Toyota Production System
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Lecture - 39
Theory of Constraints

Welcome friends, this is the second last session of this course and in our last session, we were discussing about various calculations which are required to develop a pull based system and in that system, we discussed that there are 2 important components in a kanban system, one is the card and the second is the container and card and container need to put together for developing the kanban system.

And what should be the size of container, how many cards should be there, these are important questions which we need to answer when we need to develop a pull production system and in that we discussed that our traditional inventory management model where we have Q and ROP that what is my reorder point and what should be the order quantity, these are very simple tool which can help us in designing a pull based system.

And when we were discussing that, we also discussed that the number of cards can also play a significant role in reducing my work in process inventory and when we try to improve our system with the reduction, continuous reduction in WIP or my kanban cards, that is a very interesting point in improving my overall performance of the production system and with that idea the philosophy of theory of constraints is also proposed.

And in this TOC, theory of constraints we identify the weak point of my system, that this is the problem area in my system and if I can target that problem area, the performance of my entire system is going to improve and there will always be some problem area, there will always be some kind of weakest link in my system. So, as operations manager we already know that what is the concept of system.

And therefore we develop the system and we continuously try to identify the weak links in my system. We concentrate our entire energy, we focus with our full attention on that weak link and we try to improve, we try to strengthen that weak link so that it gives us a systemic effect by improving the overall productivity of my system and we keep on doing this process

and by doing it again and again, we will continuously improve the performance of my system, so that is the idea of theory of constraints.

And if I link my discussion of kanban with theory of constraints, so by reducing the number of kanban cards that becomes a very interesting point for theory of constraints. So, there is a proper scope, there is a sufficient scope of putting these 2 concepts together that how my calculation of kanban can lead to the concept of theory of constraints. You need not to look around that where is weak link even you continuously think of your number of kanbans and if you reduce the number of kanbans that itself will give you enough scope of improvement.

Now, in our previous session, we were discussing in the last about inbound and outbound buffers and we discussed that the lead time is basically the combination of 2 times, production time and conveyance time and based on that we have this particular discussion which we are going to start in this session.

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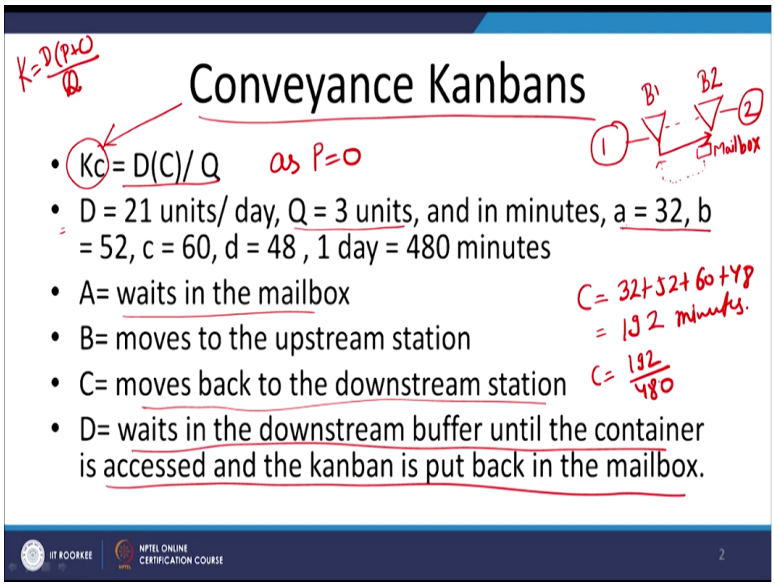

That is the conveyance kanban and then we will discuss the production kanban. So, these are the 2 types of kanbans we are going to have in any pull production system. Now, in the conveyance kanban, we actually discussed in our last session that these are outbound and inbound workstations. So, between 2 workstations, you have buffer number 1 B1 and this is buffer number 2.

So, B1 is the outbound buffer for workstation 1 and B2 is the inbound buffer for workstation 2. Now, the role of conveyance kanban come when from this outbound buffer, some material

is to be moved to this B2 buffer. So, in that time, we require conveyance kanban. Now, in the conveyance actually if you remember, the formula of calculation of kanban, number kanban is demand*production+conveyance time/the size of container.

Now, since there is no production activity involved in this particular place, it is only the movement of items, movement of containers particularly I say from the outbound buffer to inbound buffer. So, only the conveyance activity is involved, so the P is already 0, as P is 0, so the formula remains D*C/Q and Kc represents my conveyance kanban. So, if I am simply writing K that is kanban and if I am writing Kc subscript c, it means conveyance kanban.

So, conveyance kanban is D*C/Q because we are not involving into the production activities. So, whatever is already stocked in the outward buffer that is going to inbound buffer. Now, for a purpose just we have this small example, some numerical data is with us. We have the demand of 21 units per day, size of container is 3 units and there are few activities which are required from buffer B2 to B1 and these are represented by A, B, C, D.

And all these times are given in minutes. Now, A is waiting time in the mailbox because when you are putting this card, so there may be a mailbox here and from this mailbox this kanban card is going here. So, this is the mailbox, so A is the time that how much time this card is waiting in the mailbox, B is the time which it takes in moving from this mailbox to the upstream workstation.

Then, C is the moves back to the downstream station, then this card goes back to the downstream station and then it waits in the downstream buffer until the container is accessed and the kanban is put back in the mailbox. So, a card is going through these 4 processes, these 4 steps A, B, C, D are those 4 steps through which this card is going. So, if we say that in minutes this much time is taken, so total C is actually 32+52+60+48.

Now, in a day we are considering 480 minutes, so you see that this is going to be 8+2=10+2=12 6+4=10, 15, 318 and 192 minutes, so how much per cycle is required, so you will have C=192/480. So, you put this value here, D is given to you 21 units and Q is 3, so you will have that much your time for this particular kanban number for the conveyance purpose.

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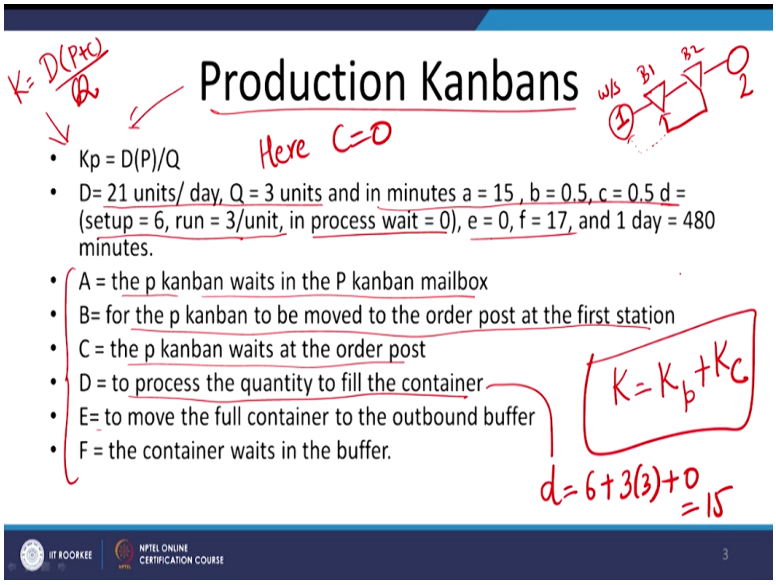

Then, the second particular kanban is for the production because when the signal is coming from this B2 to this B1 that you replenish the stock at B2. Now, at B1 also there is a kanban which will go to workstation 1 because when the conveyance kanban helped in moving item from B1 to B2 but because items have moved from B1 to B2, so there is a requirement at B1 also now to replenish its stock.

And therefore, we need to discuss now the second type of kanban that is production kanban. So, now at B1 there will be a signal which will go to workstation 1 and in this you will have only because it is related to production activity, the conveyance is not there, here C is 0 and you are only taking P into consideration. So, the original formula again you refer that is D*P+C/Q.

So, here since C is 0, so this formula reduces to this. So, you also need to understand this important thing that now in this entire process from workstation 1 to workstation 2 we have 2 types of kanbans and the total number of kanbans therefore become Kp+Kc. You have production kanbans and you have conveyance kanbans and therefore you need to have separate calculations for both these type of kanbans systems.

Sometime, it is also possible that you may have a factor of safety also. So, you may further increase the number of kanban depending upon how much factor of safety you want to have 5%, 10%, 20% so that is also likely to increase the number of kanbans, so how much uncertainty are there and we certainly need to reduce that uncertainty so that we can reduce the number of kanbans because that is directly proportional to your WIP.

Now, the similar kind of example which we discussed for the conveyance kanban is again here that you have the requirement of 21 units per day, the size of the container that is determining the Q is 3 units and now all A, B, C, D, E, F all these things are related to production activities. In that these are related with conveyance activities. Now, these are related with the production activities.

And we have given the explanation of all these A, B, C, D, E that the p kanban waits in P kanban mailbox because there is a separate mailbox for p kanban and separate mailbox for c kanban. So, in our short form, we call them P kanban and C kanban. P kanban means production kanban, C kanban means conveyance kanban. So, then B is for the p kanban to be moved to the order post at the first station.

The p kanban waits at the order post, then to process the quantity to fill the container that is very important and it includes the setup time, run time and in process waiting time. So, you see when I am giving the data for D, there are 3 things in that setup time, run time and in process wait time. So, therefore if I am calculating the value of this d, it will have 6 minutes+3 minutes per unit so 3*3+in process waiting time is 0.

So, that means the total value of d will be 15 minutes. So, normally we present the value of d in 3 items, what is the setup time, what is the run time and what is the in process waiting time and then E that is to move the full container to the outbound buffer from workstation 1 to B1 and then F the container waits in the buffer. So, all these are the important components for like in this particular case if you see the data for E is 0, it means the buffer is very close to your workstation.

So, it is almost taking no time in putting your output into that buffer. So, that is how this calculation is done. So, if you add up all this A, B, C, D, E, F from here you will and then how much time you have in a day that is given as 480 minutes, so you divide that by 480 minutes, you get the value of production and then production time. You multiply it by number of units in a day divided by 3 units; you will get the value of Kp.

I request my students that they calculate the value of Kc and Kp as discussed and in our forums because if these values are not coming in integers, if these values are coming in

fractions, we cannot have containers in fractions, so we will keep containers in full quantity and like in the previous session, we discussed that the number of cards was coming 0.7 but we need to contain 1 full container.

And what is the implication of this? If you are getting some fraction values and you are keeping the next higher integer value as your answer for designing the system, what is the meaning of that? So, that I am thinking to have your inputs in our forum discussions and I request that you do these calculations and what inputs you get and these are giving you what type of insights that is very important for our discussion in the understanding of these kanban system and WIPs.

Now, we go to discuss the context of theory of constraints, which is actually the title of this particular session.

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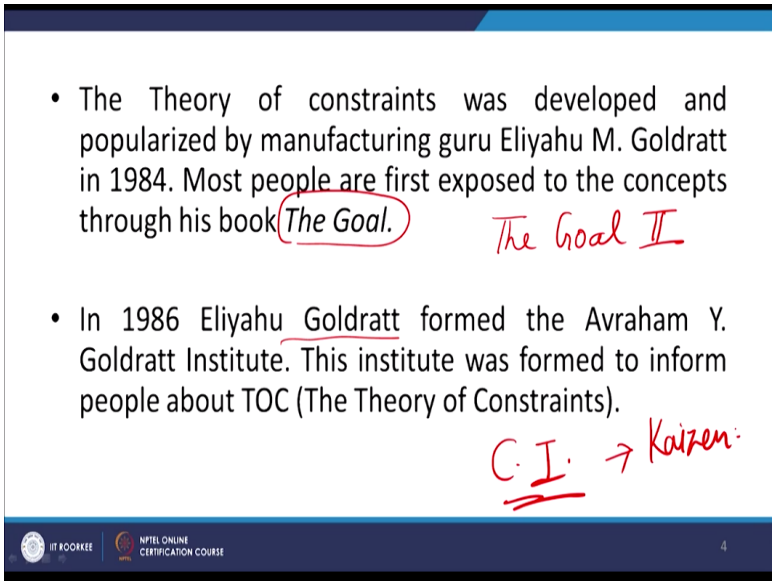

Now, the theory of constraints is basically from this book The Goal and when I am standing here, so presently The Goal II, the second version of this book is also available and Goldratt who came with this concept of theory of constraints, so because this theory of constraints is going to help us in continuous improvement, it is going to help us in kaizen and as we just discussed that it is also going to help us in reducing the number of kanbans.

For an example, I just go back let us say here Kc comes 10 that we need to have 10 conveyance kanban from workstation 1 to workstation 2. Now, as a part of this TOC activity I will say that can I reduce this 10 to 9 and if I do this 10 to 9 I may find that okay the system

is still working fine. So, you can understand that my WIP has reduced because I have reduced the number of kanbans.

Next is I will further reduce from 9 to 8 but then I realize that sometime I am running out of material at work station 2 and when I am running out of workstation 2, I cannot do that and so I will go back to keeping 9 kanbans. Now, I will do one kind of TOC activity that why I cannot work with 8 kanbans? What is that point which is restricting me in keeping 8 kanbans? So, that is the scope in which I am going to discuss this concept of theory of constraints.

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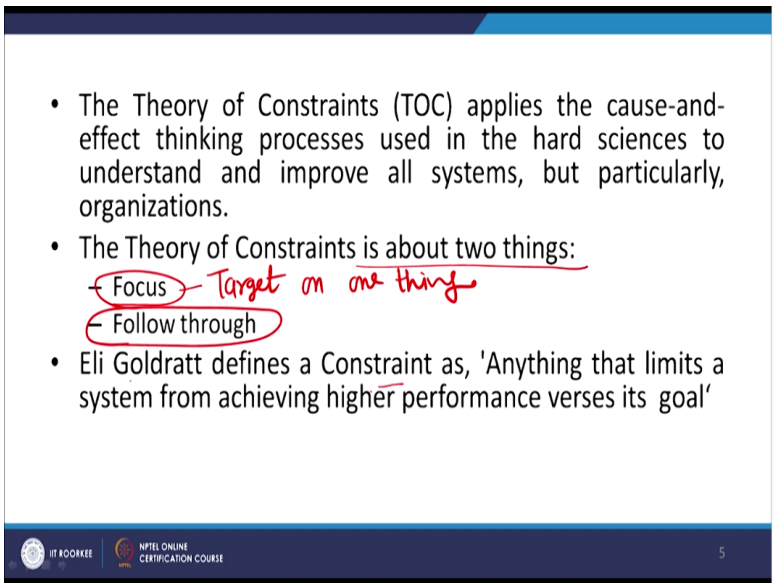

So, the theory of constraints is about two very important things; one is the focus, where to keep your focus. So, like this example of kanban is helping us to understand that if my focus is on reducing my WIP, so I will continuously follow through that particular thing. So, these are the two important things, identifying the focus, where to keep the focus because if you are distributing your focus to many things then it is not possible to achieve the objective.

So, focus means target and target one thing only and then you follow through that, you keep chasing that target. Now, what is the constraint, because it is theory of constraints? So as per the Goldratt, constraint is anything that limits a system from achieving higher performance or the goals which you are thinking, so like we want to become a world class manufacturing organization.

We want to become a world class organization, so what are the things which are stopping me to become that world class these are the constraints. So, these are those challenges which are burden to your system and that burden we want to remove.

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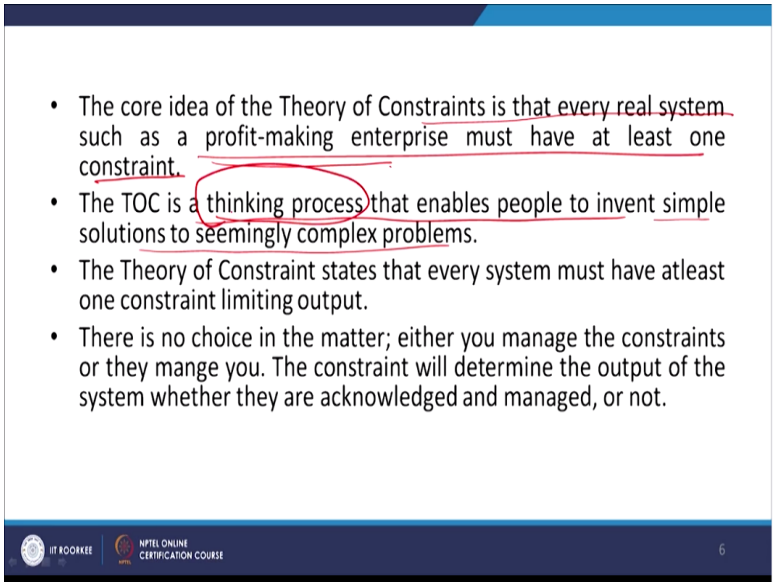

Now, the core idea of theory of constraints is that every real system such as a profit making enterprise must have at least one constraint. So, we assume that all systems have at least one constraint and this assumption is very true in fact in reality there are more than one constraint, there are many constraints. So, this idea of having at least one constraint is not that significant that important because there cannot be a system which is a profit making system and having no constraint.

So, we all have the constraints, no system is absolutely without constraint. The TOC is the thinking process that enables people who invent simple solutions to seemingly complex problems. The entire concept of Toyota production system which we are discussing since last 7 weeks is about the thinking that you need not to have the rocket science solutions but problem may look like a rocket science.

But their solutions may be very simple, so this is another myth and therefore we need to empower our manpower, we need to develop this kind of mindset that we are capable of solving any kind of problem in my organization. So, that is the meaning of this a thinking process. The TOC states that every system must have at least one constraints limiting output. There is no choice in the matter either you manage the constraints or they manage.

So, if you are not able to overcome those constraints, so they will always keep you underperformer. It is not possible that you live those constraints and you become a world-class organization. So, for becoming a world class organization, you certainly need to overcome those constraints.

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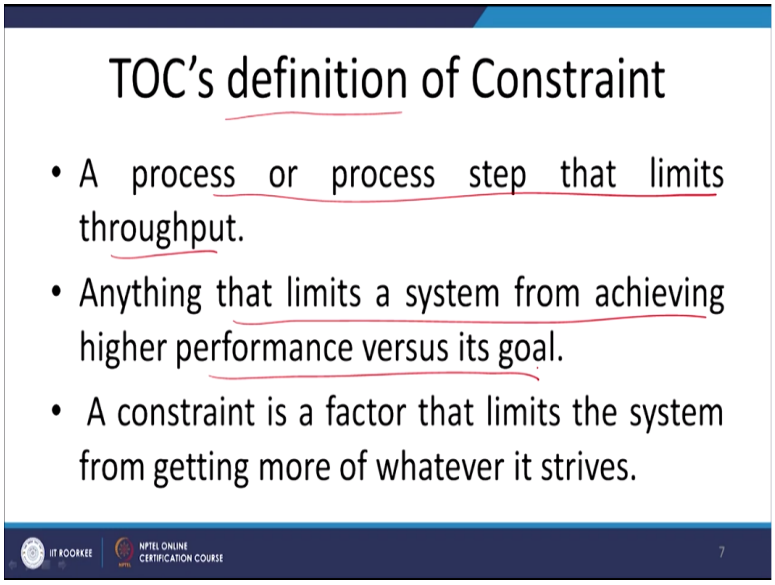

So, as per this Goldratt's concept of constraint, the definition is a process step that limits the throughput, so out of various from A to Z, there are various intermediate processes, so it can be a process or group of processes that is limiting your throughput. Anything that limits a system from achieving higher performance versus its goal. So, other than process there may be some other thing which may be limiting the performance of your system and a constraint is a factor that limits the system from getting more of whatever it strives.

So, whatever thing is reducing or contributing in your lower performance, your poor performance is according to TOC is a constraint.

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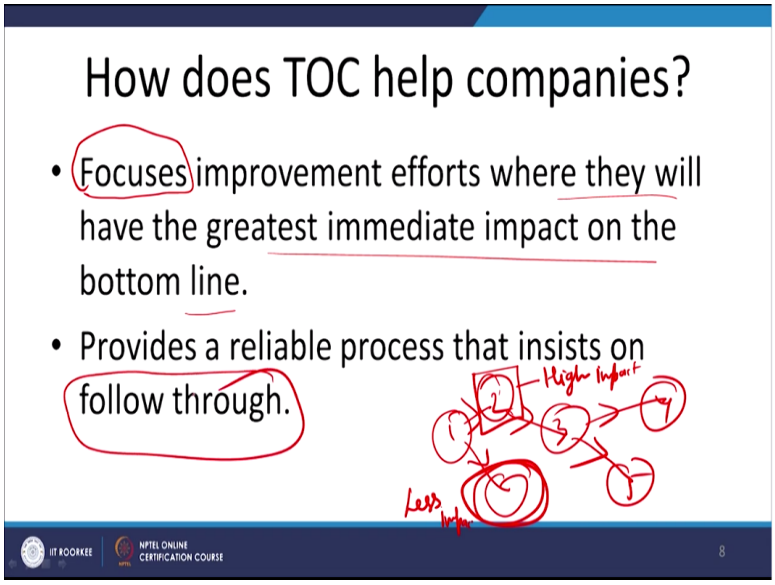

Now, how TOC helps companies? It focuses improvement efforts where they will have the greatest immediate impact on the bottom line. So, out of various things which are there in your system? Now, you will see that if I target for example in this diagram if someone targets on this particular activity. So, this is not going to have much impact on the output, less impact but you can very well understand if I target on this particular activity high impact.

Because it is connecting to workstation 3, 4, 5, so all these steps, all these stations are affected because of your improvements taking at the workstation 2. So, you will see that where to add so that you get the greater immediate impact on your system. It provides a reliable process that insist on follow through and then you continuously see that whatever process you have improved whether that is consistently followed or not followed.

So, that is another important point. So, as if you remember, we have just discussed that focus and follow through, these are the two important things in a TOC work.

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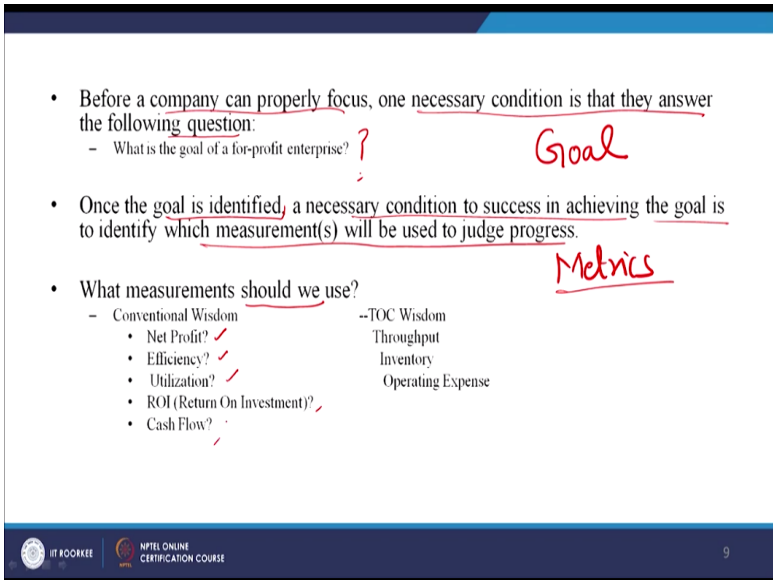

So, like if we go to this TOC discussion, you see that before a company can properly focus one necessary condition is that they answer the following question. So, when you are starting some theory of constraints project in your organization so what is the goal of a for-profit enterprise? So, you just ask this question. What is the goal of your company? Obviously, your company is a for-profit company.

Or even you can think of a NGO, you can think of a non-profit company also, so what is the goal of that organization so that is one important thing you need to ask. Once the goal is identified, therefore the name of that book was The Goal. Once the goal is identified, the next condition is in achieving the goal is to identify which measurement will be used to judge your progress. So, first is your goal and then the metrics.

That what are the criteria on the basis of which you will say that yes my progress is there, we want that my child should become more educated, so the metrics we use the examination and the numbers scored in the examination will give us an idea whether my child is becoming educated or understanding the concepts or not understanding the concepts. So, that is the second important thing that may be for somebody, the marks scored in the examination may not be the criteria of your child being getting education or not education.

There may be people without going to the formal school, they are very knowledgeable. So, depending upon organization to organization, you can select metrics to determine for your performance progress and you can use different type of you can say metrics. Now, in over

conventional system, the type of metrics which we use like net profit, efficiency, utilization, ROI, cash flow, etc.

These are the different kind of you can say (()) (28:52) which we used to determine whether we are on the right track or not but in theory of constraints, we use 3 important you can say criteria, one is the throughput rate, the second is the inventory and third is the operating expenses. So, in TOC whether my organization is moving on the right or not is determined with the help of these 3 important criteria; throughput, inventory and operating expenses.

Now, 2 things we have discussed in case of TOC; one is the focus, another is the follow through. Now, the focus for that we have these steps and what are these steps?

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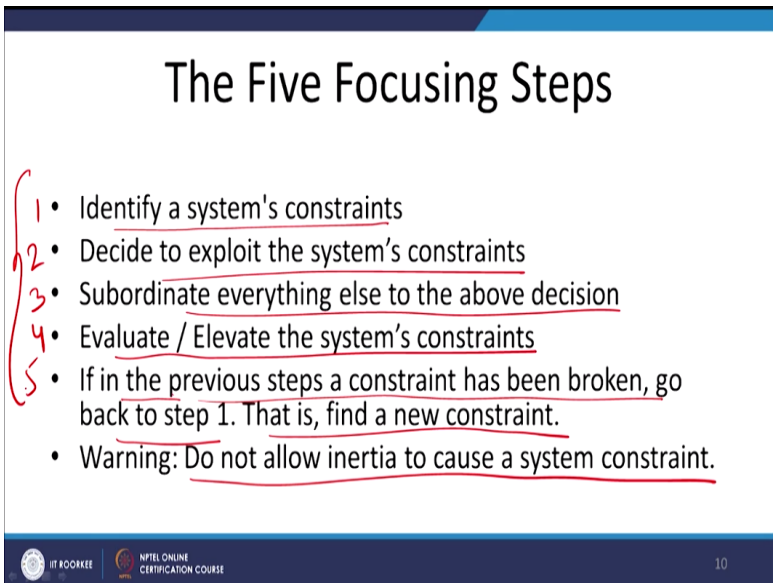

Identify a system's constraints that what are the things which are making a system not performing up to the mark, decide to exploit the system's constraints, then we need to exploit means we need to overcome, we need to overcome that constraints, subordinate everything else to our decision. Now, you need to put every other thing in your organization on the secondary seat, on a back bench and put this particular constraint and the idea of exploitation of that particular constraint on the front seat.

If you are not doing this, then you will not be able to overcome this constraint. So, that is also very important and that is why it is under the part of focus that we need to subordinate everything else to this particular decision. Then, evaluate, elevate the system's constraint by

continuously focusing on that particular constraint, we will evaluate on the basis of metrics and will work to improve the constraints.

So, these are the steps. Now, if in the previous steps, a constraint has been broken, go back to step 1 that is find a new constraint. So, you are doing step 1, 2, 3, 4 and then once you have overcome, once you have finished that particular constraint that you need to identify a new constraint because as we go with this assumption, as long as I am a profit making organization, as long as I am an organization, there will be at least one constraint.

So, when I am starting my exercise, there may be many constraints but even if I am continuously doing this TOC for last 10 years, 20 years, there may remain a constraint and therefore it gives me an idea, it gives me a scope of continuous improvement and do not allow inertia to cause a system constraint. If you are not dynamic, if you are in a stage of inertia, so this is not considered as a constraint.

So, unless until you are dynamic enough, you are having zeal to become a world-class organization, this whole concept will not work. So, these 5 process steps are very important to understand that how in a sequential manner, we are able to improve our organization by following the concept of TOC. Now, since in TOC, we are going to change our conventional way of working.

We are going to change some of the things where we had some kind of a comfort zone and all my comfort zones are my initial target in TOC. Because of these comfort zones, my performance is not coming up to the standard. So, when I am going out of my comfort zone, it will involve some kind of resistance, so therefore in the last slide the last point was do not allow inertia to cause a system constraint and therefore the next slide, we start with the process of change.

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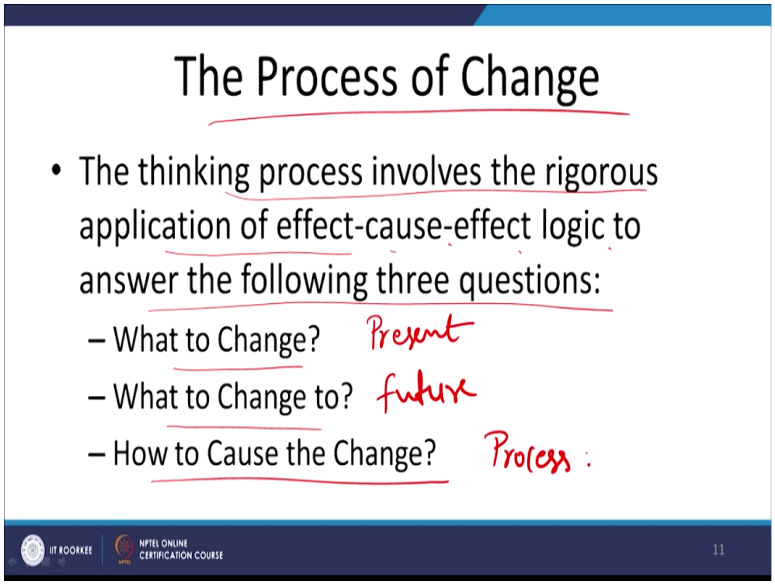

Because of my inertia, because of my comfort habits, I will be resisting the change and therefore the process of change is also very important in the success stories related to TOC. The thinking process involves the rigorous application of effect-cause-effect logic to answer the following 3 questions. What are these questions? What to change? What to change to, after change what will be the new stage and how to cause the change.

So, these are the 3 things, this is present, this is future and this is process. So, these are the 3 important steps in this process of change that you need to know what is my present thing, this is what I want to change, then after changing where I want to be and then how to cause this change, these are 3 important thing and if I know that how to do these things, then I can probably have a very good TOC implementation in my organization.

And with the help of TOC implementation, I can continuously improve the whole idea of discussion of TOC is that it is going to improve my organization's performance and since the metrics of TOC are inventory, throughput and operating expenses. We did not discuss about expenses but if I only discuss about inventory and throughput, it is very much in line with Toyota production system.

So, therefore it became very important relevant to discuss the concept of TOC while we were discussing the Toyota production system. With this, we come to end of the session. Thank you very much.