on the one or 2 years planning horizon and finally, a short term planning activity or the operational planning activity may be focussing on 3 to 6 months of the time horizon.

So, the aggregate planning as we can see here it focus on the intermediate time horizon, aggregate refers to product lines or families. So, we can see that aggregate word may be focus on the product lines or families aggregate planning matches the supply and demand. So, supply means, we have to see that how we can meet the demand using the production alternatives that are available at our disposal. So, next, we will try to cover that what are the major objectives of aggregate production planning.

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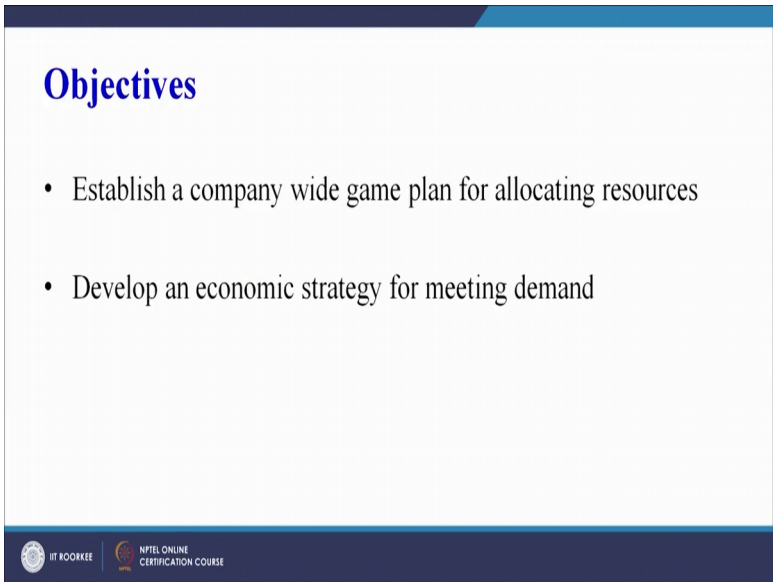

So, the major objectives, we can see are to establish a companywide game plan for allocating the resources.

So, we have seen in the previous slide that it matches the supply as the demand. So, basically, we have a demand data available with us, we know that what is going to be the demand or we have forecasted the demand for the next year or may be it can be on the quarterly basis, it can be on a monthly basis, it can be on a bi monthly basis. So, time horizon may vary for which the demand has be forecasted. So, we may have forecasted the demand on quarterly basis that for quarter 1 of the financial year 2018-19, this is going to be the demand for the next quarter; this is going to be the demand.

So, we have forecasted the demand. Now we have to plan our production in such a way that we are able to meet that demand that we have covered in the previous slide that our aggregate production planning matches the supply and the demand. So, the demand has been forecasted that we are assuming that their data is already available with us. We may have forecasted the demand using any method, qualitative method, quantitative method; within quantitative, we have seen there are number of method; averaging methods are there, time series models are there, then maybe exponential smoothing methods are there.

So, any method; we may have used for forecasting the demand, but we assume in aggregate production planning that the demand for the next year is available with us. So, it will establish; we can say our strategy to meet that demand on a quarterly basis or on a

yearly basis and develop an economic strategy for meeting the demand. So, only one word is very important here that is economic. So, we will take a decision which is going to save the money of the organization.

Now, let us see if we have to meet a demand of suppose 1000 products in quarter 1, 2000 products in quarter 2, again 1000 products in quarter 3 and 2000 products in quarter 4. So, we have 1000, 2000, 1000 and 2000. So, it is 6000 products in a year. So, these 6000 products; we must be able to produce using the available production alternatives available with us in the most economical manner.

Now, most economical manner means that we have to utilize our resources in such a way that we are able to meet this demand of 6000 products in a most cost efficient and effective manner. Now some of you may be wondering or maybe thinking; what are these production alternatives. Now production alternatives may be our regular time production, sometime we may have go have to go for a overtime production, sometimes depending upon the demand, it may be overshooting our capacity, we may have to hire some more people many times because of less demand, we may have to fire some workers many times, we may have to subcontract a portion of the demand to some other sister concern.

So, these are the production alternatives that are available with us, we have to distribute our demand among these production alternatives in such a way that we overall the total production cost for a particular year for which we are making this aggregate production plan is maximized or minimized is it cost. So, we have to see that it is minimized, we have to find out the strategy in such a way that the overall cost of production is minimized and we will try to understand this with the help of a problem and I think the problem will make the things very very clear to all of you.

But the overall maybe the summary of aggregate production planning is the first thing that we must remember that it is a intermediate time horizon plan that is we are planning for the next one year or at the maximum 2 years, then the inputs can be we can say the company policies, we can have a economic policy of the company, then maybe the material policy for the company, we will try to see that with the help of a diagram.

There will be some input and the aggregate production plan will give us some output the output that the production plan will give us is the workforce required the normal time

production required, the overtime production required the number of people required maybe to be hired, to be fired, how much amount we must subcontract to a particular sister concern in a particular quarter, how much back ordering can be done, backordering means we enter into a contract agreement with our customer that we may not be able to supply all the amounts of products required in one quarter, it may be distributed must be distributed in the next 2 quarters.

So, that is kind of backordering a contract agreement between the customer and our company. So, the output of this aggregate production plan will be an optimal distribution of the demand into these production alternatives. So, we may have different production alternatives available with us and we will distribute the demand among these production alternatives in such a way that our overall cost of production for the complete year is minimized.

So, we may have as you can see that there can be so many permutations and combinations possible to meet the demand, but which alternative is going to give us the best result that we have to find out and there are scientific mathematical models methods that can be used to find out the optimal combination of production alternatives that are going to give us the minimum total production cost.

That is our target and we will see a list of methods that can be used to optimize this problem of minimizing or maybe I should not use the word optimize to solve the problem of minimization of the total production cost now this diagram few things I have already explained.

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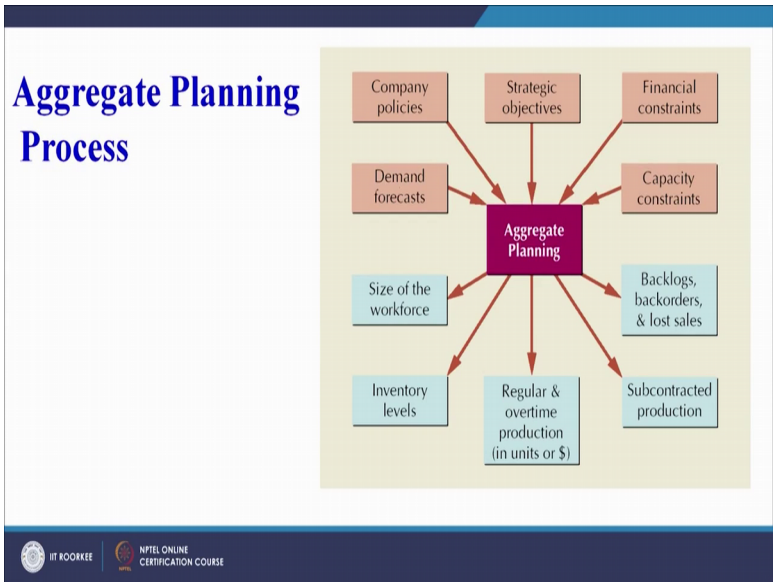

So, let us quickly go to the focus area here aggregate planning is what we are doing and these are we can see the basis or the inputs based on which we are going to make our aggregate production plan. Now company policies strategic objectives financial constraints capacity constraints demand forecast, all these are kind of inputs that we require to make our aggregate production plan.

One of the foremost is the demand forecast we must know that what is going to be the demand in the next year if we want to make a forecast on planning activity on quarterly basis, we must know that what is the quarterly forecast for a for the next year, then the capacity constraints is also very very important, we must know that what is the regular time production that we can do, we have maybe 100 machines; each machine as a capability of making 100 parts. So, that will define our capacity capability to do the normal time production we can use it for overtime production also.

Then, if we have a demand which is still higher than the capacity that we have, we may have to subcontract, we may have to give a portion of the demand or a portion of the number of products to any sister concern and get the products from them and then complete the maybe consignment and hand it over to the customer some portion or some part of the demand, we are satisfying some part of the demand we are getting it satisfied or getting it made by our sister concern or any other company that we have feel, we may feel fit deem to make this product.

So, basically these are the 2 important things or the inputs that are going to play a very important role in our aggregate production planning activities the other things are also very very important, but may not be playing a direct role in the aggregate production planning calculations. So, company policies, strategic objectives and financial constraints are other important inputs and we can see when you understand the problem, you will be able to appreciate these 3 inputs also when we are doing the aggregate production planning. Now, what will be the output? What we will get out of the aggregate production?

Once we solved this problem, but we will get a output that what is the size of the workforce required; must we have same number of workers working throughout the year or should we ration the employment of workers that is for a particular quarter when the demand is very high, we may have a larger workforce for a particular quarter on the opposite side, if we have a very low demand or there is no demand, can we fire these workers or can we put them to rest; can we give them holidays. So, that we are not paying them; maybe extra amount of money when they are not required in the organization or sometimes the companies may even like to fire these employees.

That is one output, we will get another output will be; what are the inventory levels that we must maintain. Now inventory is we can set the materials are the prod finished products that we are keeping in the organization or in our warehouse. So, what is the inventory levels that we must maintain how much regular time production we must do how much overtime production we must do then backlogs back orders or lost sales this is also one of the outputs that we will get from aggregate production planning lost sales maybe the demand is. So, huge that using all our alternative we are not able to meet the demand maybe some portion of the demand may go to the competitor.

So, we will say; this is last sale from our part, then subcontracted production is another output. So, basically we have numbers that we get from the demand we have constraints on our production alternative that we can make this many products only using regular time production we can make this many number of products only using the overtime production we can hire only this many number of employees because of the financial constraints of the organization.

So, we have certain constraints we have the numbers in terms of demand now we have to solve this problem how to allocate these resources to a particular number of demand. So, that the demand is satisfied and the cost remains minimum.

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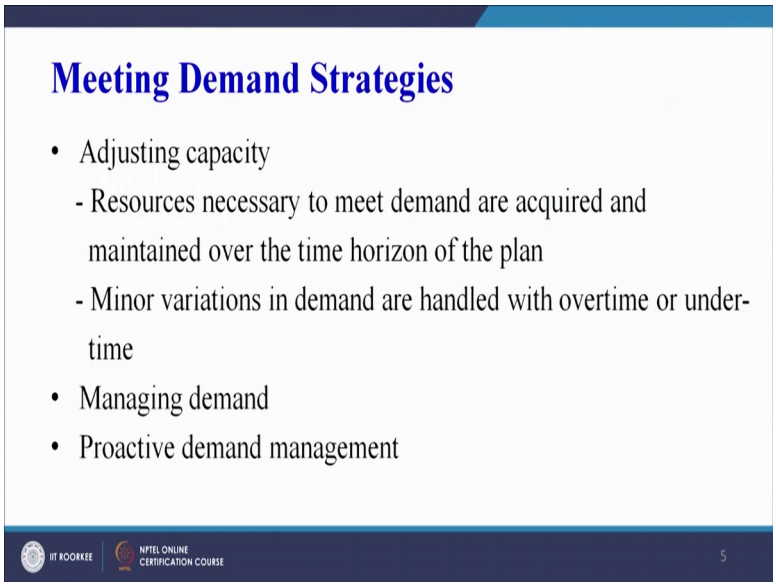

Now, meeting the demand strategies we can now we have a target that is our demand we have to meet this demand now how we can meet this demand by using the production alternatives now let us see how we can meet the demand adjusting capacity resources necessary to meet demand are acquired and maintained over the time horizon of the plan now resources can be terms of machines this can be in terms of manpower.

So, adjusting the capacity; so, first thing is we need to adjust the capacity that is required to meet the demand very simple example we can take that suppose we have to meet demand of 100-1000 products and our regular and overtime production is not able to meet that 1000. So, what we can do we can take 2 more machines for a period of maybe 2 years and then we can just sell of those machines we are only acquiring the capacity to meet that demand.

So, first is adjusting the capacity resources necessary to meet the demand are acquired and maintained. Maintained means we have to meet that demand regularly for next 2 years. So, we have to maintain those 2 additional machines with us minor variations in demand are handled with overtime or under time. So, if there is little variation we can go for overtime operations then we have to manage the demand and then we have to finally,

be very proactive demand management that is an another maybe strategy to meet the demands I am a little bit quick in the discussion because it is easier to understand the maybe philosophy of aggregate production plan with the help of an example.

So, I am trying to jump to the example as quickly as possible now strategies for adjusting the capacity can be level production, we will see with try to understand this level production with the help of an example now producing at a constant rate and using inventory to absorb the fluctuations in demand, we will try to understand this with the help of an example now level production means that all round the year we will make the products maybe uniform number of products per month or per quarter and for one quarter we may have less demand for other quarter we may have more demands.

So, we will be making a level production only every quarter or every month same production. So, whenever there is more demand we will be using the material or the products stored in the inventory chase demand chase demand means whatever is the fluctuation in the demand over a period of time maybe if we are taking yearly demand. So, how the demand is varying over one year from January to December or if we talk of a financial year from April to March, we will chase the demand, whenever the demand is more, we will hire more people, we will subcontract, we will use all production alternative or combination of production alternatives to meet that demand.

But wherever the demand is less, we will fire certain people; we will stop production for maybe 3 days or 5 days in a week to meet that demand. So, when the demand is less, we will adjust ourselves accordingly when the demand is more we will gear up accordingly. So, we will be chasing the demand. So, we will try to understand this with the help of a diagram peak demand maintaining resources for high demand level.

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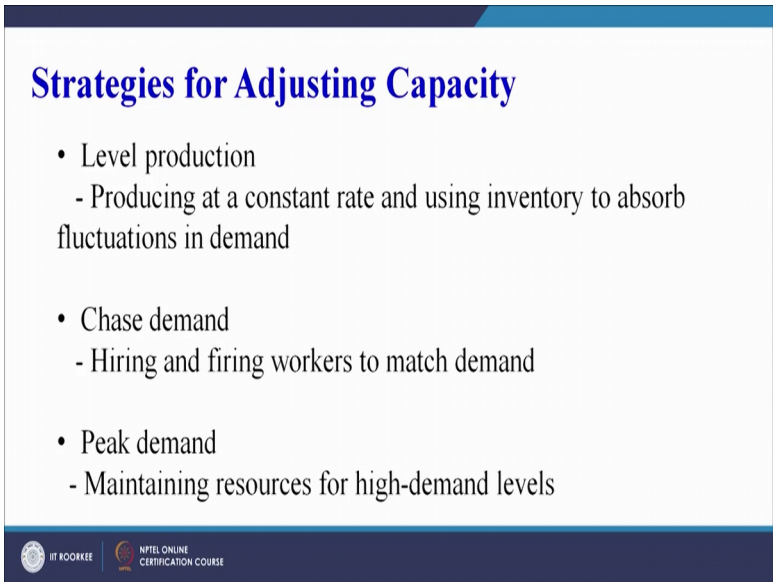

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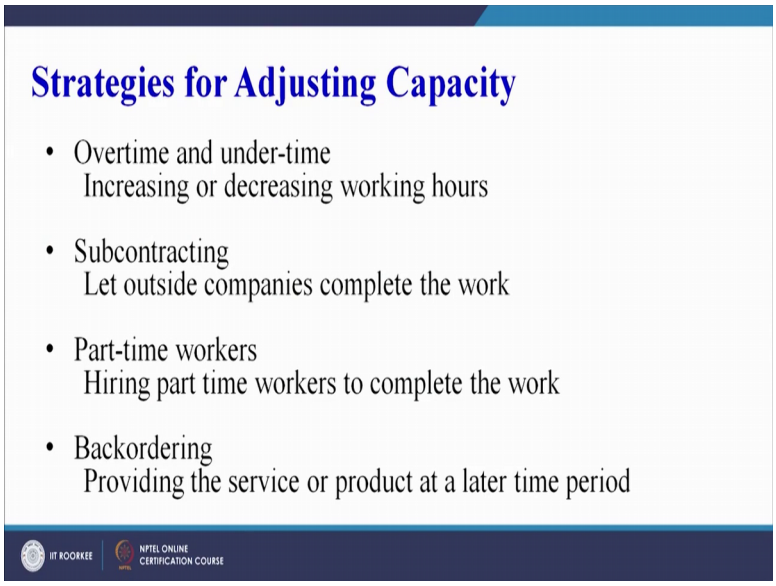

So, we may keep some reserves; in case of the peak demand, we can have overtime and under time increasing or decreasing the working hours. We can usually in most of the organizations, we have the provision of overtime subcontracting, let an outside company complete the work part time workers, we can hire part time workers to complete the work backordering providing the service of the product at a later time period, I think I have already highlighted backordering in today's session only.

So, these are all the alternatives that are available with us to satisfy the demand or to meet the demand targets. So, you can see, we can focus on regular time production, we can focus on overtime production, we can focus on hiring more number of people, we can focus on firing the extra or the excessive baggage that we have in terms of worker. So, we can go for subcontracting we can go for backordering.

So, as a production manager I am rich man because I have so many production alternatives available with us available with us, but if I do not reduce or if I do not maybe minimize the total production cost for meeting the specific demand for a particular year I can be the poorest man in the organization now I have to use as a production manager my skills in order to minimize the total production cost for the company.

Now, I have so many alternatives available with me based on the information in terms of the capacity constraints for each alternative because each alternative will have a capacity constraint, we have our regular time production there is a capacity that we can produce overtime also we have a capacity.

So, based on the capacity constraint and the cost of production for each production alternative as we can take an example; for example, regular time production when we are using our production facility for making the regular time production, cost will be maybe just as compared to if we subcontract the same thing to any other organization because their profit will also be added in the cost or maybe the price of the product that we are buying from any subcontractor. So, the cost will be different.

So, as a production manager, I have to see 3 important things; what are the production alternatives available with me or the strategies available with me, then what is the cost of each particular production alternatives; that is regular time production, what is the cost per unit for overtime production, what is the cost per unit for hiring up people, what is the cost for firing the people, what is the cost. So, I must have the number of production alternative, what are available with me that is one thing, second is the cost involved with each production alternative and third thing that I must know is the capacity constraints on each alternative.

So, these are the 3 things that I must know the type or number of production alternatives available the cost involved in each production alternative and the capacity for each production alternative. So, if this data in simple mathematical numbers is available with

me, I can very easily calculate the total production cost for the complete year based on the demand which is the forecast for the next year based on the forecasted demand, I have another number that this is the number of products that have to be made in the next year.

So, that demand is available with me and all other things are also available in terms of mathematical numbers very easily I can calculate and how to do the calculation that we will try to see in our example. So, this is level production, this is the variation of the demand over a period of time.

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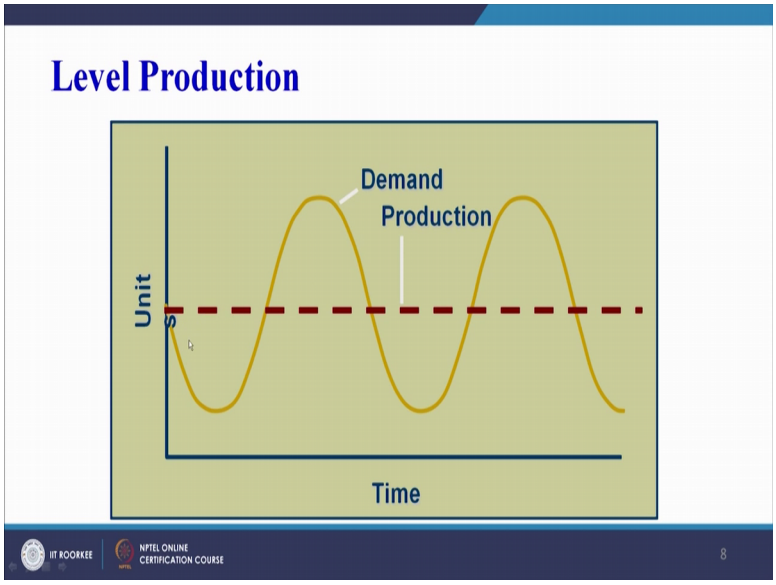

And in level production, we will do uniform production all round the year. So, we can see that wherever the demand is more we are producing less, but wherever the demand was less the demand is less here, but we are producing more. So, this is the extra production that we will utilize here some extra production, we are doing here because the demand is less.

But we are producing more; we are producing at the level production here. So, we are able to satisfy this additional demand with the inventory generated here during the lean period of the demand.

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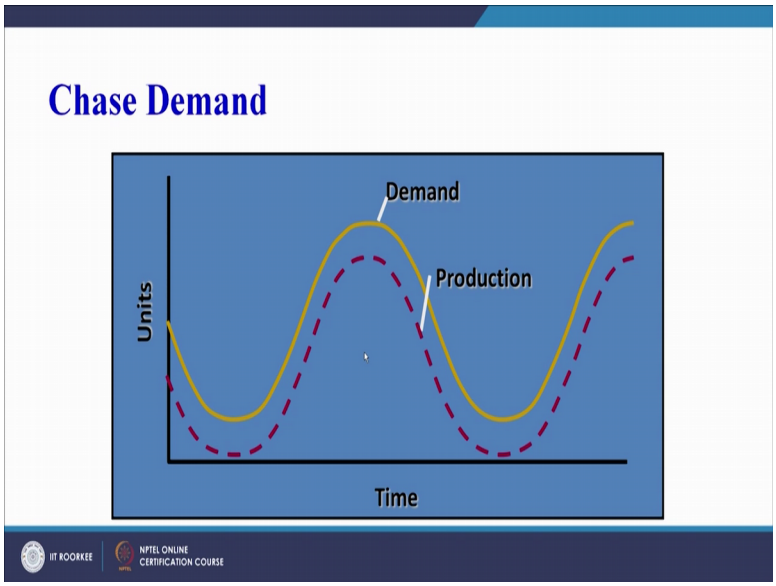

Now, chase demand as I have already told they will chase the demand like this. So, this is the demand curve and we will see wherever the demand is less we will produce also less wherever the demand is more we will produce more.

So, we will manage that demand as per the time. So, if the in any particular quarter or any particular month the demand is more we will produce we will use our alternatives in such a way that we are able to satisfy the demand there. So, we are not maintaining maybe inventory. So, the focus on inventory is less in case of chase demand. Now, how we can optimize this problem. Now we see that there is some mathematical data available with us cost for each production alternative per unit is available with us capacity constraints are also available with us the demand that has to be satisfied is also available with us.

How we can solve this problem of minimization of the total production cost, we can use pure strategies, mixed strategies, pure strategies in terms of level production.

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Or chase demand strategy mixed strategies combination of both linear programming transportation method and there are other quantitative techniques available. So, we will use any of these methods to solve the problem of minimization of the total production cost for the year.

Now, let us quickly take 1 or 2 examples. So, here we can see quarterly demand is there sales forecast in pounds. So, spring 80,000 pounds, summer 50,000 pounds, fall 120,000.

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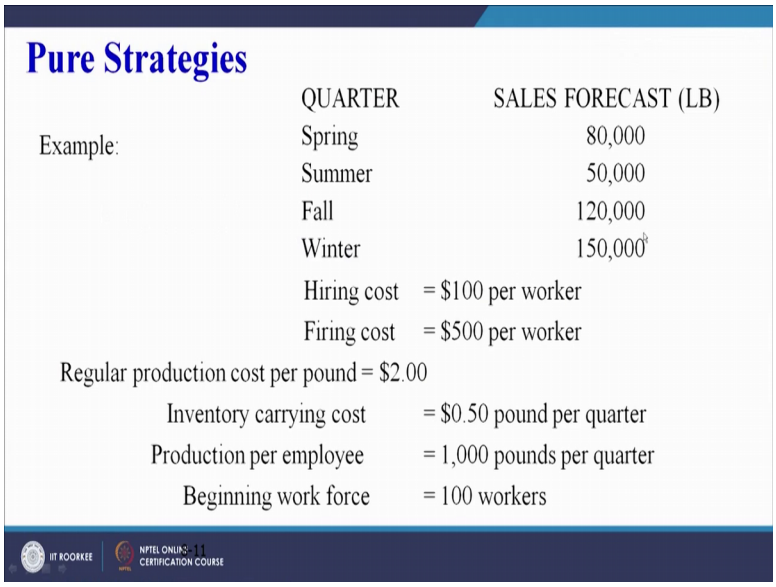

So, we have a quarterly demand data hiding cost is dollar hundred per worker firing cost is dollar 500 per worker, regular time production cost per pound is dollar 2, inventory carrying cost is dollar 0 point, we can say 50 cents or half a dollar per pound, per quarter production per employee is 1000 pounds per quarter and beginning workforce is 100 workers.

So, this is we can say available information with us for solving this problem. So, 2 things you can see here which I have already highlighted; we must have a demand. So, here we have a sales forecast on quarterly basis we must have the cost data also. So, hiring cost for worker firing cost for worker regular time production cost per pound of the product produced because the forecast is in terms of pounds 8000 pounds.

So, regular production cost per pound is available with us inventory carrying cost is also available in maybe 50 cents per pound per quarter production per employee is also given 1000 ponds. So, this is capacity constraints are also given that production per employee every employee can make 1000 pounds per quarter only and beginning workforce is also given that we have a workforce of hundred people available with us.

Now, what is the problem the problem is that we have to satisfy this demand; we have to plan our production in such a way that this demand is satisfied over a period of time or enough for a one year period of time. Now we one strategy can be level production.

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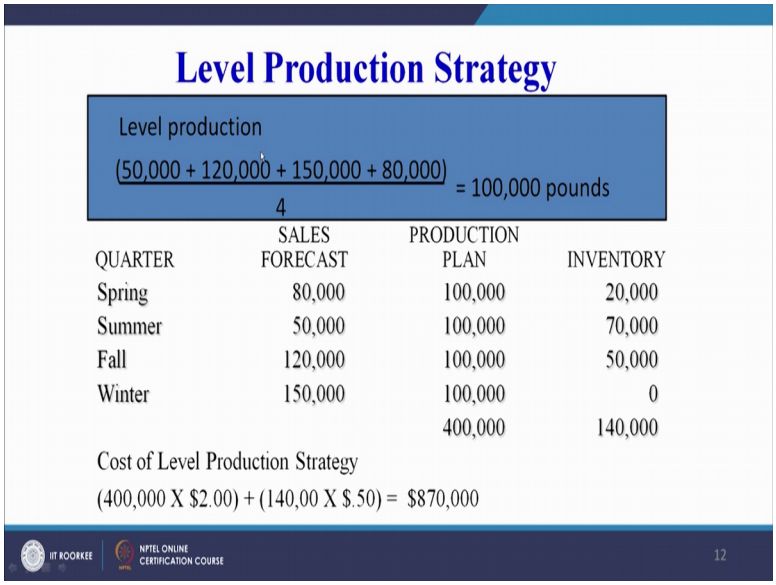

So, we can see the level production strategy, we will produce uniformly all round the year. So, what is the total requirement? 50,000 is the forecast for maybe we can see, there are 4 forecasts available with us. So, if we add this 4 forecast our level production average production comes out to be 1000 pounds.

So, we are going to make 1000, sorry not 1000, 100,000 pounds per quarter. So, we are level production; how we are calculating we have the spring summer fall and winter for 4 quarters we have the demand data available with us. So, for each quarter we are adding this and dividing it by 4. So, it comes out to be 100,000 pounds per quarter, we must produce. So, for spring, the sales forecast is 80,000 pounds, but our production plan says 100,000 because we are leveling our production on quarterly basis; for every quarter, we will produce 100,000 pounds of product only.

So, we are producing 100,000, 100,000, 100,000, 100,000 that is the 400,000 pound that is the overall yearly demand for the next year, but we are managing the inventory in spring the forecast was 80,000, but we have produced 100,000. So, 20,000 goes to inventory. Similarly in summer the forecast or the second quarter the forecast was 50,000, but we have produced using level production 100,000.

So, 70,000 is the inventory, 20,000 produced here and 50,000 extra produced here. So, we have an inventory of 70,000 and in fall we see our production is only 100,000 as per our level production strategy, but the demand is more. So, 20,000 is used from inventory now and then in winter also we had 100,000 regular time production, but 50,000, we used from inventory. So, there is no inventory at the end of the year. So, we have used our inventory in a judicious manner and solved the problem of 400,000; producing 400,000 pounds of a product in a year.

Now, what is the cost we know that dollar 2 per pound is a regular time production cost. So, we have produced 400,000 pounds multiplied by dollar 2 plus we have to add the cost of managing the inventory here. So, averaged out inventory cost is 140,000 if you see here the overall inventory 70 plus 20; 90 plus 50; 140. So, 140,000 pounds was stored in the inventory. So, per quarter cost is 50 cents here; 0.5 dollars. So, we add this overall cost and it comes out to be dollar 870,000 is the cost for one year of production of 400,000 pounds of the product. Now this is one strategy that is level production strategy.

Now, other strategy if you remember can be a chase strategy in chase demand strategy we are not going to do the level production we are going to chase the demand.

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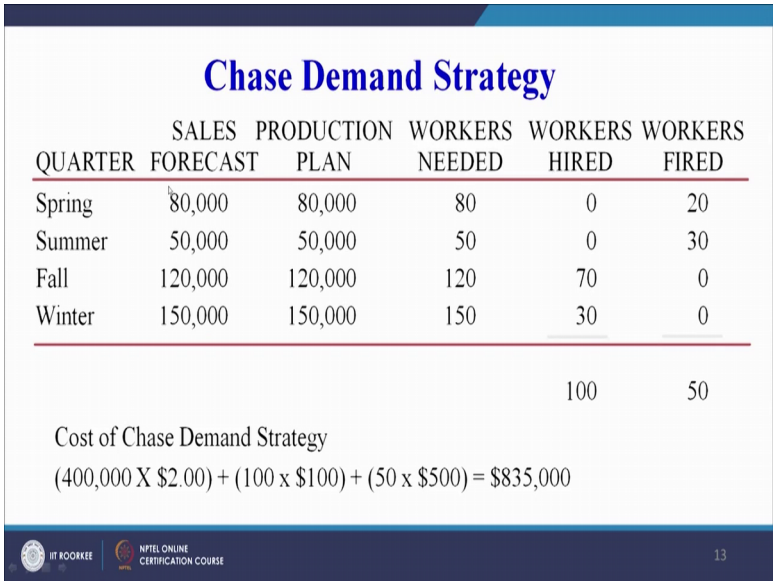

So, if 80,000 dollar; if 80,000 pounds is required, we will go for 80,000 pounds only; Now you can see sales forecast is 80,000 production plan is also planned for 80,000 only. So, we know that each worker can produce 1000 pounds per quarter. So, we need 80 workers only, but you if you remember, we have a starting work force of 100 workers. So, we will hire only 8 workers for the first quarter. So, 20 are additional. So, we will fire 20 workers here, in the summers the demand is only 50,000 pounds and we will plan for 50,000 pounds only.

Each worker can produce 1000 pounds per quarter. So, we require 50 workers, we will fire 30 workers here because in first quarter we had 80. So, we will fire 30 more to maintain a workforce of 50 workers, but in fall third quarter we have a demand of 120,000 pound. So, we require 120 workers here, but currently, we are having only 50 workers. So, we will hire 70 more workers and similarly for winter, we have a requirement of 150 workers and we have 120 workers in quarter 3. So, we will hire additional 30 to make it 150.

So, we are chasing the demand if you see our production plan is focusing on the exact demand requirement for that particular quarter where as in level production we have averaged out 100,000 pounds per quarter and here we are producing as per the demand.

So, we can calculate the cause of chase demand strategy 400,000 pounds, we are producing in regular time production the cost is dollar 2 per pound. So, this gave us the regular time production cost plus we are firing if you see here we are hiring hundred workers 70, we are hiring in third quarter and 30 we are hiring in fourth quarter. So, 100 workers, we are hiring and the cost of hiring for worker is dollar 100.

So, this is giving us the hiring cost and then we have to calculate the firing cost also we are firing 50 workers and 50 multiplied by the firing cost for each worker that is dollar 500. So, this is giving us the total production cost for the next year where we have the demand available to us on quarterly basis. So, this is giving dollar 835,000.

So, we can compare among the various strategies to meet the demand and see that which strategy is giving us the minimum overall production cost and this way we can save lot of money for the organization there can be mixed strategies also which is a combination of level production and chase demand strategy.

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The examples can be no more than x percent of the workforce can be laid off in one quarter that is one capacity constraint inventory levels cannot exceed x dollars. So, that is also maybe another constraint on a mixed when we are using a mixed kind of strategy to meet the demand.

So, many industries may simply shutdown manufacturing during the low demand season and schedule employee vacations during that time this is also one of the mixed strategy that whenever the demand is less you just tell workers to go on a vacation. So, that you are not producing and managing the products in the inventory. So, we can have a purely level production strategy we can have a chase demand strategy we can have a mixed strategy. So, different types of strategies can be adopted to satisfy the demand.

So, with this, I can conclude the today's session, I think with the help of an example all learners might have understood 2 different type of strategies which fall under the aggregate production planning and the overall summary of today's session is that we have to optimally utilize the production alternatives available with us in order to satisfy the demand with the overall objective of minimizing the total production cost.

Thank you.