Manufacturing Systems Management
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Lecture - 27
Cell control and JIT

This lecture we continue the discussion on Cell Control and Just-in-Time Manufacturing. In the previous lecture we define just-in-time manufacturing as manufacturing system where the goal is to optimize processes and procedure by continuously perceiving waste reduction.

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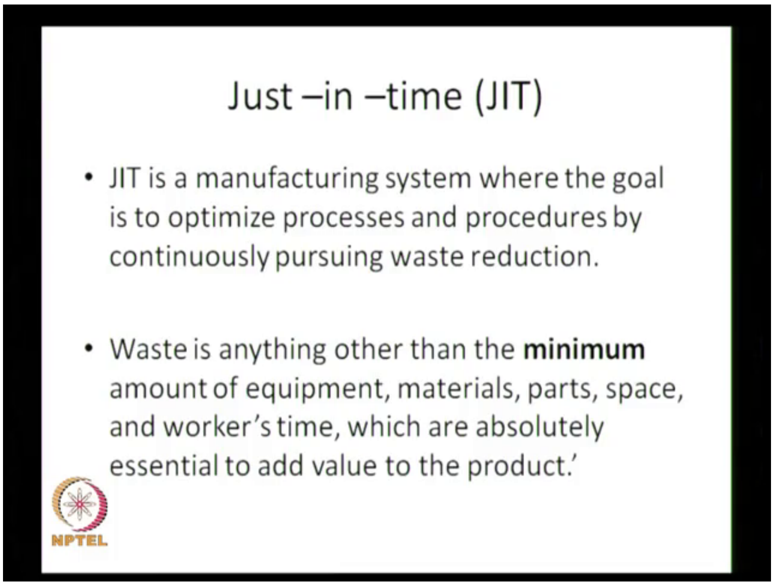

The important words in this definition are waste and reduction and continuous. So, the main objective is to reduce or eliminate waste and we define waste in the next bullet. More importantly it is not a onetime activity it is a continuous activity which is stressed by the word continuously perceiving waste reduction. The net result is to optimize the processes and procedures and true optimization, we achieve higher efficiency and productivity as well as lower cost. So, explicitly cost minimization is not shown as the only objective. The objective is to optimize the process and procedure as a result of which we can active cost maximization as well as through put maximization and productivity maximization through waste reduction and continuously perceiving waste reduction; we also define this definition for waste.

So, waste is anything other than the minimum amount of equipment, materials, parts space and time which are absolutely essential to add value to the product. So, any effort over and above the minimum required, which is spent on an activity is defined as a waste; provided it is not able to add value to the product.

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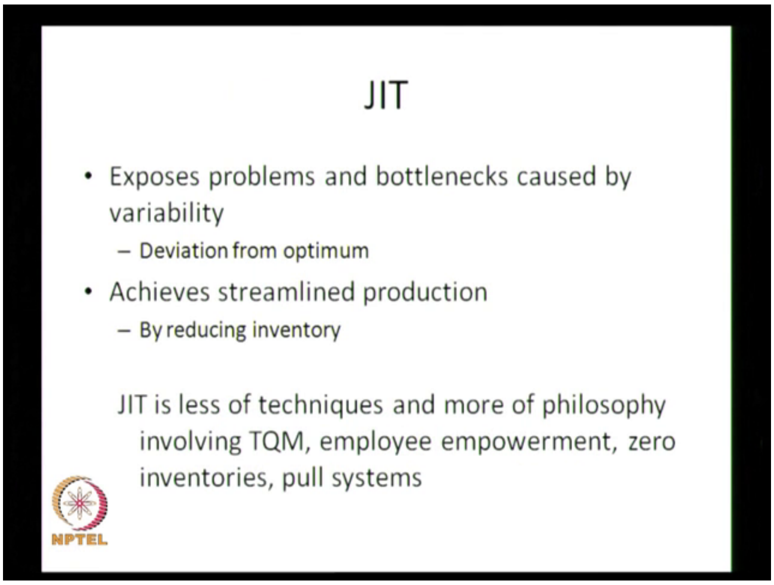

We also mention this that JIT or JIT is less of techniques and more of a philosophy. Involving total quality management employee empowerment, 0 inventories and pull systems we show some aspect of total quality management and employee empowerment in the previous lecture. We will continue the discussion on 0 inventories and pull systems. Now one of the reason that just-in-time manufacturing picked up was because manufacturing companies had a lot of inventory lying in the work place, it was quite common to have anything between 3 to 6 months of inventory in the system, which was very large in terms of quantity, in terms of money and was affecting the performance of the system both from financial viewpoint as well as from an operational viewpoint.

So, organizations felt the need to have better control and that is the reason you will find that the title of this lecture is cell control or production control, and just-in-time manufacturing can also be seen as a way of production control, though it is scopes is far higher than only production control. So, there was a need to control the inventories and extend of inventory had to be brought down in organization. Many reasons existed for the increase in inventory and these reasons are also well known.

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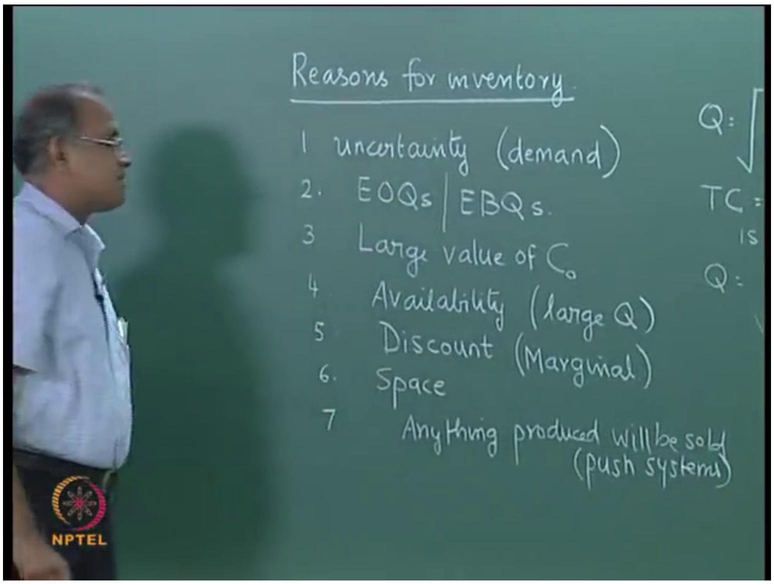

One of the main reasons is uncertainty; particularly uncertainty in the demand. The easiest way to counter uncertainty is to have inventory and it became common practice to increase the inventory so that any fluctuation in demand or uncertainty in demand could be met comfortably. A second reason for large inventories was insistences on economic order quantities and economic batch quantities.

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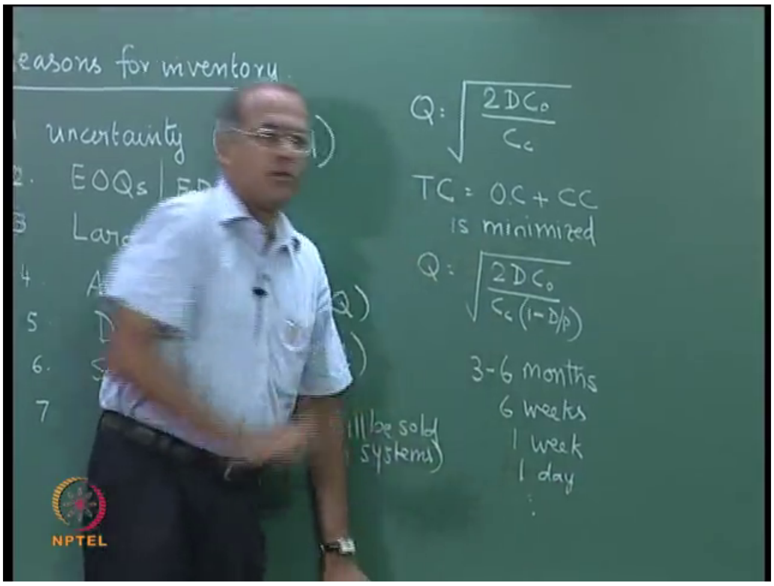

Now, the economic order quantity formula and economic batch quantity formula are well known. So, the economic order quantity formula is given by root over 2DC naught by Cc where D is the annual demand of the item, C naught is the order cost for the item and Cc is the inventory holding or carrying cost for the item. Now using these data one would get what is called the most economic order quantity or the quantity for which each order has to be placed such that total cost comprising of order cost plus carrying cost is minimized. Now this formula is easy to use and people started using this formula to determine their economic order quantities and rounding of these quantities to comfortable integer numbers such that orders can be placed for such numbers.

Now, while the economic order quantity can be different for different items, when the ordering took place people did not take this into consideration. Now different items could have different demands and even if the order cost and carrying cost where different, the economic order quantity would be different for different items, even if the order cost and carrying cost are the same for certain number of items. So, because the demand is different, the economic order quantity was also different.

So, if several items where bought to make a or assemble a product, each one of them now had different ordering quantities and therefore, there was either excess inventory of one or there was shortage of another. The ordering quantities did not synchronize and this led to higher inventory. In a similar manner the economic batch quantity formula, which inconsistent notation will become 2 DC naught by Cc into 1 minus D by P; where C naught now is the setup cost here D is the demand this is the inventory holding cost this is the same demand here this is the production capacity. So, D by P is a fraction less than 1 so that one minus D by P is positive and we get a positive number here.

So, this formulas gives us the economic batch quantity, which means what is the best batch quantity to run a particular production batch. Once again since demand for each of these items are different the economic batch quantities would also be different for different items, which led to a lot of work in progress inventory while this let to raw material inventory or inventory at the store. Even though advanced models existed for synchronizing various the order quantities is for various parts or for synchronizing the production batch quantities for various item, the economic lot sizing formula takes care of sum of these. Many times the more difficult part of synchronizing the purchase and synchronizing the production batches where not taken into account and therefore, EOQs and EBQs increased and not only did they increase, they were different for different items resulting in very large amount of raw material as well as work in progress inventories; third is large value of C naught.

Now, here the term C naught in the economic order quantity formula, which means when items are purchased C naught represent the order cost and in the batch quantity formula when items are produced C naught represent the setup cost. Now both the C naught as ordering cost or C naught as well as set up cost where very high. C naught as setup cost was very high because the time taken to do set ups and changeover was very high therefore, C naught was very high here. In this many times C naught was very high because C naught would also involve cost like transportation inspection and so on and these are quite expensive. And therefore, C naught became very high. So, when the value of C naught is high automatically the value of Q is also very high. So, large value of C naught was also a reason for large quantities to be ordered or produced, which resulted in large inventories in the system. Forth is also availability particularly in the context of ordering.

So, there would be situations where the availability was a kind of a restriction and when some very few suppliers were there and when the material was available with the supplier, it was necessary to buy them in large quantity. Availability detected purchase of large quantities; now fifth reason also would be discount, which forced buying of large quantities here. So, we study we have studied inventory model considering discount. So, this economic order quantity formula is modified to include discount, and when we considered discount we particularly and buying a very large quantity. 2 types of discounts exist; one is all quantity discounts, the other is a marginal quantity discount particularly when we use the marginal quantity discount we understand that that the marginal quantity discount leads to larger ordering quantities.

Even though there is a certain optimization that takes place in deciding the order quantity under marginal discount condition, and the best value of Q the order quantity is chosen based on an optimization. It still leads us to buying large quantities with result in the presence of a large amount of inventory in the system. Availability of lot of space amongst the machines or within the storage area, when lots and lots of space is available there was always a tendency to use space by filling it up with inventory. So, people started increasing the inventory that they had through, because lot of space was available. Last but not the least the main reason why there was a lot of inventory that was available;

because people believe that anything that is produced will be sold and therefore, it is not wrong to produce in large quantities keep them and sell them when they are demanded.

So, when this led to the feeling that one need not produce current demand, but one produces to an aggregate demand, which meant that they were following what are called push systems. Produce to forecast, produce to aggregate demand, produce large quantities and make them available when the demand actually comes. So, this leads to producing in very large quantities. So, all these are reasons for large amount of inventory this is indicative; it is not exhaustive reasonably exhaustive there could be other reasons that also exist because of which large amount of inventory is being ahead. So, because of all of these organizations had at least about 3 to 6 months of inventory and organizations felt that this inventory has to be brought down. So, there was a systematic exercise which almost every organization carried out, to bring down this 3 to 6 months inventory to a manageable one month inventory. Actually bringing the inventory down from 3 to 6 months to say 3 to 6 week is difficult, but not very difficult where is bring it down from 6 weeks to 2 weeks or 2 weeks to one week is very very difficult.

So, what happened this organization progressively give themselves deadlines of saying that from 6 months I bring it down to 6 weeks and then I try to bring it down to one week and if possible I bring it down to one day and so on. So, the ideal situation that we could think of is called I have 0 inventory. When I produce something we did see some we did see some aspects of single piece transportation and single piece production. So, the ideal situation is a single piece production and the only inventory that I have is that piece which I am currently produce. So, leads to a very ideal situation called 0 inventories.

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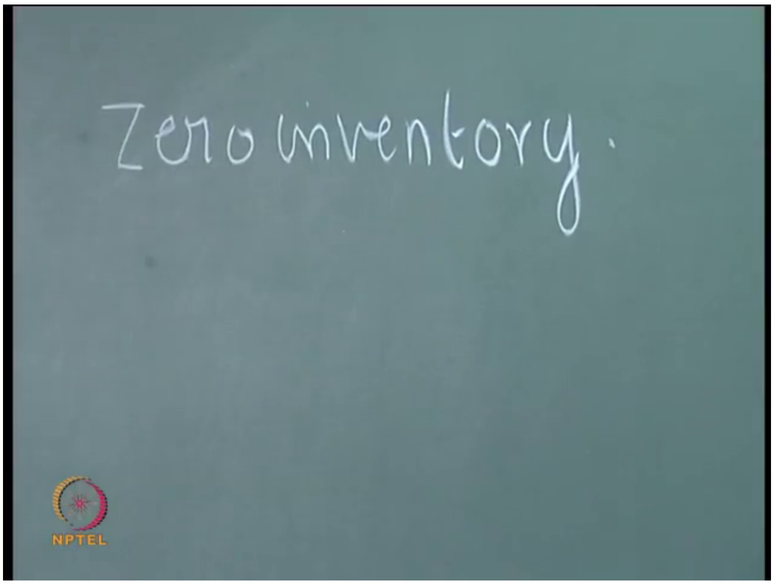

Bring down the inventory to 0. It is an ideal situation we know that we cannot have zero inventory in any plant nor can we have only that piece which is being produced in the system. But zero inventory is like an ideal target which we would all the time try to achieve, whatever be the present state of the system it will be worse than the zero inventory and zero inventory target would actually give us the motivation to try and get better than the current position or situation that the organization is in.

So, this is the ideal situation called zero inventory, which is a very integral part of just-in-time manufacturing. The other thing that organizations did is called push system.

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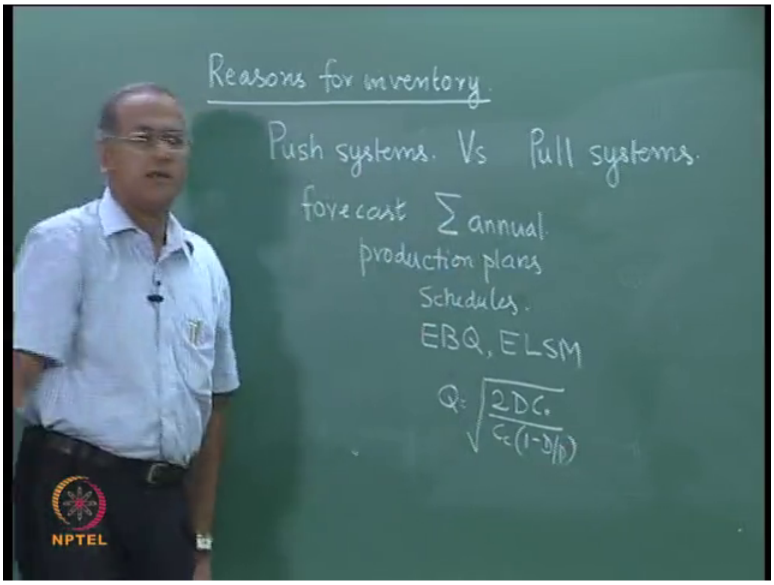

So, traditionally organization used what is called push system verses pull systems, push system are traditional were push system work with forecast. So, based on the previous data as the demand for the next period are forecasted and since forecast also has a certain accuracy associated with accuracy are lack of it that could be forecast errors then the aggregate forecasts is taken to have the annual forecast based on which production plants where carried out. So, the annual forecast the sigma indicates some of the forecasts. So, an annual forecast is taken, and the annual forecast is divided into productions plans and production schedule. And most of the times these decisions where based on economic batch quantity or the economic lots scheduling model.

Now, these used the formula Q is equal to root over 2 D C naught by Cc into1 minus D by P which was written earlier, and once again C naught used to be large because set up times and change over times where large. So, order quantities where large not only where order quantities large, if there where if even if we take a very simple system where there are 2 product 2 parts that go into an assembly.

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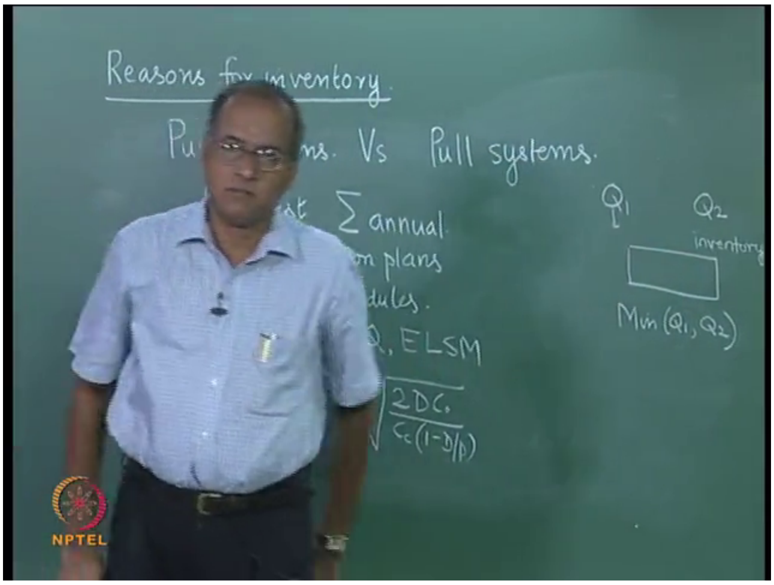

If we say the batch quantity for one of them is Q 1 the other one is Q 2 Q 1 and Q 2, will not be equal and therefore, the assembly would always produce minimum of Q 1 comma Q 2. And if we assume the Q 2 is more then there is an inventory buildup here. Now what is expected is that since Q 1 production quantity is less than the production quantity Q 2 Q 2 being slightly more the production cycle for Q 1 would be little less than that of the production cycle for Q 2. Now this production cycle will start operating immediately; so as this items coming.

Now, from the inventory this will be taken and this will be used for example, these machines could produce some other item or product in between. Sometimes we could have situation where both Q 1 and Q 2 are produce by the same machine.

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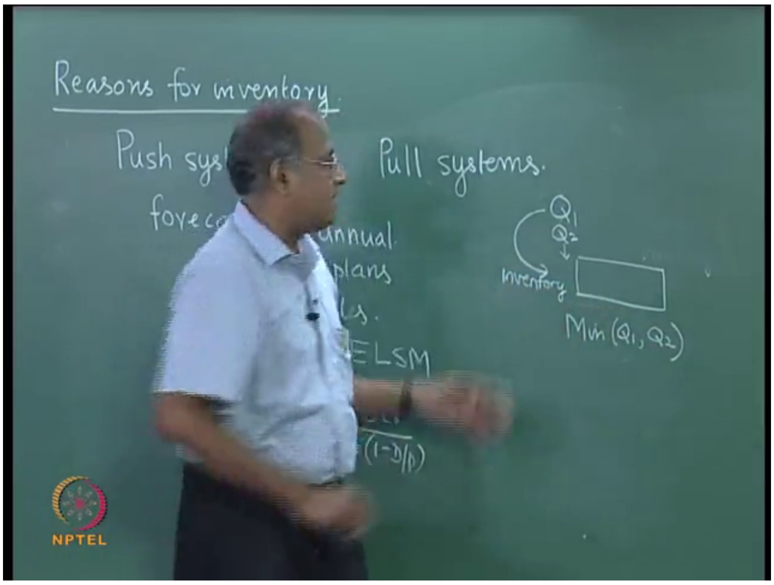

So, it will produce a large batch of Q 1 because the lay out was also more a process kind of lay out with functional are departments specialization. So, this will produce a large quantity of Q 1 and then keep it here and then when it is start producing Q 2, Q 2 will feed directly Q 1 will feed from inventory and then minimum of Q and the items starts getting producing then after while it is switches it as produce a large quantity of Q 2 now. So, it as built up inventory now it is start producing Q 1 and then once again the item will come the only think that will happen here is that at any point in time will have a large inventory of Q 1 or Q 2.

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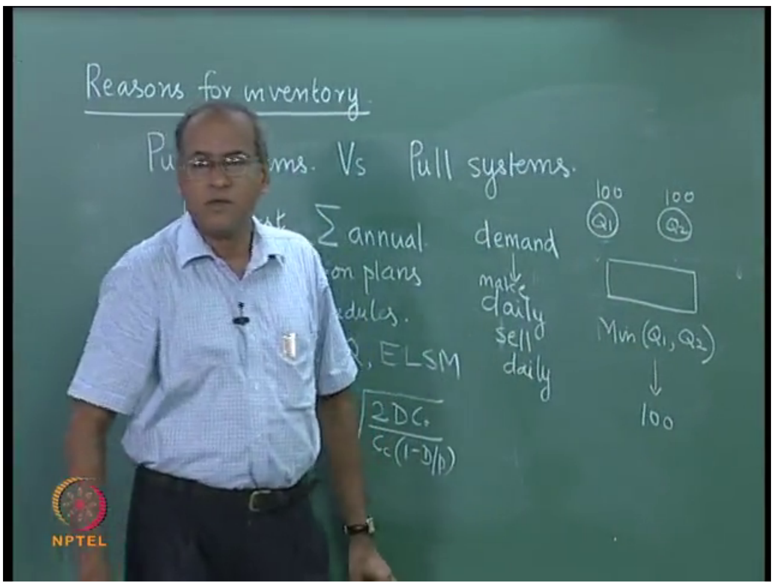

Now, the next question is can we have a system by which this cell make Q 1, this cell make Q 2 instead of a machine and these 2 are separate and then they feed. Now when they feed this will be producing at some rate, this will be a producing at some rate if we use the economic batch quantity model, the rates will not be equal they will be unequal. But still the amount of x is inventory that is getting build up will be less because this are producing in parallel and they can feed into the assembly.

Now the next thing if we really want to minimize the inventory is to let them produce at the same rate. So, that there is build up here and the items come out. So, the only reason why this could not be done is because this would involve creating some more facilities or buying some more machines and keeping it. And when we start doing that in some way the utilizations would come down, because earlier what a single machine could do now, 2 machines are doing.

So, automatically the utilization will come down here. So, imposes and measurement was more on utilization then on output. So, when the in order to create something like this, is now necessary to change the measurement which is from utilization to output. So, the measurement is now change from utilization to output. Now how do pull system work pull system do not produced forecasts, but essentially try to produce to demand. So, they try to produced demand you tend to get estimate of daily demand.

Now today it is little easier to get estimate of daily demand than 10 years ago. The reason being the ability to capture information is much better today than it was 10 year ago. Now today we have supply change management principles, we have point of sale capture of data we also have ways by which customer preferences are learned and therefore, this things get translated through advance packages such as ERP and other SCM packages into demand and there is a lot of data analytics and data mining that happens which gives a everyone feel of what is the demand for the day.

So, the demand for the day or demand for any period can now be estimated quite accurately, and now the production is based only on demand. So, when the production is based only on the demand let say at the demand is 100 then it is enough to produce 100 of this and it is enough to produce 100 of this. So, insistent on the economic batch quantity goes way, now because we are producing in quantities other than the economic batch quantity. So, one might get a feeling that you are not producing them optimally.

The economic batch quantity for this could have been 125, the economic batch quantity of this could have been 200, but we are producing only 100.

So, one would get a feeling that I am losing out on some aspect of optimization here, but the gain is that we are able to produce an quantity, there is no build of inventory here the items come out and they are sold. So, the measurement now shifts towards thorough put and sale the measurement is not about cost. So, when a measurement was about cost then one would had the total cost producing these 2 using the EBQ formula and using production quantities like this and then we would realized that EBQ was more cost effective, but today organizations are willing to use this and finish the production in time. So, we measure time this system will be much faster to produce than insistence on the EBQ. So, with pull systems coming in all this disadvantages are overcome, production quantities become smaller and when production quantities become smaller the inventories that are there in the system also become smaller. More importantly in pull system organization move to what is called make daily and sell daily.

So, make daily and sell daily once again this is close to an ideal situation there could be some issues with respect to this. When we follow the model make daily sell daily we are indirectly sell that we should not hold inventory at the end of the day, to meet the next days demand if for example, the capacities is 100, now today demands is 80 tomorrows demand is 120 and the capacity is 100. Now if we follow strictly the make daily sell daily discipline, we assume that we do not know this information.

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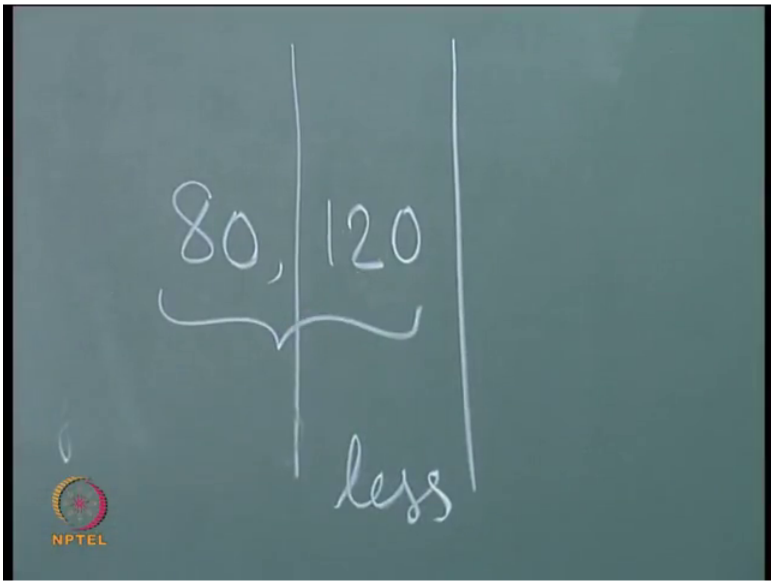

Because this is going to come tomorrow today's demand is 80 my capacity is 100. So, I can make 80 and I can sell today's demand, but tomorrows demand is 120. So, when tomorrows demand strikes me I quickly understand that my capacity to make is only 100 and not 120 now will I be willing to 4 go that 120 demand. I cannot affect to do that at the same I know that if I had aggregate these 2, my total demand is 200. So, I could make 100 today seal 80, keep 20 for tomorrow and make another 100 tomorrow and meet the 120.

So, once again make daily sell daily is radial situation is a very good situation that one as to look at. And this situation is achievable; if the variation here is less if the variation here is less. At the same time I cannot build 120 capacity here because 120 is the bigger number of the 2. One of the reason I went to this is because the variation was higher; now if I want to implement this then I have to have a less variation in these which is explain by the first bullet exposes problems cost by variability. So, when there is variability pull systems suffer, pull system required that the variation is less the ideal situation is daily all daily demands are the same and equal to the capacity, but that is something which we cannot achieve. So, in situation where the variation is slightly less this kind of stream line production system work very well organization will; however, meet this 80 and 120 by hold a small amount of inventory.

So, organization will tell themselves that I go up to a maximum of 10 percent that I can keep and I do not keep it for months I may just keep it for 1 or 2 days; so that I need instance fluctuation. Though the moto or the philosophy would be to make daily sell daily organization understand that certain amount of inventory is unavoidable other view you will not be able to meet demand and you will sell less and the entire profitability will go. So, some of these things such as zero inventories zero defects and make daily sell daily are all ideal situations for which the organization will always aspire to achieve.

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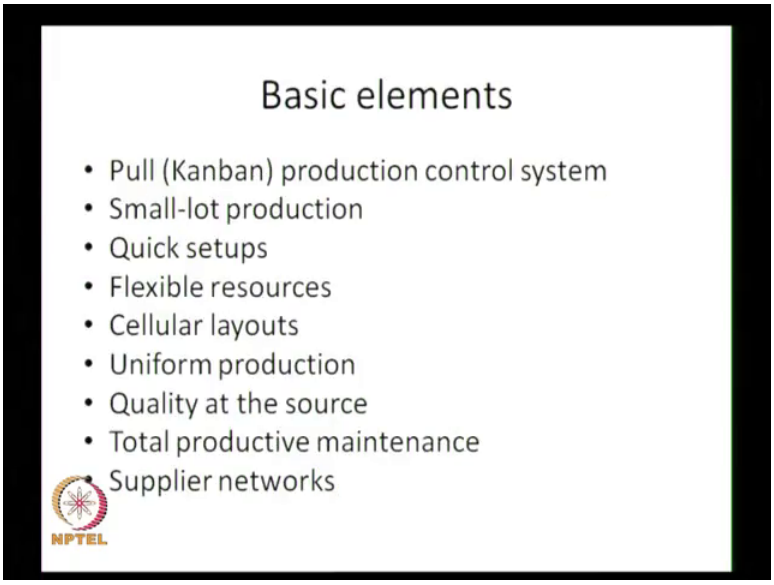

Now, we get into what are called the basic elements of JIT systems. So, the set of basic elements are listed here staring with pull or Kanban control production system, small lot production, quick set ups, flexible resource, cellular layout uniform production quality at source productive maintenance and supplier networks now all these are seen as some of the basic elements to implement a just-in-time manufacturing system.

Now, let us go through each one of them, but in a slightly different order even though the order given here is starts with kanban production control system. Now we could star with cellular layouts because we have seen a little bit of cellular layout from there we would get into flexible resources and then we would get into small large production quick setups and kanban taken together, and then we would get into quality at source productive maintains and supplier maintains. So, let first being with cellular layouts because we have seen so much of cellular manufacturing in this lecture series. So, let me explain the cellular layout first and then add.

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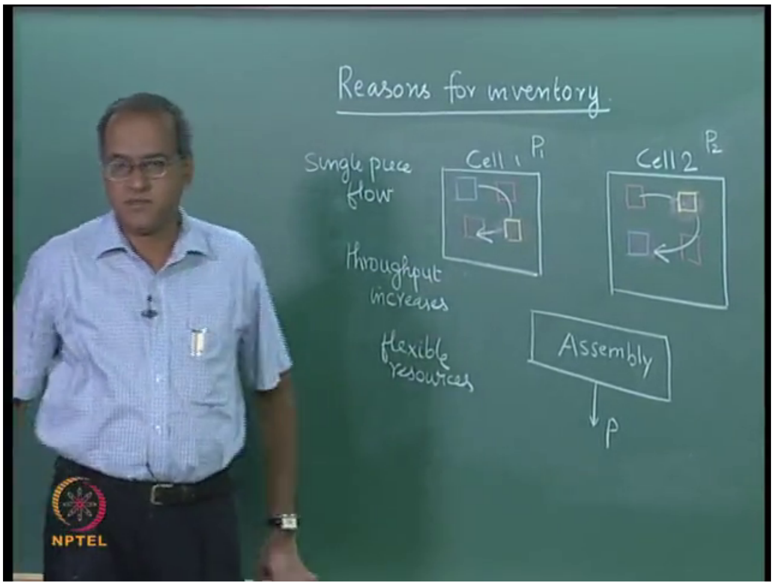

So, let us say we have cellular layouts. So, let us take a very simple case of 2 cell feeding 2 parts to an assemble. So, a cellular layouts would look like this machines of course, will be here. So, there will be machines here. In fact, I would even used different color. So, show that just to show that the color machines are the same, but there are in different size. So, the simplest advantage of cellular manufacturing is something that we have already seen.

So, if this 2 let us say we call them as P and Q are 2 parts or if it make a single product. So, let us call P 1 and P 2 as the 2 parts that will go to the assembly and finally, give us a P. Now we if we do not have a cellular manufacturing system, then we would have a system like this.

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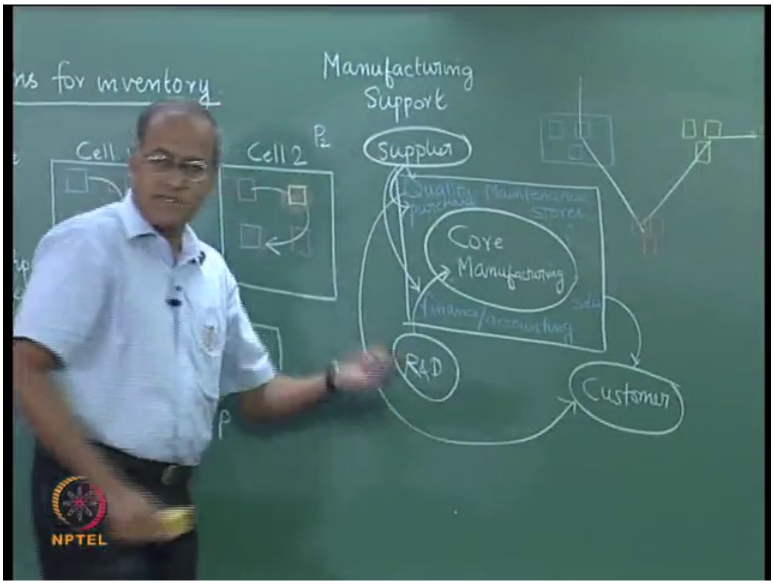

Where we would have a system like this where all the blue machines where here, all the yellow machines where here and all the red machine are here and these could even be separated by kilometer or 2. So, the each of this would now move from a blue to a red to yellow and out and so on this kind of a thing we have already seen. So, the cellular layout very quickly brings all this machines together, which enables what we call as a single pieces flow. I have explain single piece transportation and single piece production in one of the earlier lectures.

So, this enables single piece flow in this system. Now when it brings single piece flow into the system it automatically improves the through put. Because martial transportation is easily taken care of the time taken to produce within a cell is far smaller than the time taken to produce if it moved from one machines to another and it moved large distance to do that. So, cellular layout facilitated a whole lots of things to achieve in a just-in-time manufacturing system. And we have already seen that cellular layout would involve flexible resources, in terms of machine in terms of people and also in terms of process and aspect which we have not stress up on in this course which I would possibly do now. If we take this cell the first place this cell would have machines which are functionally dissimilar. So, if it is a labour intensive cell, then it is necessary and if we use our habit chasing or dedication method, it is necessary for operators to be able to handle a verities of machines and therefore, we need flexible resources in terms of operators.

Now, even though these resources these machines are functionally very very dissimilar, at some point in time they also should have the capability of substituting or carrying out some operations in the event of some emergencies, and particularly if they are sophisticated and advanced machines then they will be flexible enough to handle a variety of operations. So, flexible resources in terms of machines and in terms of people; one of this strings are cellular manufacturing is the fact that not only are the production processes are production decisions simplified in the cellular manufacturing.

Production support or manufacturing support should also be simplified or is also simplified in the context of cellular manufacturing. Now what are these manufacturing support? Now if we look at manufacturing the central the central portion is called core manufacturing, and then we have something called manufacturing support which is outside of this and manufacturing support would involve quality, maintenance, stores, finance or accounting and so on.

Now, these are all activity which are needed for the cell to function. Now many time we would create cells and give a lot of control to each of this cells, but there would be time when these are not decentralized. Now we one way of looking at cellular manufacturing is to kind of decentralized is the whole process so that processes becomes simpler. Many time we will see in organization, that these are also not these are not decentralization where as there is a need to decentralized all of them for example, one could say that for this cell the quality group could be divided into 2 or 3 groups, and say one group will be in charge of quality for these 2 cells. Some other group will be in charge of quality for some other cells.

Similarly the accounting systems is maintains the stores can also be made smaller and dedicated. Just as machines are dedicated so that better control and performance of the cell happens. This would also involve additional resource just as when we did this we realized the additional machines may they required. Now when we do this we also realized that additional resources may a required and then organization will have to take care of this then to continue this now outside of this is the supplier.

Now, this side is the customer and some where is the R and D the research and development which changes or provide inputs to this to this the supplier invariable comes here quality accounts. The customer also comes there could be marketing and seals purchase. So, the supplier comes here, seals comes here, quality comes here and so on. So, all these will now have to be decentralized and the cellular manufacturing systems have to be made simpler so that it they perform extremely efficiently. So, we have see some aspects of flexible resources and cellular layout.

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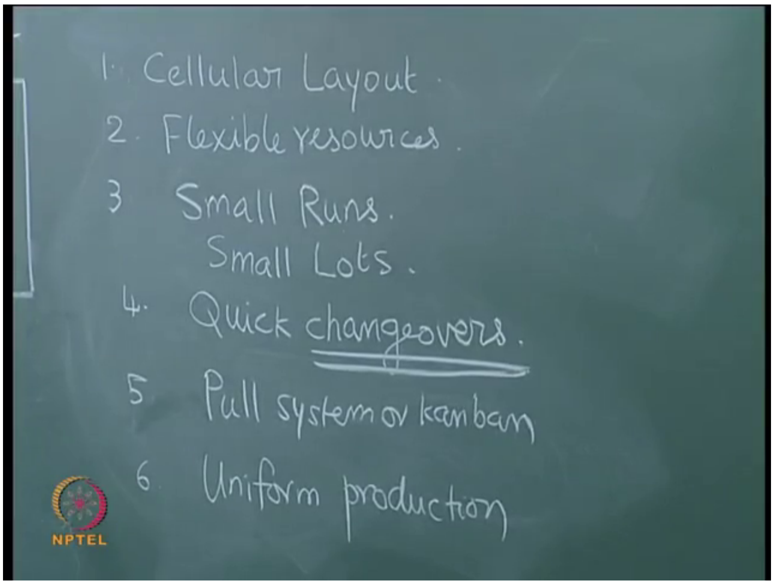

Now, will start looking at thing that are related to that. So, first we show cellular layout, flexible resources, small runs; small runs are small lots is possible in this we have seen examples of small run particularly when we show 2 aspects in an earlier lecture.

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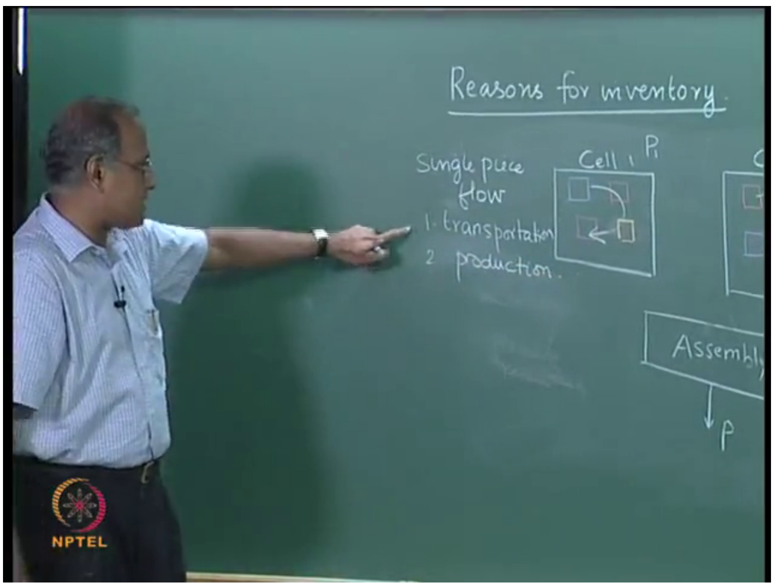

We show single piece flow in terms of transportation and production. Implementing a single piece flow systems in transportation makes the time to produces a little smaller because of which either an additional items in terms of variety can be produce or the volume of production can increase. That other that we show is single piece flow in production where we give an example of a batch size of 10, but there were 4 parts and we said we would do P3 P4 P 2 P 1 followed again by P 3 P 4 P 2 P 1 which meant that 4 parts are now produce in 8 batches each part having 2 batches with batch size being 5 instead of 10.

Now that is an example of small runs or small lot production. Now small lot production is enabled here largely because the time spent on transportation is also much less. Now when we did that example in a previous lecture we also found out that when we did production batches of 5 instead of production batches of 10 the total time to produce was increased. The reason for the increase was if we were making 4 parts and each in a batch of 10 there would be 3 or 4 change overs.

If we start making them in 8 batches each with the batch size of 5, there would be 7 or 8 change over depending on whether we want to come back to the starting part. So, the number of change overs increases. So, when the number of change over increases the time taken to produce also increases. So, if we do not want that time taken to produce to increase considerably, it is necessary to have a smaller time for setups. So, we move to what is called quick setup or quick change over.

Every systems that implements just-in-time will concentrate on reducing changeovers are change over time. By reducing change over times we will be able to achieve single piece production flow and single piece production flow is a necessary thing to try at if one is using just-in-time manufacturing system. So, we need to look at pull or kanban control systems as the fifth one here pull system or kanban controlled system, which we will do a little later we move.

Now, to the last 2 or 3 things there we now look at what is called uniform production I already given an example for uniform production, when I gave this example I said that if.

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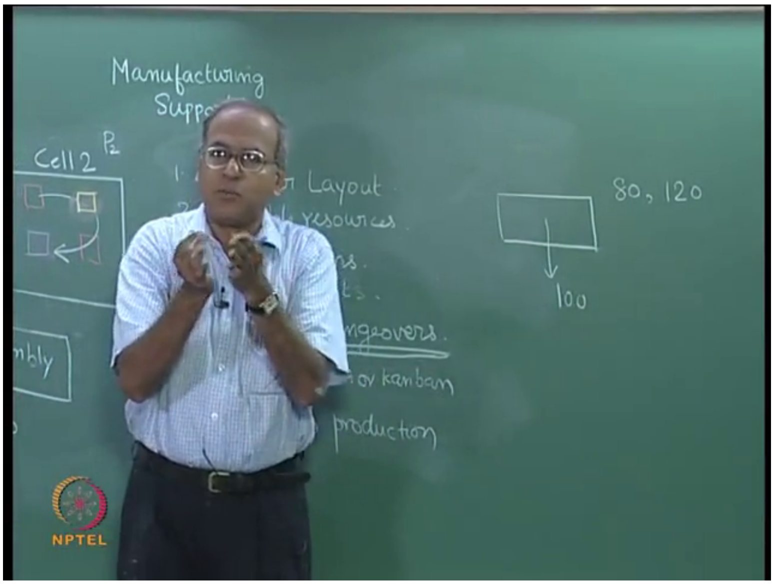

There are 2 ways of looking at uniform production, one is if I with the example that I gave where it my capacity is 100 here and my demands for 2 consecutive days are 80 and 120 and if I am willing maintain a small amount of inventory here, assuming that this variation is not very large I produce a uniform quantity of 100 here. So, that I am able to play around with every minimal inventory and yet meet the demand and other way of understanding uniform production is if for some if this 100 capacity is for 3 products and let us say.

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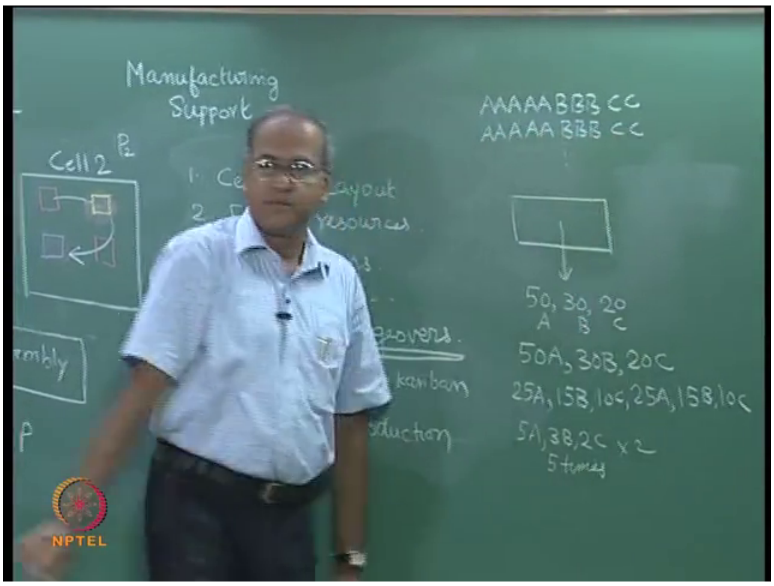

I could make 50 of A, 30 of B and 20 of C in a day where A B and C are 3 products that I can make or 3 verities of the same product that I can make then one thing I can do is I can have one batch of 50 of A followed by 30 of B followed by 20 of C which or I could think in terms of 25A 15B 10 C another 25A, 15B and 10 C. Now this would mean I am making 6 batches now actually if my batch size minimum batch size is 5, I can go for 10 plus 6 plus 4 up to 20 batches I can produce. If I provided I have quick change over and I have that time to change over 20 times within a particular day by having quick change overs. Now this uniform production it at the end I could do for example.

So, instead of doing 25 A 15 B 10 C I could actually do something like this is 5 AAAA A; so 5 A, 3 B, 2 C, 5 times for this in to 2. So, I could do something like AAAAAA BBBCC 10 times again followed by AAAAA BBBCC etcetera and I could do this 10 times to make this. So, this would give me something like a uniform production in my system.

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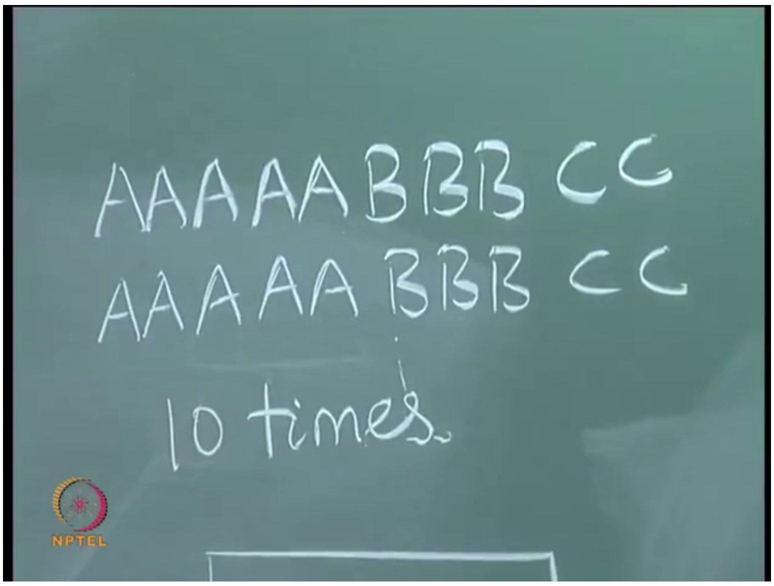

Now, all these are enabled because of almost all of these which are above this thing called uniform production. We still have not seen much about the pull systems are the kanban systems as well as about aspects of quality maintain and supplier.

Now we will see all those aspects in the next lecture.