Six Sigma
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Lecture – 16
Process Characteristics and Analysis

Hello friends, I welcome you to lecture 16; Process Characteristics and Analysis. We are gradually advancing in our six sigma journey and trying to go deeper into the various concepts and see the utility of each particular aspect in implementing six sigma successfully.

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So, before we actually begin, let us have a very good inspiration thought of the day; "quality is never an action. It is always the result of intelligent effort", said by John Ruskin. So, this is exactly what we are trying to do as a part of our six sigma course, and we know that there are many areas where quality improvement is necessary. But some ad hoc approach will not bring sustainable improvement in the process in the function.

And that is why we are trying to go ahead with a systematic approach and let this approach to sustain; so let us believe in the intelligent effort.

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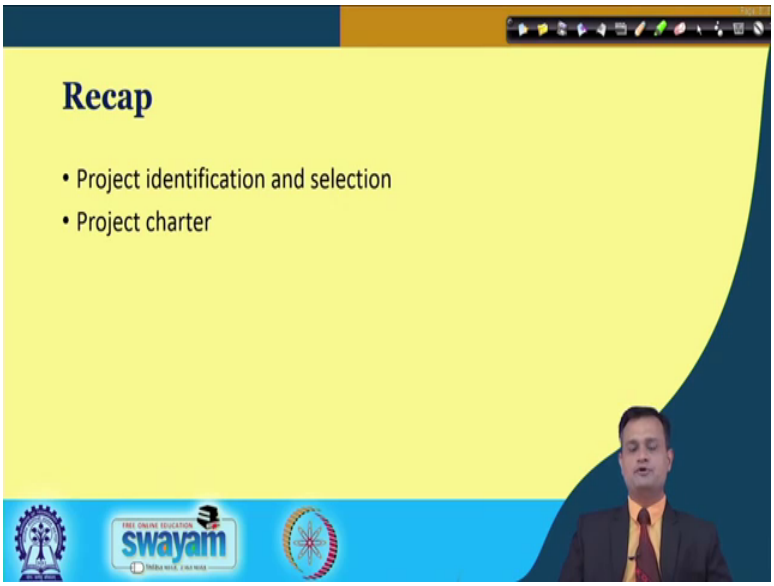

A small recap would help you to revise your understanding. So, we have talked about project identification and steering and project charter in the previous lectures. And it was mentioned that it is extremely important to see that the project you select must have a potential to be considered as a six sigma project, because six sigma project execution requires commitment of the people top management and allocation of the resources.

So, this part we had seen. And then we have seen that just identification of the right project is not enough, you cannot execute it unless you have a very sound project charter defining, the project statement, problem area, scope of the project people involved, team members, responsibilities timeline and so on.

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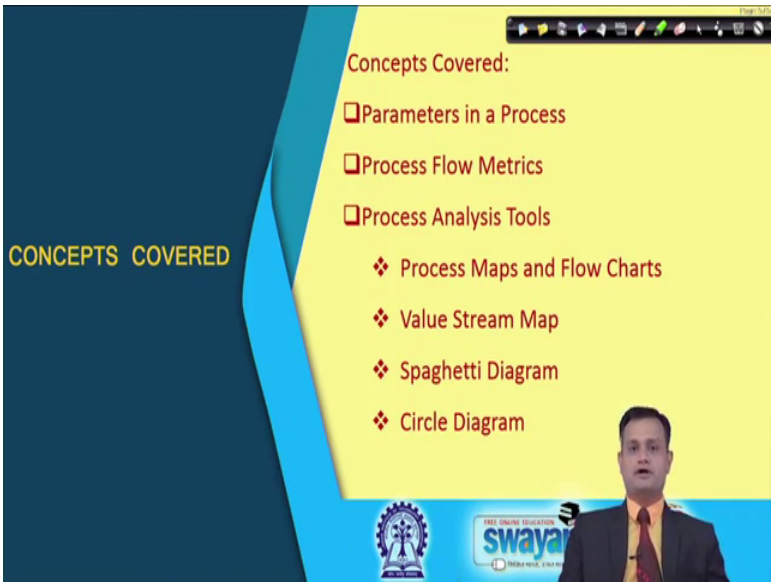

So, these were the points of discussion, now today this lecture will focus on parameters in process. So, we are talking about reducing the variability of the process, and it is important to understand what the process is, and what could be the different parameters metrics by which the process can be measured.

So, we will see the process flow metrics, process analysis tools very important tools we have, process maps and flowcharts, value stream map, Spaghetti Diagram, Circle Diagram. So, we will try to see the quantitative as well as the qualitative aspects in analyzing the process.

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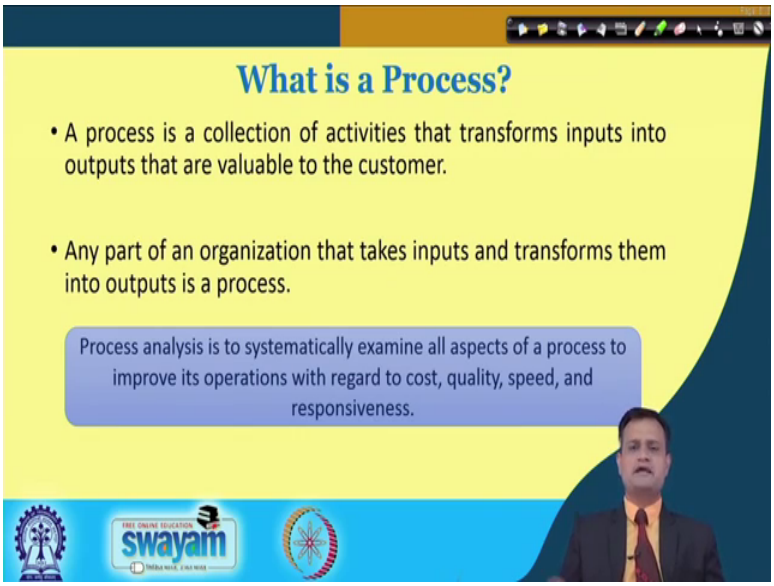

So, let us begin with a very simple question; what is a process. Some thoughts are coming in your mind, and let us try to put it in a structured way; a process is a collection of activities that transform your input into output that are valuable to customer. So, not that I will deploy the resources, machineries, equipments people set up and I will just convert into input into output, I need to see that my output is valuable to my customer.

So, any part of an organization that takes input and transform them into output is a process. So, you may have a transactional process like accounting finance or maybe customer services, and you can have manufacturing processes like your regular production and other activities. Process analysis is to systematically examine all aspects of the process to improve it is operation with regard to cost, quality, speed and responsiveness.

So, I am putting here 4 different important criteria; one is cost quality speed and responsiveness, if my process can really satisfy this 4 criteria, then I would say that I am executing with a right and adequate process.

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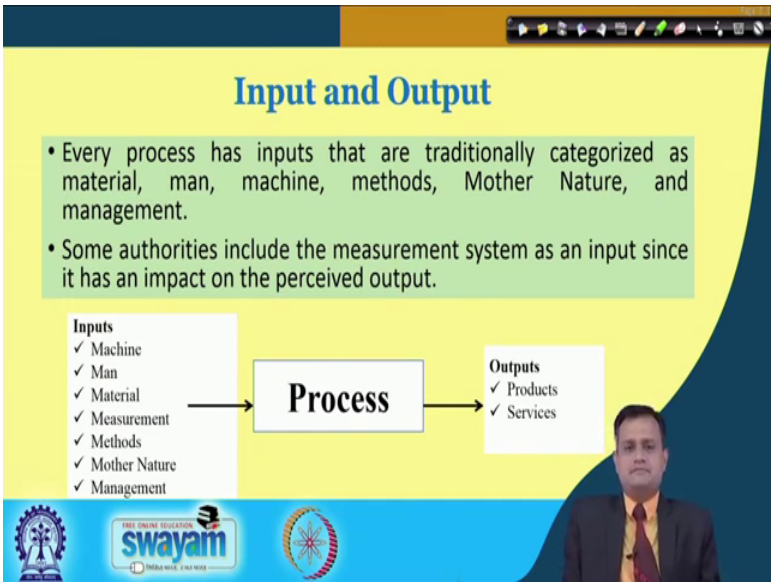

So, just see the input output diagram, and you will get an idea that every process has set of inputs it goes through the transformation process, and you convert it into set of outputs. So, typically you have machine, man, material measurement, methods maybe or mother nature, and management these are the typical inputs which goes into the process of transformation, and as a result you have output product and services.

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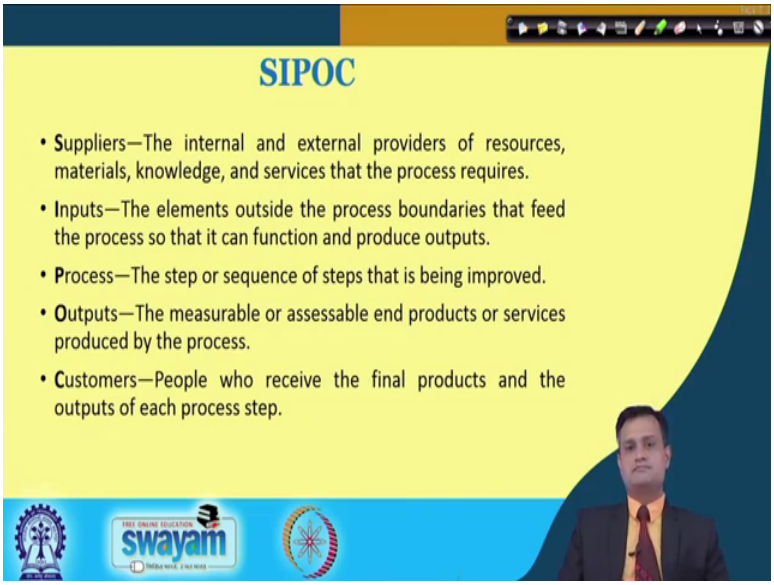

So, there is a important tool in order to analyze the process, because please understand that process is not something which is taking place in a very, very narrow domain; when

we talk about process which can satisfy the customer requirement and leads to the value creation for customer. Then it is not only a functional process we must broaden our understanding on the scope of the process.

So, here there is a very important tool called SIPOC, SIPOC and this tool basically helps us to jot down the various issues specific to processes taking place at different places in the value chain, in the supply chain, and then it helps us to see the proper linkages set the matrices for regular and continuous monitoring of the processes. So, supplier is basically the internal and external providers of resources, materials, sometimes knowledge and services that the process requires. If you look at the inputs, then the elements outside the process boundaries that need the prose feed the process so that it can function and produce the necessary outputs.

If we look at the process typically it is, the transformation of the input, and it is a step by step sequence of step that is being say by imparted to improve or transform my input. Outputs the miserable or assessable and products or services produced by the processes. And customers finally, which is the most important entity, people who receive the final products and the outputs of each process step. So, here I would like to make a mention that this particular say dimension is very important output of each process step. So, please remember that customer is the last 20 d maybe in the process he is receiving the product, but he is just not receiving the product from one step before proceeding step. It is the outcome of all the preceding steps process is performed and that decides the quality, and hence the experience of the customer.

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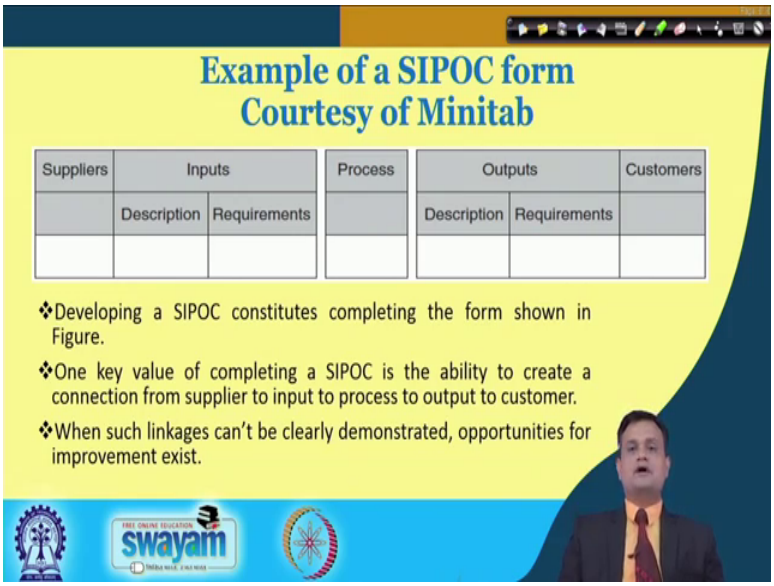

So, with this understanding let us try to appreciate the application of SIPOC and how systematically it can represent the key features of my process. So, there is an example of a SIPOC form; you can have a different kind of templates to be used. Here it is just from courtesy of mini tab. So you have a supplier input description requirements, you have process you have output, description and requirements and then you have the customer. So, developing this SIPOC constitute completing the form typically shown here and one key value of completing SIPOC is the ability to create a connection from supplier of the input to the process and to the output to the customer.

So, please remember that SIPOC should not be seen as a disjointed format. It is basically trying to connect the various entity which is the part of the process right from the raw material to the final product given to the customer.

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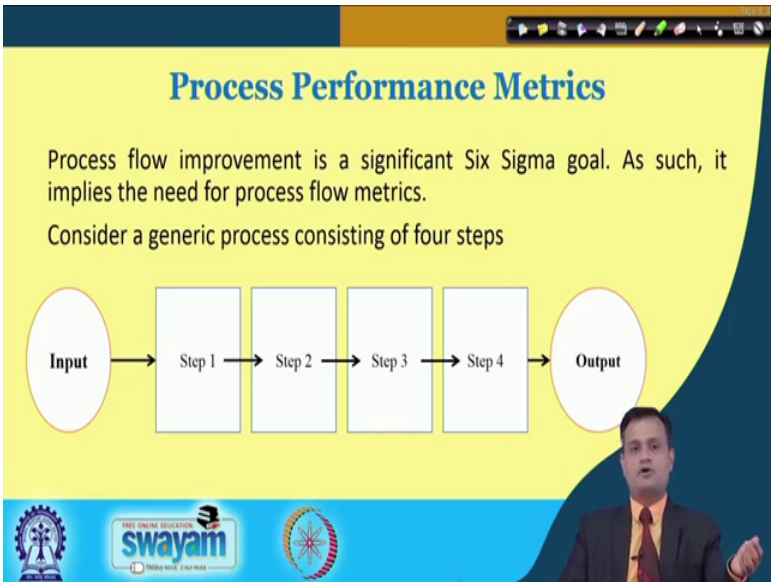

So, process performance metrics is an important area to see the health of my process, to see the efficiency of my process and process flow improvement is a significant six sigma goal. So, I want to minimize the variability, I want to minimize on the rework and rejections, I want to minimize my WIP. And I want to see that right from the raw material stress to finish product I can have a very smooth flow of the process.

So, we can consider a typical generic process where you of the input; step 1, step 2, step 3, step 4 so on step end and finally you get the output.

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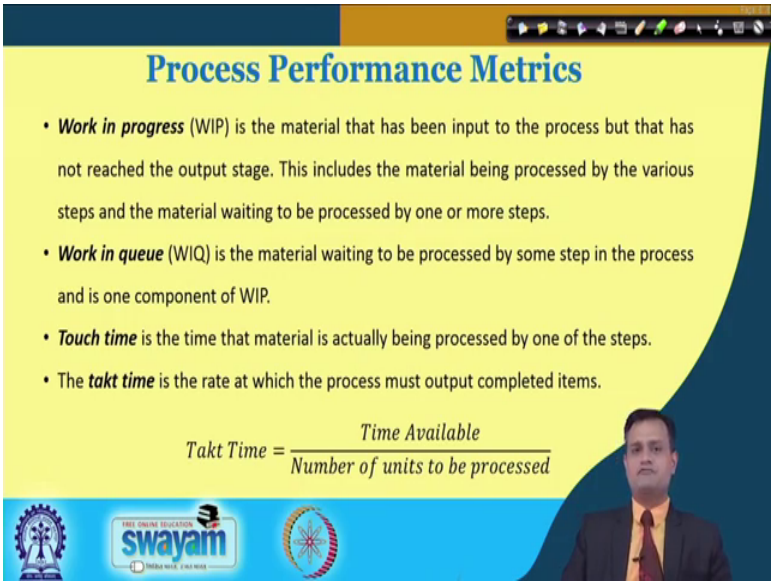

Let us see couple of important performance metrics, process performance metrics so one is WIP, it is the material that has been input to the process, but that has not reached to the final stage. This includes the material being processed by the various say equipment setups or through steps in the overall process and WIP is necessary, I will not say that should be 0 all the time, but too much WIP is a clear cut indication that the synchronization among your various steps machines is very poor, and there is a difference in the capacity of processing at different steps.

Working queue WIQ is the material waiting to be processed, and by some step in the process and one component of the WIP. You just see that you are visiting a restaurant, and you are just sitting nobody is attending you, even after taking your order you get the food after maybe 30 minutes, 40 minutes and this is a very very painful period. So, same applies to manufacturing or service segment, wherever material or people they have to wait, then this leads to see a poor flow in the system and that reduces the overall efficiency of my system.

Then there is something called touch time. So, if this is the time that material is actually being processed by one of the steps. So, here actual machining value addition is taking place, and this is where we say that material is touched to a particular transformation and such as time. So, this is value at a time takt time is a very important performance indicator. And just see that it is the rate at which the process must output completed items it is a ratio. So, takt time is time available a divided by number of units to be processed.

So, here you have a target, as per your demand to process number of items and you have the time available. So, this will really help you to appreciate that what is your capability in meeting the demand or in processing the units that is to be processed in the given time. So, takt time is a very very important performance indicator or I would say in a very simple way to judge the health of my process.

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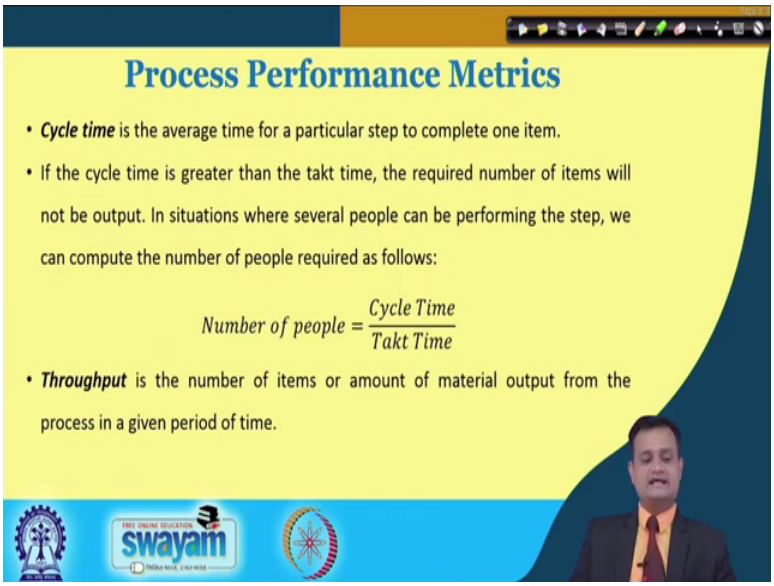

Then you can have a cycle time. So, it is the average time for a particular step to complete one item. So, you have step one step 2, step 3, step n and how much time a particular step will take to complete the item that I will call it has a cycle time.

So, if the cycle time is greater than the takt time the required number of items will not be output, in situations where several people can be performing the step we can compute the number of people required as cycle time divided by takt time. So, it is a very important observation that if your cycle time is greater than takt time require number of items will not be produced as expected. And we can compute even the number of people required a cycle time divided by takt time. Throughput is the number of items or amount of material output from the process in a given period of time.

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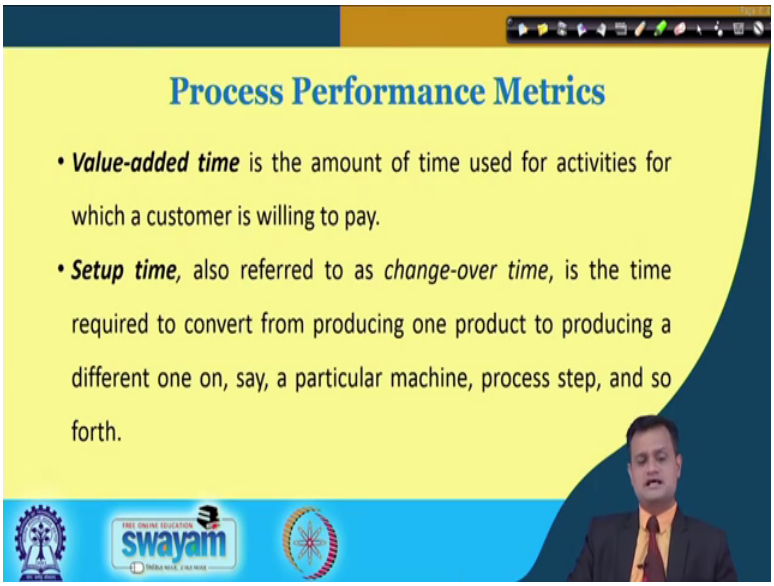

So, please understand there is a difference between takt time and throughput time, in takt time we go as per our target production as per the demand of the Market, in throughput we just see how much I have produced in a given period of time. So, process performance metrics are very important in order to judge the health of my process, and once you know that to what extend your processes are capable enough to meet your Market demand or to meet the expected speed, responsiveness cost, parameters then you can take those processes as the six sigma project which are extremely critical.

So, value added time is the time out of time used for activities which a customer is willing to pay. Now you would be confused little bit there is a touch time and there is a value added time. So, maybe you have a set up time or you are holding the product on the say typical machine, and fine whatever time is spend that could be counted as a touch time. If you take the example of service segment, you have entered into restaurant, you are attended by the manager and waiter, your order is taken touch time started.

But you would only like to pay for the material being processed or in case of restaurant, your order served or the kind of quality you are getting that is of food then that call is called your value added time. There is a set up time as I mentioned referred to as changeover time is the time required to convert from producing one product to producing a different one on, say a particular machine process step and so forth. So, we have to be extremely critical in our production schedule. And we cannot afford to have long set up

time frequent setup, because that reduces the overall efficiency of my processes and it is detrimental to my value added time.

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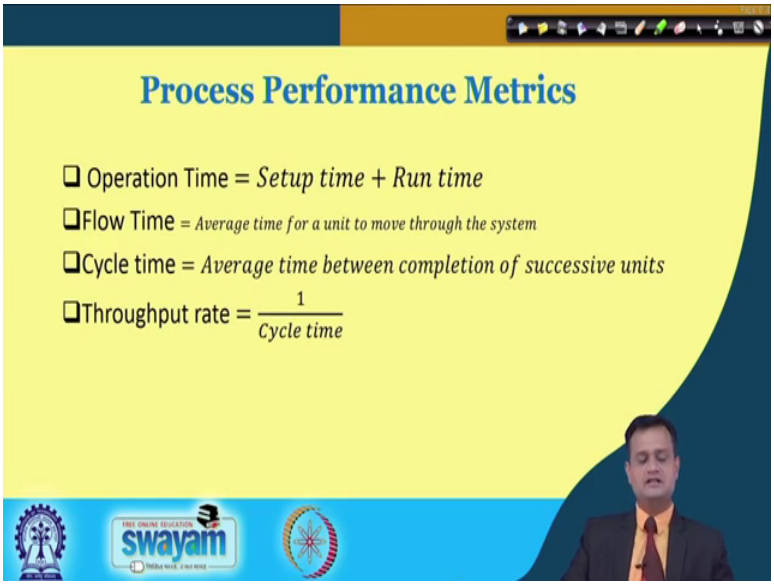

Now, if you see the operation time that is the total time, it is set up time plus run time and flow time is the average time for a unit to move through the system. The rate at which it moves through the system, it is your flow time, cycle time average time between completion of successive units, and through put rate you can count it as 1 upon cycle time.

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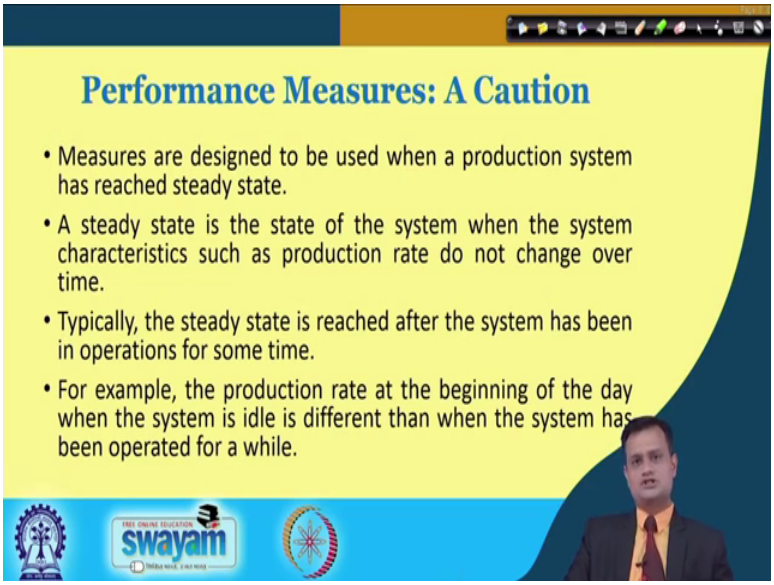

So, there is a caution when we talk about the performance measures. So, measures are designed to be used when a production system has reached to the steady state. This is a very, very important condition, let us say you purchased all together a new production system or you are operating with a new service setup. Now there are lot of issues and there is a lot of turbulence, it means your system has not reached to the steady state.

So, before you actually work on the various performance measures, you try to figure out under strain whether your process has reached to a particular state of stability or not. Once the steady state is reached, then only process evaluation through different performance metrics is advantageous. Otherwise this will mislead you to the wrong conclusions, and you will start acting on those aspects which are actually not the part of the system. So, a steady state is the state of the system when the system characteristics such as production rate do not change over time, and typically the steady state is reached after the system has been in operation for some time.

So, typically this is an important caution when we start applying the measurement evaluation of the process through different process matrices.

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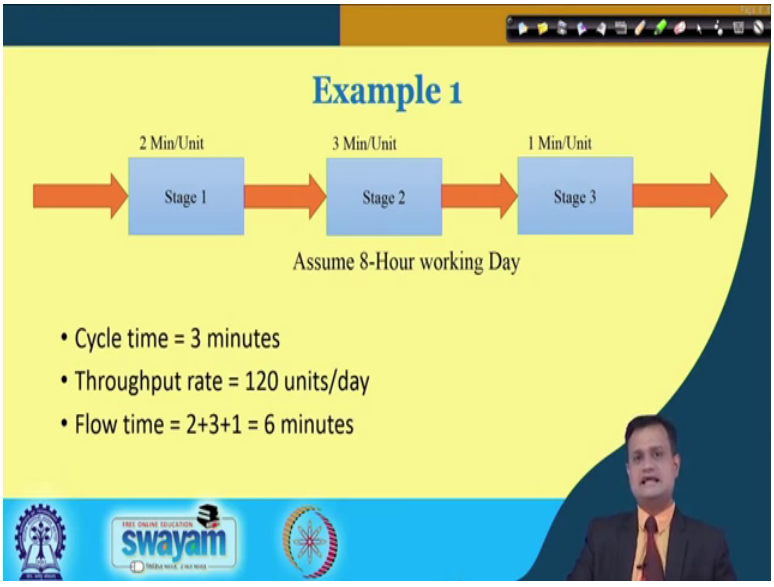

Now, just see the example a simple one, there are 3 stages, stage 1 2 minutes per unit, stage 2 3 minutes per unit and stage 3 1 minute per unit. Now just think this is to be assumed that 8 hours working day. Now here what do you think is the cycle time? Each stage has it is own time, and here whatever we discussed previously you would be able to

visualize better that stage 1 has 2 minutes stage 2 as 3 minute and stage 3 as 1 minute. So, my cycle time would be the 3 minute, maximum time taken by a particular stage, because unless this stage completes the transformation of the product or your row material you cannot really complete the entire product.

So, here I will consider 3 minute as my cycle time, my product can come out in 3 minute from this transformation process, and my throughput rate is 120 units per day. So, because I have considered 8 hours working day, if you just deduct some allowances this may go down, but otherwise my throughput rate is 120 units per day. So, here please understand there is no mention of demand or number of units to be produced as planned. It is just the rate at which my system is operating.

I have a flow time that is 2 plus 3 plus 1 this is the 6 minutes.

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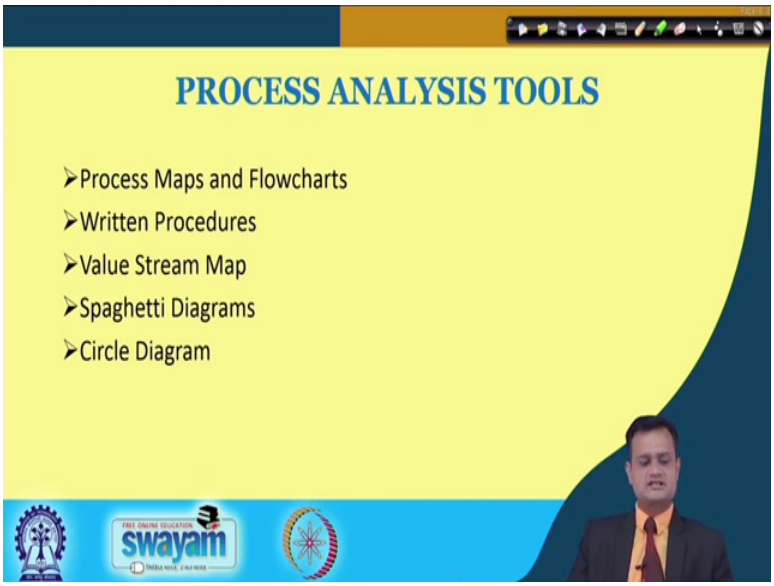

So, process analysis tools, we would like to see, and this will basically help me to go deeper into the process analysis. Process Maps and Flow charts, Written Procedures, Value Stream Map, Spaghetti Diagram, Circle Diagram. So, let us see each one in detail.

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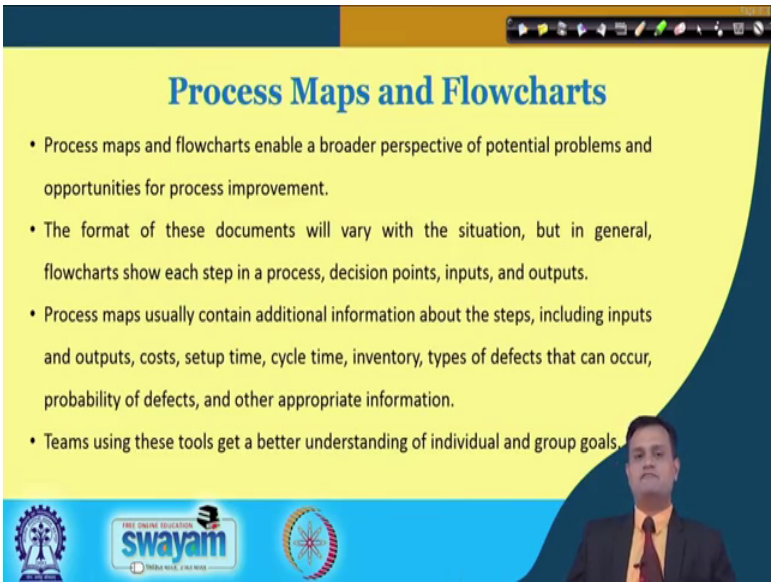

So, process map and flow chart typically, this enables and provides us the broader perspective of the process. And we can figure out the potential problematic areas and opportunities for process improvement. So, the format of this document as I mentioned, may vary from the situation to situation and company to company. But the overall purpose is to capture the various elements of the process, and indicate the problematic areas or potential areas for improvement. So, process map usually contain some of the additional informations about the steps including inputs, outputs, cost, set up time, cycle time, inventory types of defects that can occur probability of defect and other appropriate information.

So, this will give you a bird's-eye view of the process, and you can really understand the pulse of the process that how the process will actually be executed.

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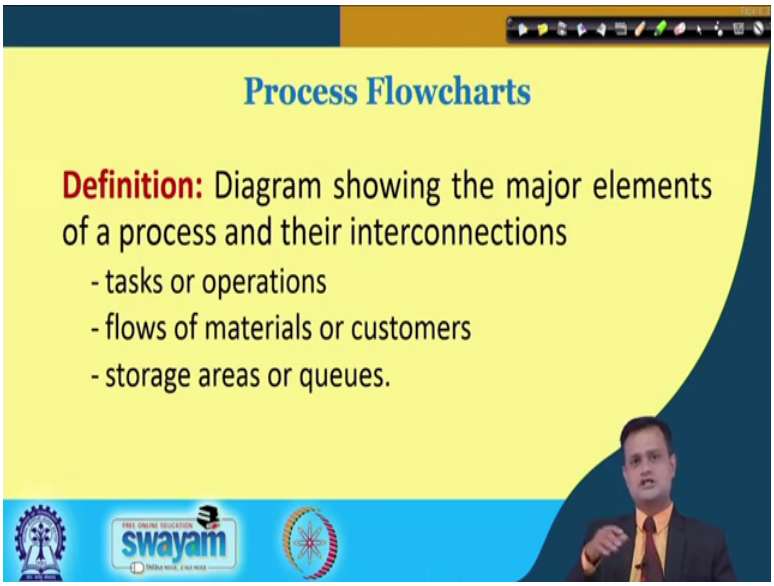

So, you have process flow chart, so definition is, it is a diagram showing the major elements of a process, and their interconnection tasks or operations, flow of material or customers, stages areas or queues and so on.

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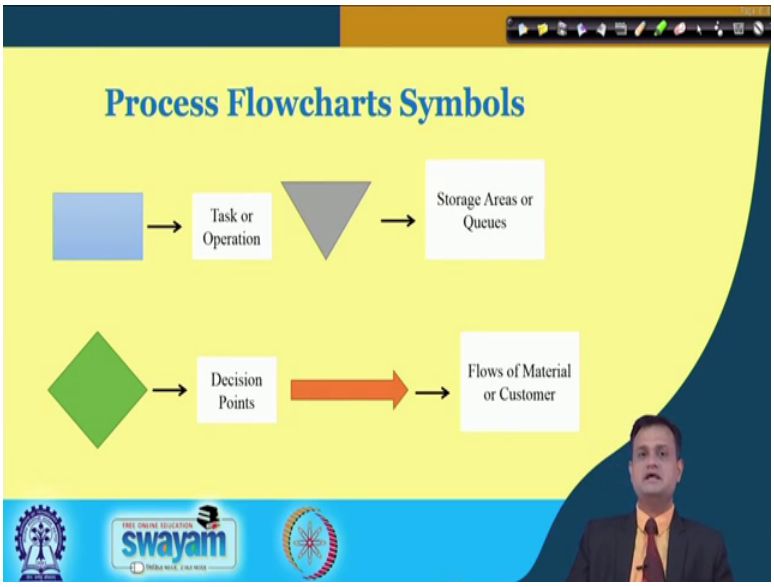

So, just see that the various symbols we use in process flow chart. So, you have something like square or rectangle that is task or operation, you have say decision point a star, you have say inverted triangle that is storage area or queues, you have an arrow that is flows of material or customer.

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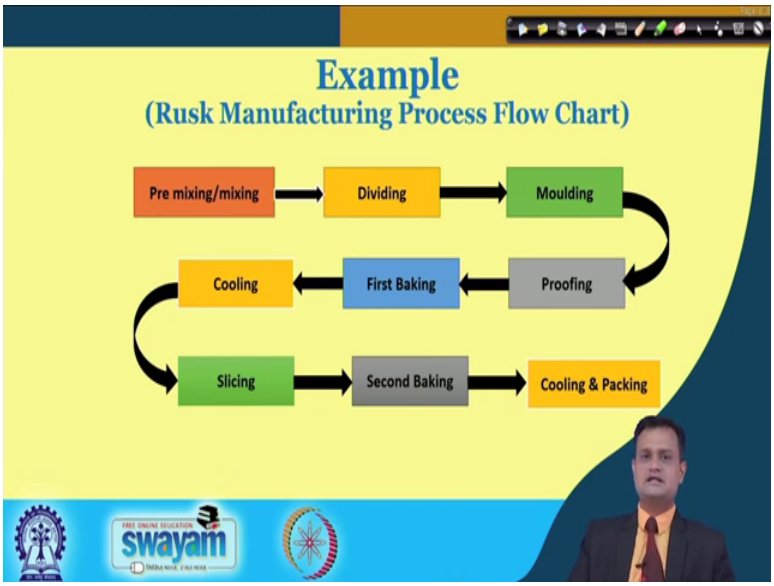

I will just present a small example to make the idea clear. This is rusk manufacturing process flowchart.

So, you have pre mixing or mixing process, then dividing, molding proofing, first baking cooling, then slicing, second baking and cooling and packing. It is a very very simple representation in terms of a flowchart. This can be supported with the process diagram, and as I mentioned various parameters like inventory or the defect rate or maybe the cycle time and other parameters that can even be mentioned.

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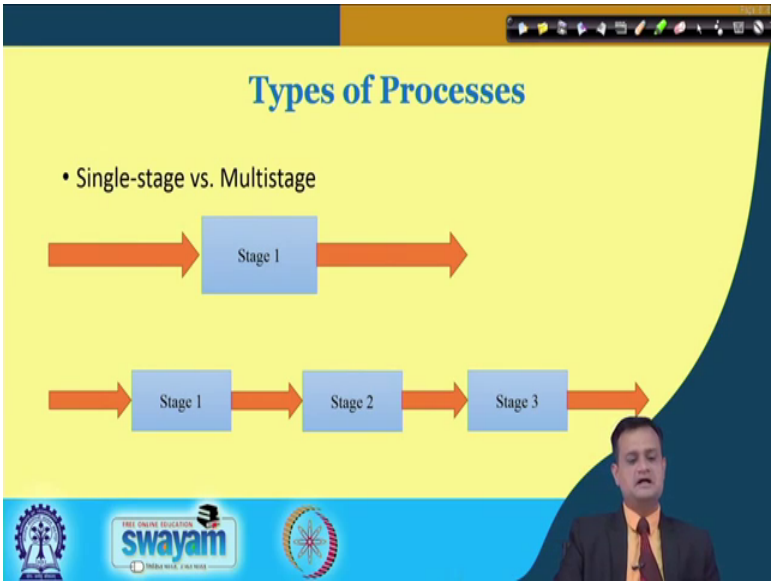

So, there are different types of processes. You can have single stage versus multi state process. So, single stage process gets completed only in one stage, multi stage you have n number of stages to be executed in order to transform your input into the final output.

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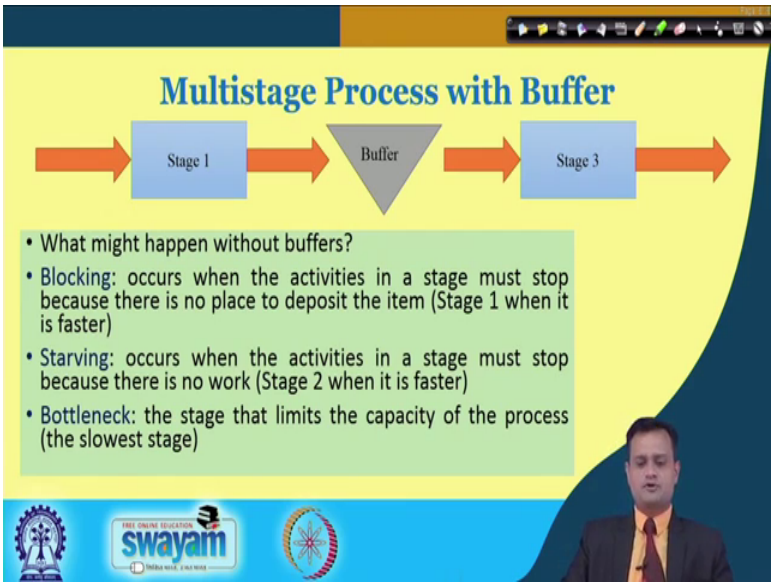

So, multistage process with buffer, that is also possible, and you should refer theory of constraint critical chain by gold rate, and in critical chain he talks about buffer. This gives the aggregate cushion buffer to the process, and you can improve upon your process flow. So, what might happen without buffer if you just think otherwise the idea would be better clear? So, there is a blocking, and this blocking means when the activity is in stage must stop because there is no place to deposit the item, stage 1 when it is faster.

So, you just see that it is something like 3 people they are running together fine, they do not have any constraint they can move on their own speed, but just think about a situation where these 3 people their legs are tied up, and they are compelled to run synchronize together. In this situation the slowest one will decide the speed of the group, and same applies to your production and manufacturing process. So, here blocking occurs my stage 1 is not able to produce because state 2 is slow, and there is no place to keep my excess material produced and I have to stop my stage 1.

If you see the starving this is the other situation; in this case stage 2 is faster, so it is consumption hunger is more and my stage 1 is slow. So, in this case if I have a buffer I

can keep feeding my stage 2. There is a bottleneck; the stage that limits the capacity of the process, the slowest stage and this is another important area where buffer can saw the purpose.

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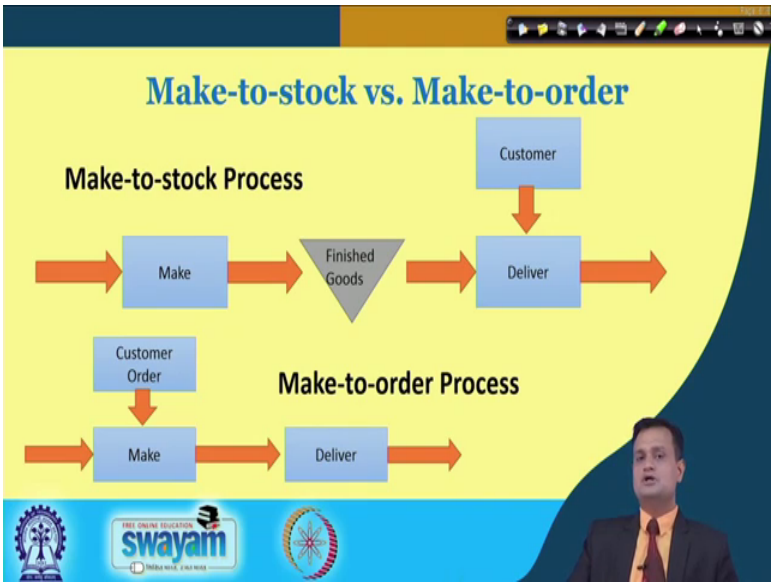

So, you have 2 different kinds of processes, approaches, make to stock versus make to order. When I say make to stock process, I will stock the material in anticipation that this much of the demand would be there make to order typically. We all know that it works on gid principle pool based system make to stock wars on push based system. And in case of make to order we see that I should only trigger the production when there is a customer demand.

So, you can see very well here, that there is a customer demand and then only production cycle is initiated, so this is pool based system. My customer creates the pool and then my production cycle initiates. So, this is the difference between make to order and make to stock; precedence versus not precedence.

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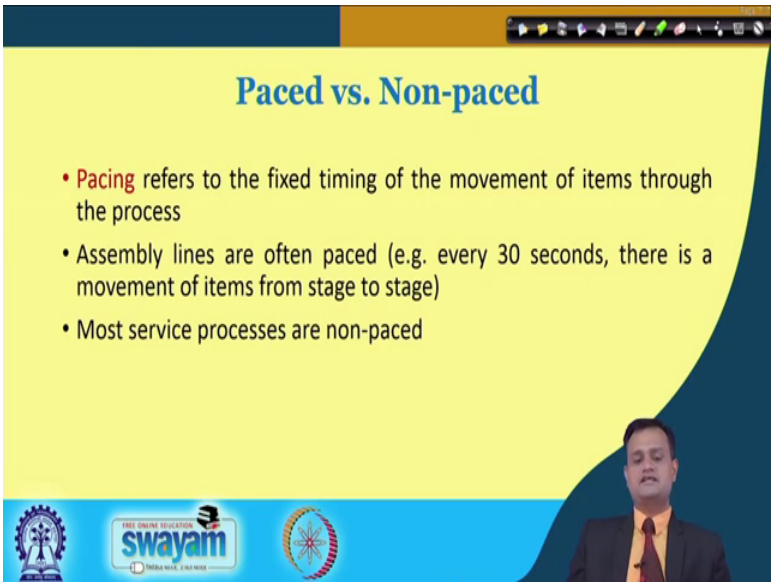

So, passing refers to the phase timing of the movement of items through the process assembly lines are often paced. So, every 30 seconds there is a movement of item from stage to stage and most service processes are non-paced.

So, you can create such kind of pacing in order to improve upon your flow management, and this is something where your paced production with precedence non precedence non pace will come in picture.

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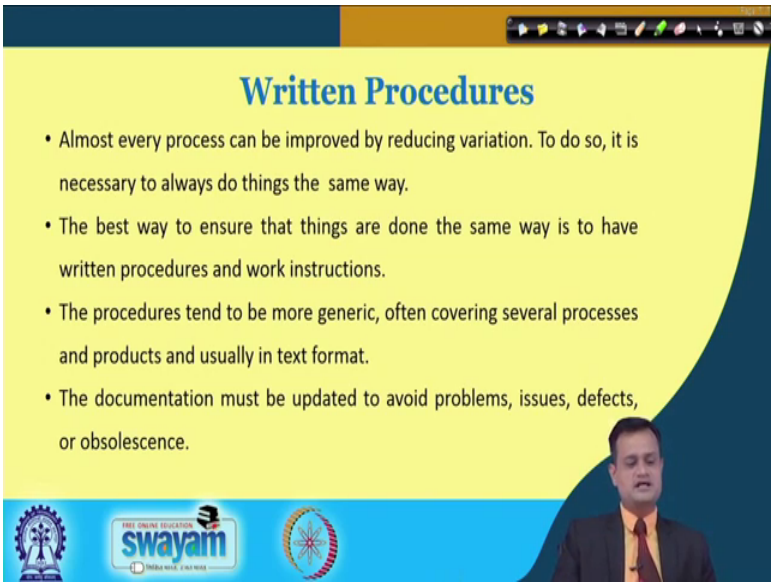

So, written procedures are something like sop, that you try to display to the workers employees so that they can understand the process requirement and religiously follow the strap safety norms to be followed in executing the process.

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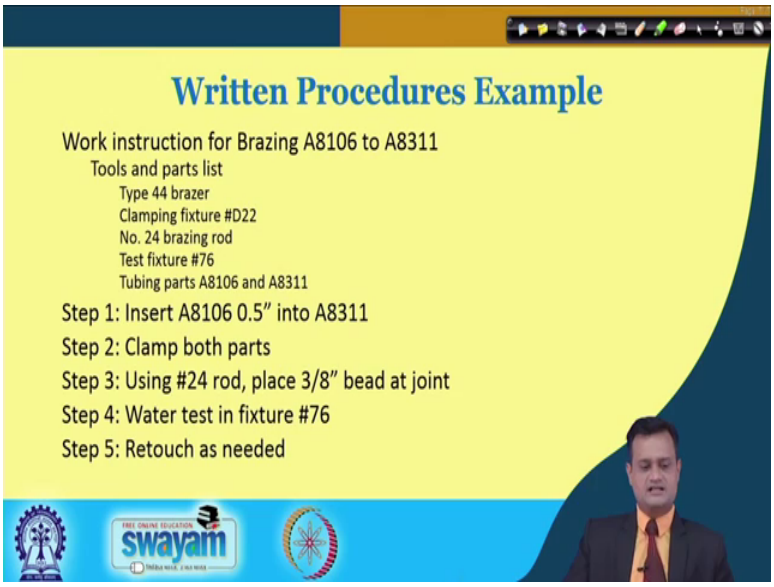

So, written procedures may be let us say you can include something like it is an example work instruction for brazing A8106 to A8311.

So, tools and parts lists, let us say type 44 brazer, clamping fixture number D22 number 24 braising rod tech fixture. Step one insert A8106 0.5 each into A8311. Step 2 clamp both the parts, step 3 using number 24 rod place 3 by 8-inch bead at joint. Step 4 water test in fixture number 76, and step 5 retouch as needed. So, you can follow these steps without much say confusion, and this will have a good impact on the process flow as well as the quality of the product.

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Another important tool is Value Stream Map. So, value stream mapping is a technique for following the production path of a product or service from beginning to end.

So, the word value is used and I am interested to see that how much actually really is the value adding time and what is the name value adding time. Once I have this much of preliminary information I can further dig out that find what could be the reasons for my non value adding time. And based on that I can propose a future map, future value stream map that can help me to understand percentage improvement in my productivity yield by reducing the non-value adding time.

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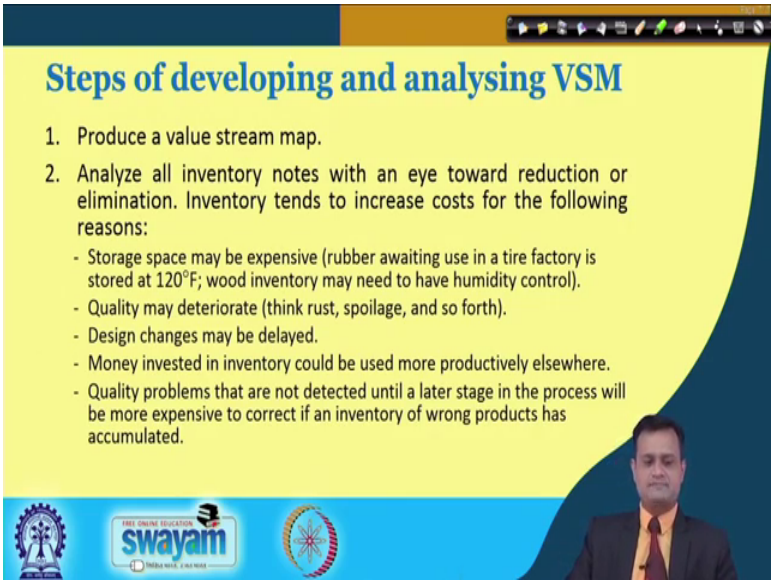

So, there are steps to be followed, produce a value stream map for the present situation, analyze all inventory nodes with an eye toward reduction or elimination, inventory tends to increase cost for the various reasons we have seen. And this could be storage quality may be deteriorated design changes may be delayed, money is invested your tied up, obsolescence may take place and so on.

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For third, analyze the entire value stream for un say needed steps, how can I reduce the non-value adding steps. 4th determine how the flow is driven; try to move towards value streams in which the production decisions are based on pool of customer demand. And number 5, extent value stream map upstream into suppliers plants, and new challenges

occur regarding compatibility of communication system. And true there you try to see that the flow of information material knowledge and money they are synchronized.

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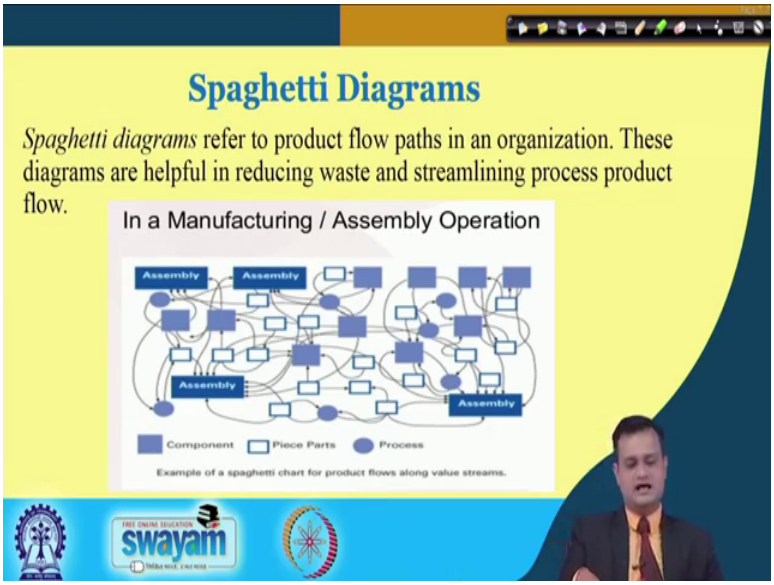

The another very important tool in understanding the process flow is Spaghetti Diagram, and very well you can see that lot of interconnection is there. So, typically this diagram is used to see the flow paths in an organization. My material, people, they are moving from 1 place to another place, and I can tap this, I can record this through camera, or I can put it on the pin board and try to our string diagram can be used, I can see that what is the overall aggregate movement. And this will help me do appreciate the bottleneck areas and hence action to be performed for reducing the bottleneck and improving the flow.

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So, these are the use of Spaghetti Diagram and as I have said, that this benefits me in identification of inefficiency of area plant layout, opportunities for less underling, opportunities for better workforce communication; when you would streamline your flow your people they also feel comfortable, less burden and in that case an effective communication for action can take place. Safety will get improved because there is not much haziness in the decision making and you can allocate the various resources optimally.

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So, there are various simple steps to follow. Sketch current work area arrangement, draw a line to describe every trip, each person or unit material is making, as more trips are made more lines can be added, and the more wasteful redundant trips can be identified.

So, if you want to put man material information and other flows on the same diagram, you can choose different color code. And that can help you to visualize even the synchronization among these entities. There is the Circle Diagram; one more tool.

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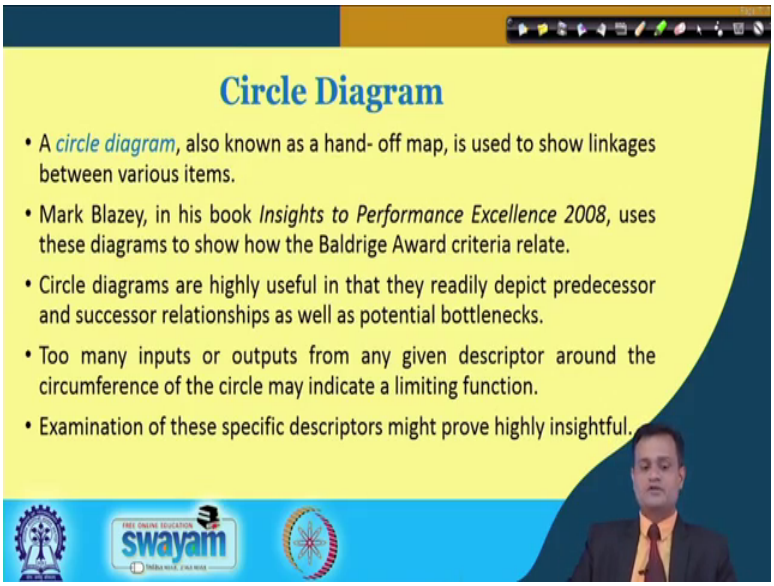

So, typically this is known as handoff map, and used to so linkages between various items. So, in the form of a circle, I am just trying to figure out that what is the linkage between various items. So, Mark Blazey in his book insights to performance excellence 2 thousand 8 uses this diagram to show how the Baldrige award criteria relate ok. So, you have a Mark and Baldrige award and there are various criteria like leadership your internal processes and others then how do you relate them. If you can figure it out then you can really put your emphasis on those improvement areas which in turn can help you to grow or improve your score in all other areas.

So, examination of this kind of chart this kind of diagram can really gain help us to gain greater insights.

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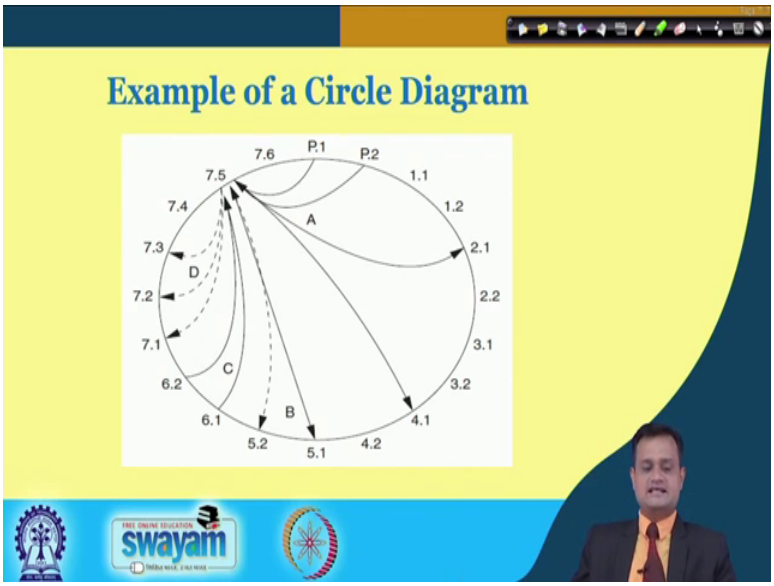

So, just see the example and I will just put here some of the items I am not labeling them. But you can see that in the circle through the arrows or I can even choose the degree of relationship strength of the relationship through dotted line full line and so on. And I am trying to portray the connection, strength of the connection within the circle and it is called Circle Diagram. So, before I end this session as a usual practice, I would like to pose couple of cautions for your introspection.

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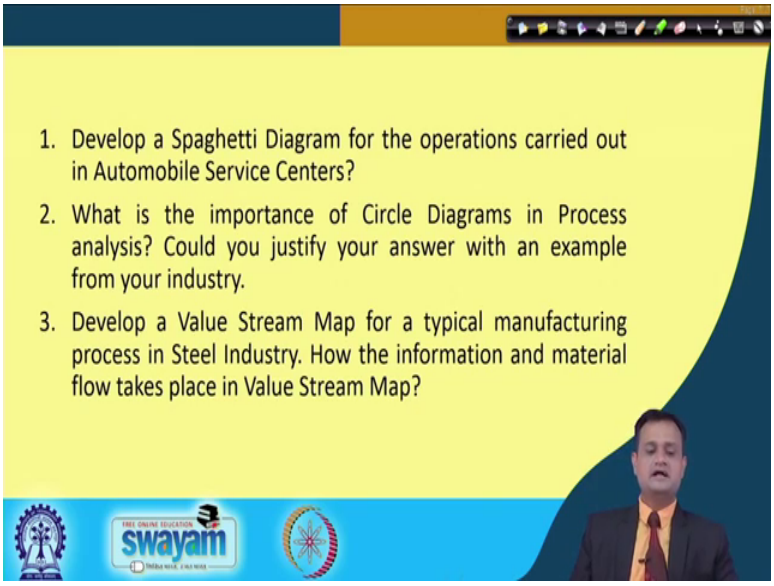

Let us say develop a Spaghetti Diagram for the operation carried out in automobile service center.

So, you can visit the nearest service center, just see or just try to focus on couple of activities and try to develop a Spaghetti Diagram, and see that how the movement of material man information is taking place. Question 2: what is the importance of Circle Diagrams in process analysis, could you justify your answer with an example from your industry or you can visit the industry. Third develop the value stream map for a typical manufacturing process in steel industry, and how the information and material flow takes place in the value stream map.

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So, you can use these references, by chance if you want to deepen your understanding, you can use these references and further clarify; your say confusions and deepen your understanding on the topics we have discussed.

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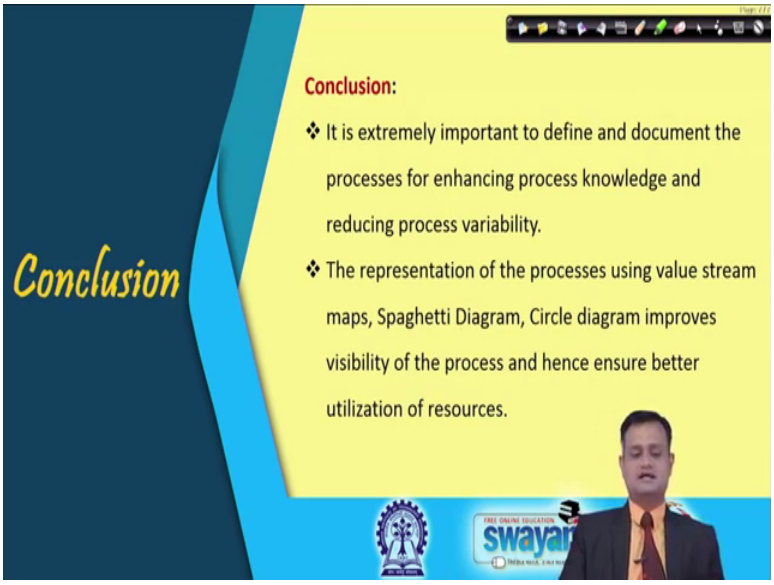

So, finally, as a conclusion: it is extremely important to define and document processes; if you cannot define, if you cannot measure you cannot improve. So, you must define measure and document the process knowledge and reducing process variability. That is one more advantage; like say, today I am imparting the knowledge through online media. This is recorded and will remain in the library forever. So, same is the case with the processes, when you record them you can easily transfer the knowledge to the new people with very less difficulty and lot of ease in the transformation. The representation of the process using value stream map Spaghetti Diagram Circle Diagram, improves the visibility of the process, and hence sense your better utilisation of the resources.

So, with this thank you very much, we have started our discussion on process analysis today. We have seen couple of tools which can really help us; and there are important matrices like cycle time, throughput time, takt time flow time which can really help us to judge the overall performance of the process. So, try to take a case, visit the industry, document the various areas, activities and try to calculate some of the measures that will help you to better internalize the concept. Enjoy, be with me.