Toyota Production System
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Lecture - 38
KANBAN Calculation-II

Welcome friends, in our last few sessions, we were discussing about pull production system and we discussed the role of kanbans in that pull production system. Pull production system is one of the very important concepts of Toyota manufacturing system and in this Toyota production system, when we implement the pull production, there are certain calculations which are required.

And how to have those calculations and particularly if I say the title of this very session is on that calculation part only. We need to have a proper designing of pull production system. In last 2 sessions, we discussed about the characteristics of pull production system, characteristic of particularly you can say kanban system but now in this system how to have various parameters, how to design your system that is the content of this particular session.

Now to have this kanban system and various calculations which are required in designing is suitable kanban system, we need to know some basic things.

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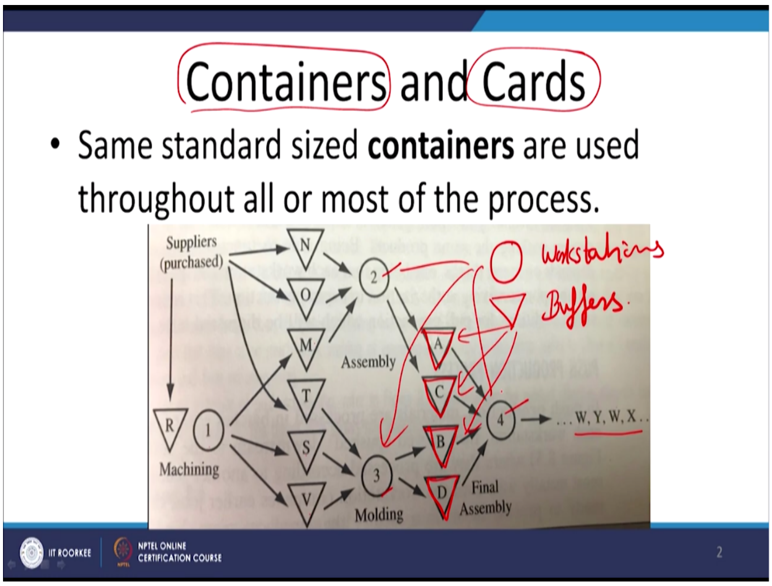

And for that purpose, you need to know that any pull system has 2 important components; one is container and another is card. So, container and card are 2 important things. Container is that you can say box in which we are keeping the items which are to be processed at downstream. So, like if you see this diagram that these are workstations 1, 2, 3 and 4. So, these round shapes are representing the workstations.

And these triangles are representing the buffers or you can say where these containers are kept. So, like workstation is one and here we have a buffer where we are keeping R is the name of some component which is being purchased from a supplier and then we do machining of that component and this machined component R is used at workstation 2 and workstation 3.

When we are machining it, it is also becoming either M or it becomes S or it becomes V depending upon the type of operation we perform on this raw material R and then therefore these M, S, V these are also kept in the buffer because these are to be used by subsequent workstations which are 2 and 3, 2 and 3 are also intermediate steps. So, they are also producing sub intermediate product like A, C, B, D which are going to workstation 4.

So, these A, C, B, D are put in the triangular boxes, these are the triangular boxes in which these A, C, B, D are kept and from here these are going to this final assembly step and then these are the different types of parts which we are making W, X, Y. These are the different types of components which are made on this system and for that we have workstations and we have these buffers.

So, containers are used all through this process and these containers are kept at this buffer location from where the workstation, the person who is at the workstation will withdraw the required amount of parts to be processed. The second important item in this is the card.

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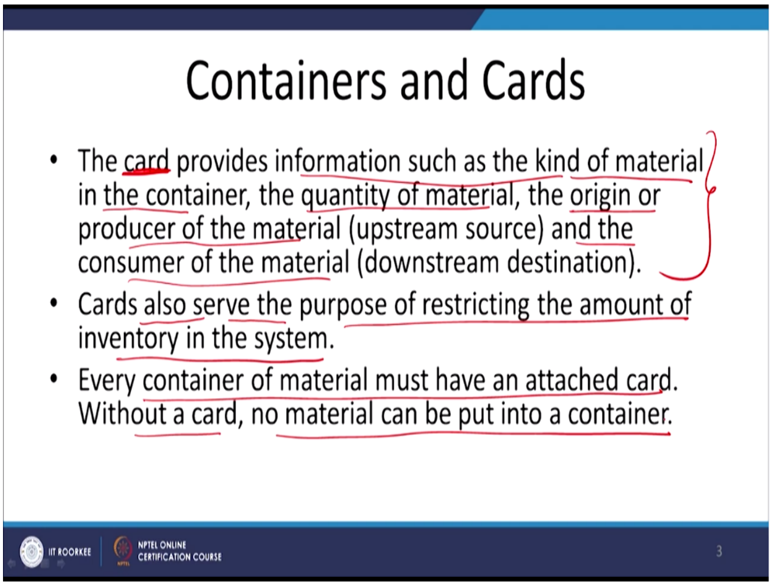

Now, container is keeping the material, now with each container there will be a card and the card provides information what is written on that card that what kind of material is there in the container, the quantity of the material in the container, the origin or the producer of the material, the upstream source whether it is coming from workstation 1 or workstation 2 or workstation 3, so all that information of origin.

And the consumer of the material where it has to go, if it is at of the workstation 2, so whether it has to go to workstation 3 or it has to go to workstation 4, that is the downstream side, so that is all. So, card provides you lot of information about the material inside that container. The second very important point which we need to know with respect to card that is cards are also used for the purpose of restricting the amount of inventory in the system.

So, depending upon how many cards are there in your entire system, in this system like we just saw that from R to W, X, W, Y so the entire system of production depending upon the number of cards are there in this system, you can control the inventory of your work in process items. Every container of material must have an attached card. Without card there cannot be a container, so you can say the number of cards and number of containers are always equal.

Without a card no material can be put into a container. So, card and container are very much closely associated and without a card no material can be there inside a container.

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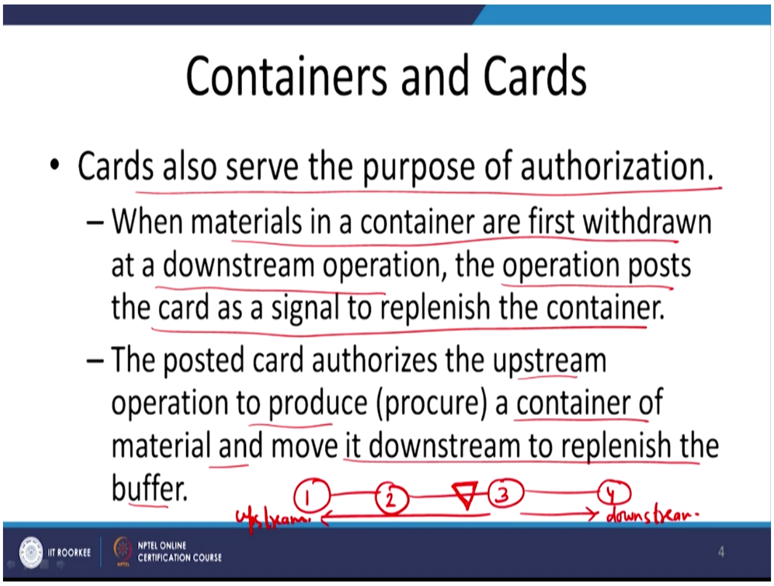

Then, further going into this discussion, cards also serves the purpose of authorization. So, cards are the visual signal for, when material in a container are first withdrawn at a downstream operation, the operation post the card as a signal to replenish the container. So, we all know in our various discussions we have already like for these are the various workstations 1, 2, 3, 4 these are the workstations.

Now, for workstation 3, 4 is in it downstream and these are in the upstream side. So, when there is a card which is shown at workstation 3 that I need material, so that become a signal for upstream that yes we need to provide that material to workstation 3. So, that way it acts as a signal, it acts as a trigger to start activities in the upstream direction. The posted card authorizes the upstream operation to produce a container of material and move it downstream to replenish the buffer.

So, when I am saying that workstation 3 requires material so it means there is a buffer before this workstation. This is a buffer, so we have actually requested our upstream 1 and 2 that we want a material at buffer of workstation 3, so with each workstation there is a buffer attached and whenever we are signaling that material is required, it means we want to replenish the buffer associated with that particular workstation.

Many a times, it is also important to know that when we are talking of pull system, when we are saying that we are working in a pull environment, people may assume that we are not keeping any work in process inventory but that is not true. We keep work in process inventory, we keep buffer before every workstation so that we can minimize our lead time because this pull system is important on one side.

But at the same time, we also want to minimize the lead time, so if everything starts in my entire system everything starts against the order of a customer, then the lead time to delivery will increase very much. So, we keep a buffer so the just in time system or pull based system of inventory is not without buffers. So, we maintain stock but how much stock to be maintained that is an important question and we are trying to answer that particular question in this session.

So, now there are 6 very important rules and we need to understand these 6 rules for developing an efficient pull production system. Toyota took around 20 years in perfecting their pull production system. So, you can understand that if pull production system is not implemented with proper understanding, you will not get any advantage rather you may incur more cost, you may incur poor customer satisfaction.

And that may be more dangerous rather you can go to your traditional system of inventory management. So, if you are going for pull based system, you need to understand the complete basis on how to design a pull system, so before we go for the calculation part, we need to quickly go through these rules for pull production system.

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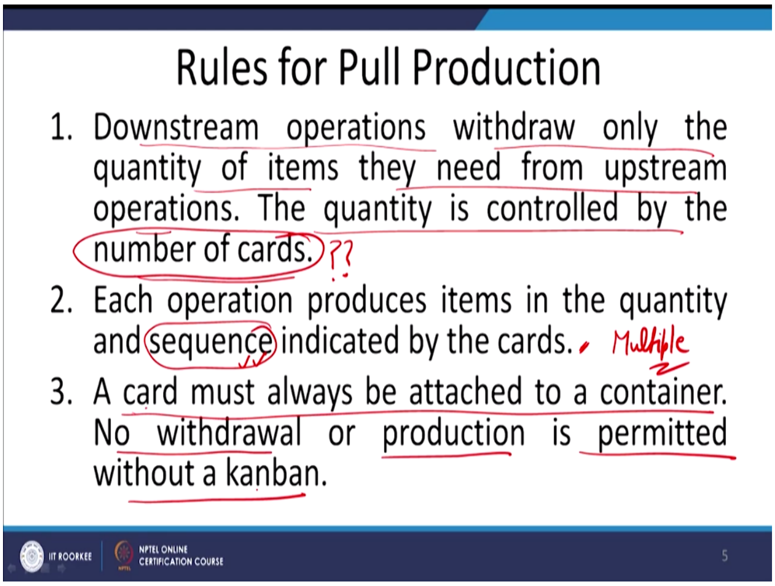

Now, as I mentioned that there are 6 rules and most of these rules will help you in eliminating different types of wastage in your production process. The first rule is downstream operations withdraw only the quantity of items they need from upstream operations. The quantity is controlled by the number of cards. So, number of card is a very important thing that how many cards we should have in our production system.

Each operation produces items in the quantity and sequence indicated by the cards. So, the card has a proper sequence of operation and according to that sequence and the number which are mentioned on the card, each operation will produce that many products. This is very important when we have multiple products. If you are producing only a single product in your factory, then this sequence part has no meaning.

But if you are producing multiple products, then this sequence part becomes very important like in the example we just discussed that you are having W, X, Y different types of product coming out of the same process, so whether workstation 2, workstation 3, workstation 4, workstation 1. So, all these workstations will produce these products in what sequence, so sequence becomes important only in case of multiple products.

If multiple products are not there, sequence will not have any relevance. The third rule is a card must always be attached to a container. So, already we discussed that card and container are always to be kept together. No withdrawal or production is permitted without a kanban. This card is actually the kanban, so without card, without this kind of information, no withdrawal, no production, no movement is possible.

Therefore, this card becomes very important and we have this full session only on this number of cards.

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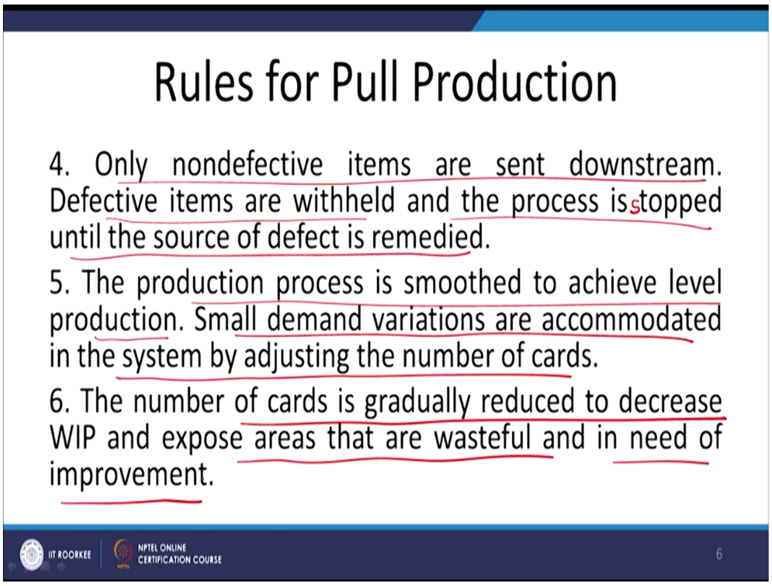

Only non-defective items are sent downstream, defective items are withheld and the process is stopped until the source of defect is remedied. So, the process is stopped so that no defective piece go to the downstream, so each operation, each activity takes the responsibility yes because of me no defective piece should go downstream, so that is the point of already we have discussed in the Toyota production system that we try to strengthen our process.

So, this is that very idea. Then, the production process is smooth to achieve level production. Now, we want to have an almost similar level of output from my process and the small variations which may happen in the demand of my final product, we will not like to change in the production process, that will affect my all internal setting. So, we want to have this kind of small demand variations by the accommodation in the system by adjusting the number of cards.

So, just by adjusting the number of cards, we will like to adjust the small variations in the demand but we will not like to do much variation in our internal processes and finally towards the process improvement, we will continuously like to reduce the number of cards so that our work in process inventory also gets reduced. So, that is very important thing because as we just discussed cards determine our WIP and we want to minimize WIP also.

We want to reduce the lead time also, so once we have stabilized our present kanban system, pull based system then slowly and slowly the next phase will be to reduce the number of kanbans and correspondingly our WIP will also get reduced. So, this will help us that what are the wasteful activities, what are the challenges in my system and it will also help us in process improvement.

So, these are the 6 rules of pull based manufacturing and we need to see that how to achieve this pull based production system.

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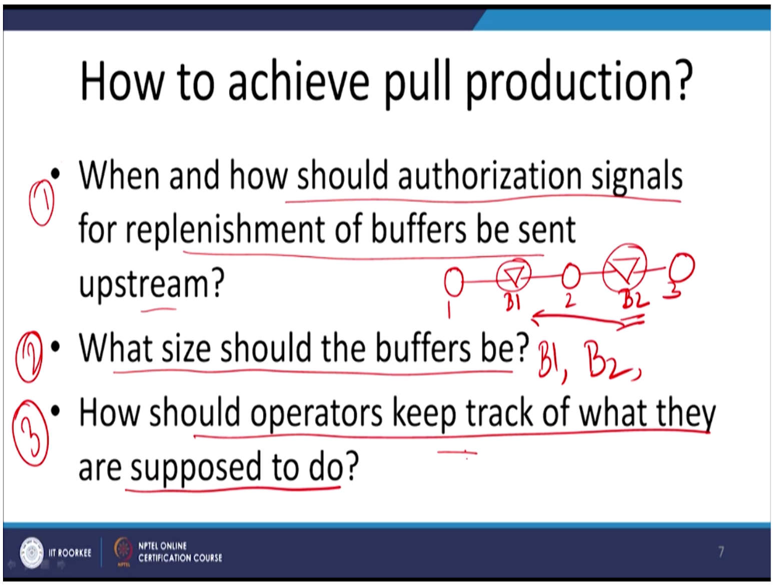

Now, when we are saying the designing of a pull based system, we are actually looking answer for these 3 questions. These are the 3 questions we want to have answer. The first question is when and how should authorization signals for replenishment of buffers to be sent upstream. We discussed that these are different workstations and these are the buffer, this is buffer 1, this is buffer 2.

Now, I want to replenish my buffer 2, so how and when? This signal should go to upstream to workstation 2 so that workstation 2 can do some kind of activities to fulfill the requirement of buffer 2. So that is the first thing that at how many intervals and how I should develop a system and nowadays we have discussed already that visual signals are possible.

And in previous time or in some companies, you can find still that we have the manual system and those cards manually are going from one workstation to another workstation for the replenishment. So, all those things are still happening but slowly and slowly everywhere now we see that the monitors are there and with the help of those monitors weekend disseminate this information in real-time.

The second question is what size should be the buffers? These are the buffers B1 and B2, what should be the size of these buffers? How much material should I keep here in my buffers so that my production process go smoothly, there is no waiting at the workstations and there is no crowding in the buffers also? So, both these things are important and therefore the size of B1, B2 these buffers are important question to answer.

And third important question which I want to answer is that how should operators keep track of what they are supposed to do? Means you have send the signal to workstation 2 from workstation 3 but it is quite possible that the operator at workstation 3 has not checked the buffers and without checking the buffers has send the single for upstream production. So, we need to see, we need to develop a system that there has to be a proper checking before sending the signal to upstream.

Like for example, you are in the kitchen and in your kitchen you saw that there is no milk available and you just ordered for the delivery of milk without checking whether milk is there in the refrigerator or not. So, sometime it is possible that your buffer is not very closely available to your workstation and it may not be visibly possible for you to just see that how much materials are available in the buffer.

So, in that case, this kind of issues are possible that you may signal an order without actually doing how much inventory is available in the buffer. So, you also need to keep track that how your operators are supposed to work. Now, let us start with the calculation part of the pull system or the development of the kanban system.

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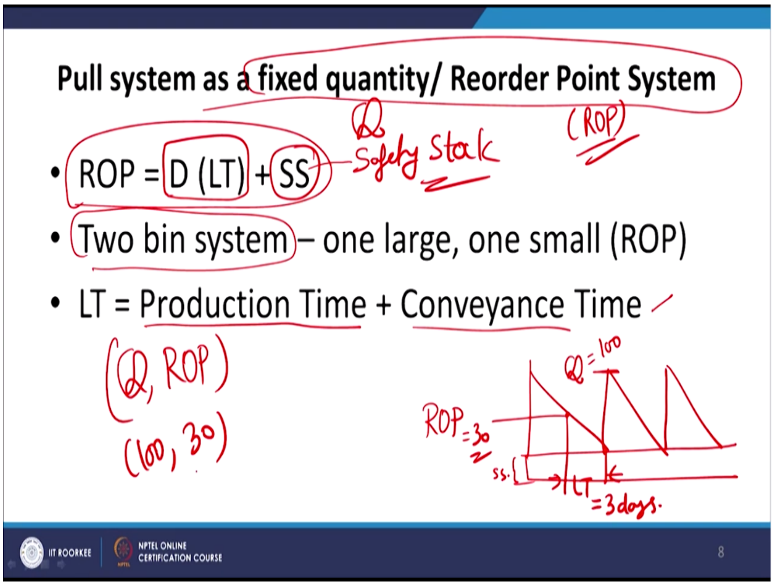

This pull system is very much similar to this fixed quantity or reorder point system. If you go back to your inventory management classes, we know that this kind of sawtooth pattern, we have for inventory management and in this we determine 2 important things; one is this point of order which we call as reorder point, ROP that is reorder point and the second is what should be the quantity of this order.

So, 2 important things that what should be the quantity of order and what should be the reorder point. So, this model is known as Q, ROP that if your stock in the buffer comes to this particular level, let us say your Q is 100 items and you are consuming these items at the rate of 10 items per day. So and your lead time, the lead time is 3 days, so it becomes very clear for you that when your stock reduces to 30 units, you will trigger a new order.

So, your Q is 100 and ROP is 30 because whenever you reduce your level to 30 units, you trigger a new order that give me the fresh supply and in 3 days you will consume these 30 units and when you are touching this zero level, you receive a new supply of 100 items. So, in this way, this model is designed. Now, in this particular case, the important thing is the determination of your ROP.

When should you trigger this new order, so this is known as 2 components are there that D*LT, LT is lead time and D is the demand during lead time. So, what is your D for the lead time that becomes the fixed quantity and the second is safety stock. So, because this example I gave here everything was fixed but in real life everything will not be fixed. There will be a lot of variability.

During this lead time period, maybe demand increases to 35 units, so you will not be having 35 units because your ROP was 30. So, for taking care of these fluctuations, these variations, we keep some safety stock also. So, our ROP is actually can be considered like this. You have this much of safety stock and then your ROP is determined that what is the demand during lead time plus this safety stock.

So, a very common example which you can practically see in any industry, they follow this two bin system. Under this two bin system, we have 2 containers; one container is a large container, another container is a small container. So, whenever you receive a supply, the quantity which is required for ROP level that is kept in that small container and rest of the supply is kept in the large container.

And you start consuming from that large container and by the time you finish the large container, it means you have reached that ROP level and as soon as you finish that large container you trigger a new order and that new order is being fulfilled and in the meantime you consume that small bin and when the new supply comes, you will replenish your large container as well as the small container.

So, that is a very simple thing which is there in many organizations and when I am talking of this lead time, this lead time is actually made up of 2 things. One is this production time, the setup time, the actual processing time, the unloading time, all those things are the part of your production time and the second is the conveyance time that from workstation putting that item into the downstream buffer that is the conveyance time.

So, within plant also or may be from another plant to another plant, this conveyance time may increase. So, production time and conveyance time are the 2 important components of my lead time. We are trying to reduce the lead time by having better material handling equipments for reducing my conveyance time and by having a quick setup, quick loading unloading of the dies, we want to reduce our production time also.

So, that is the beginning of the calculation of this pull based system. Now, when we are using this pull based system and we are using containers in the buffer as we have discussed.

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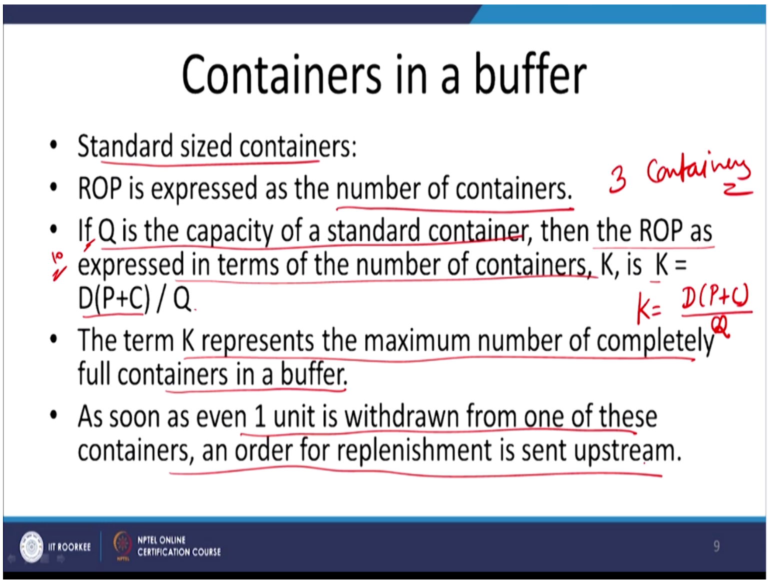

So, we are like in this example, I said that my ROP is 30 units and the order quantity is 100 units. Now, these units, these items are kept in some container, some boxes. So, if you remember, we discussed in the beginning of today's session, containers and cards. So, these are kept in containers. So, containers are of the standard size, each container contains same number of units.

So, we are not going to express ROP or order quantity in number of units rather we will be expressing them in number of containers. So, like if each container contains 10 units so my ROP will be 3 containers. So, if in each container, I am keeping 10 items and 30 units was my ROP so in fact in my language of pull system, I will say that 3 containers is my ROP and if Q is the capacity of a standard container, now if in one container I am keeping 10 units, then the ROP as expressed in terms of number of containers K is like this D P+C/Q.

So, this K is D that is demand P+C production time and conveyance time/Q that is the capacity of a standard container. So, that is the formula to calculate the number of containers which is one important part of your kanban system. The term K represents the maximum number of completely full container in a buffer. As soon as even 1 unit is withdrawn from one of these containers, an order for replenishment is sent upstream.

So, even if it is used by 1 unit, you have just started using 1 container, it means the order will be triggered to the upstream. So, that is the role of container in these buffers. Now, just to have a quick example.

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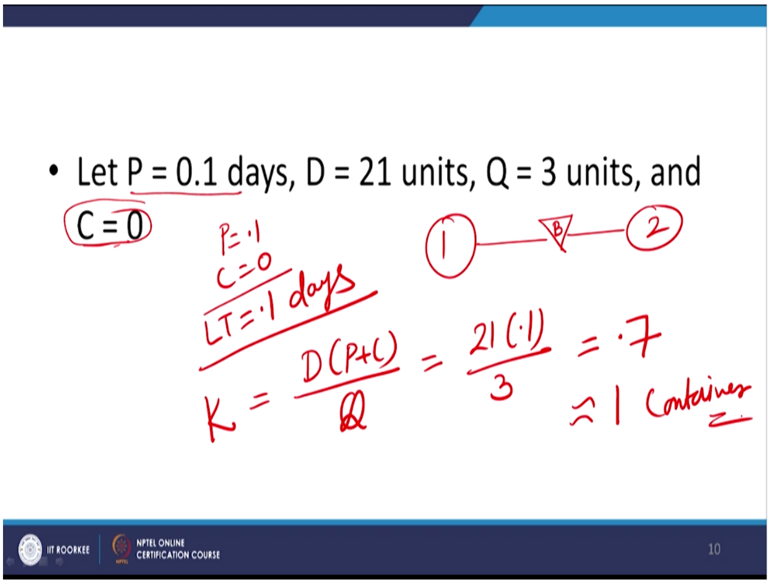

Let the production time is 0.1 day and the C because this buffer maybe closely allocated between 2 workstations like this way. These are the 2 workstations and this is the buffer. So, there is practically 0 conveyance time, so your P is 0.1, C is 0 so our lead time becomes 0.1 day and Q is 21 units, so D*P+C/Q that is the number of K, so it becomes 21*0.1/3 so that means 0.7.

Now, you cannot have 0.7 container, so you will approximate it by 1 container. So, maximum 1 container is required in this buffer. So, that is the standard thing that only one container is required between these 2 workstations. Now, it is going to increase if you have some C also, so if you have some C, then obviously you can understand the numerator value will increase and if the numerator value will increase, you will like to have more containers.

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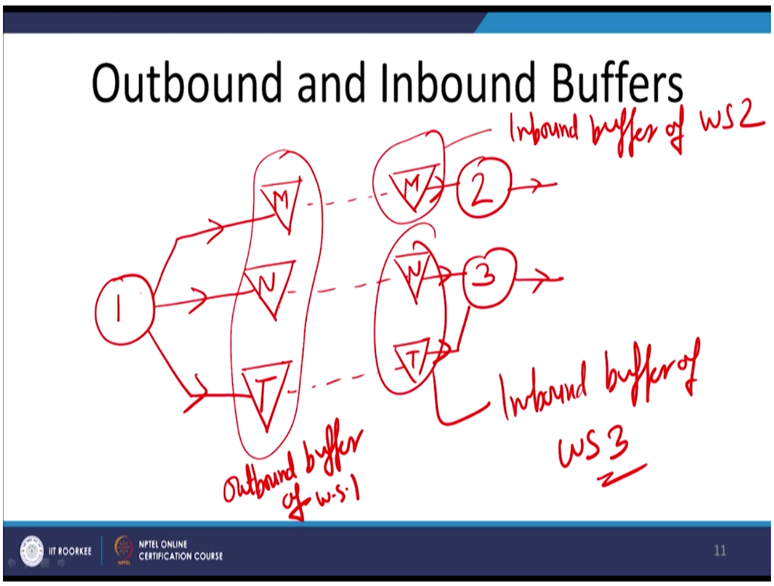

Now, before we go further, one important thing we need to know that is outbound and inbound buffers. Now, what is the meaning of outbound and inbound buffers? Like this is a workstation, now this workstation is producing different types of products and I am putting them in different types of buffers. Now, you see that the output of workstation 1 or 3 components M, N and T and these M, N, T here these are kept in the outbound buffer.

These are outbound buffers of workstation 1 and these are this is inbound buffer and these are inbound buffer of workstation 3. So, because workstations may not be very close to each other so one workstation is very far from another workstation. So, the output of your workstation you will keep immediately very close to you that is you are putting the output of your workstation in your outbound buffer.

Similarly, the inbound then you will transport that item into a buffer which is close to your downstream operation. So, like in this case, I am putting M here which is close to station 1, so whatever output of M type is coming from workstation 1, I am keeping that initially in the outbound buffer. Whenever there is a signal from the workstation 2, I will put that output into the inbound buffer of workstation 2.

So, 2 types of buffers are there, outbound and inbound buffers because our further calculation is dependent on these outbound and inbound buffers. So, this very concept is important to discuss. Now, we need to understand that our lead time is made up of 2 particular components; one component is my production component and another is conveyance component. So, we need kanban for production and we need kanban for conveyance also.

So, in our next session, we will discuss that how to develop, how to have the calculation of kanbans for production and kanbans for conveyance. So, we close this session at this very point. Thank you very much.