Operations Management
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Lecture – 50
Six Sigma

[FL] Friends welcome to session 50 in our course on Operations Management. And in the current week our focus is primarily on quality and in the four sessions for this week which we have already conducted; we have focused on the word quality. In the very first session we try to understand what is quality how do we define quality, what is quality of design quality of conformance; quality of performance?

And then we tried to take the examples of relative quality that if the quality is perceived as a customer what is the definition of quality? If the quality is perceived from the point of view of a manufacture manufacturer how do we define quality?

In the next session our focus was on total quality management and we try to understand that what exactly is total quality management, what is the process or strategy of total quality management, what are the important things that have to be kept in mind when we are implementing the concept of total quality management in our organization and then we have seen that it is a overall concept; it is not just department wise or a business unit wise concept it is an organizational concept and it has to be implemented in totality.

Then we focused our attention on total productive maintenance that to with the focus of achieving quality. We have seen that if our equipment is scheduled for maintenance if we do the scheduled maintenance of the equipment as per the maintenance policy of the organization. The equipment will be up and running and will give us the desired results without defects. So, the quality will be a certain if all our equipment is functioning properly and the purpose of total productive maintenance is to ensure that the production line is functioning without any defect, without any accidental maintenance stoppages or any unscheduled maintenance stoppages.

So, if we are able to maintain that we will be able to produce good quality product in adequate quantity and we will be able to meet the delivery schedules. In our next session after the total productive maintenance our focus was on statistical quality control

wherein we focused on the statistical aspect of quality control and we have seen that what a statistical process control. And in that we considered the control charts and we have taken example of an X bar chart and an R chart which are the control charts by variables

There can be controlled charts y attributes also which can be c chart and p chart which we were not able to discuss because of the paucity of time and today we want to wind up the discussion for this week by considering an important aspect that is six sigma that when we are producing a product our focus is to minimize the defects. So, our systems must be so, designed the operations must be so, organized that we are able to produce the product without many defects.

So, our degree of variability in our product has to be minimized as much as possible. Every company has a wish that they are able to produce all the products without any defect, but because of the inherent process variability there is always a degree of variation which we have seen which is within the limits. So, whenever the variation goes beyond the limit, we have to stop the process we have to check for the causes and try to improve the process so, that we are able to produce a good quality product.

So, that variation part we have to focus and that deviation or the variation should be within the limit. If it goes beyond the limit then the process is not producing the products as per the specifications and the quality of the product is not acceptable. So, six sigma also is a concept which helps the companies to design its system in such a way that the products that are produced are well within the specified limit.

So, we will see if the current industry practice is to accept within plus minus 3 sigma limits, but the focus worldwide is toward six sigma even toward towards higher orders of six sigma, but six sigma is relatively acceptable standard of manufacturing or managing our operations in order to achieve the target of six sigma. So, the defects that are acceptable in six sigma limits that we are going to cover in today's session. And we will see that how we can change the quality of our product, how we can manage the quality of our product improve the quality of our product by adopting the concept of six sigma

So, the number of failures, number of defective items, variations deviation from what is expected will be minimized if we use the concept of six sigma. So, six sigma is we can say a philosophy a technique which can help organizations to improve the quality of the

products that they are offering to the customers. In the long run the branding of the company improves and the company is able to develop loyal customers because the quality standards of the company are very very high. And the customers are satisfied with the quality the company is providing them for the money the customer is spending on the product.

So, overall we will try to see the concept of six sigma in today's presentation maybe in the next 25 minutes. So, on your screen you can see which pilot would you choose. So, here is an example the airplane landing example.

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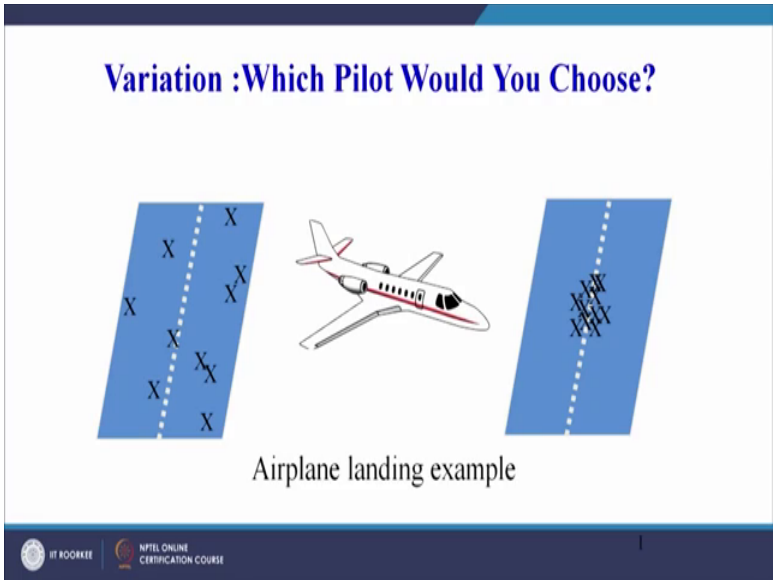

So, you can see a airplane is landing; here there is a lot of variability on the runway; the pilot is landing here where this is maybe the central line on which the plane must land the target value for the plane to land on the runway, but you can see where the plane is landing; you can see the variability in the landing process here, but on the other hand we see the variability is very very less the data is scattered around the central line and is focused on the central line only.

So, I think if I would have to choose; I will choose this pilot whose landing at these locations because it is fairly accurate as per the mean value of the target. So, the mean value of the target is this white dotted line and the plane is hitting the target most of the time it is landing at the place where it must land where it is designated to land.

Similar is the concept that we want to be as accurate as possible we need to be as precise as possible as time does not permit I may not be able to explain the concept of accuracy and precision here. But usually the concept is explained with the help of a shooter who is shooting on the target.

So, there is a mean value or a central bull's eye; if a shooter is shooting all his shots in the bull's eye we can say he is both accurate and precise. Whereas, if the spread is uniform around the bulls eye we can say it is accurate, but if there is a maybe far away from the mean; far away from the mean if the shooter is shooting we will say that he is precise because he is shooting in a small range, but that range of the variability is less maybe let me explain with the help of a simple diagram.

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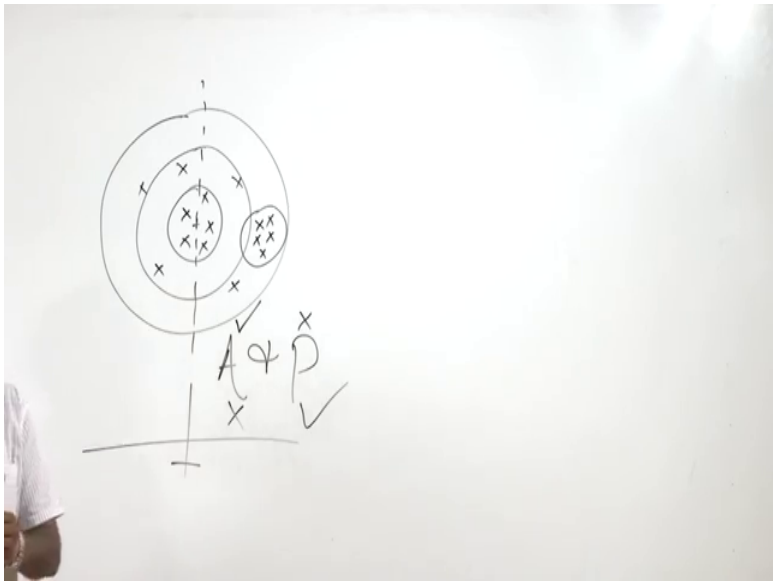

Now, this is the target value and we say; this is our main target value. So, if the shooter is shooting his 5 shots here; we will say the shooter is both accurate and precise. Now if the shooter is shooting, we can say he is accurate, but not very precise. Now suppose the shooter is shooting, we will say the shooter is precise, but he is not accurate because accuracy is this is our target that is the accuracy target.

So, we can try to see here the difference between accuracy and precision and in manufacturing our focus has to be on both accuracy as well as precision also. So, we will say that if this is our target and we are getting precise shooting here; it is accurate also. So, we can say that accurate accuracy and precision both are achievable if the shooter

hits all the shots in the bulls eye only. This is precision, but not accuracy the spread is accurate it is uniformly spread around the target value, but not precise as the range is more.

So, this is the concept of accuracy and precision I think very briefly I have tried to explain. So, here also we see the our focus must be that our target value whatever is our target value; our values or the data that we are collecting the measurements that we are doing must be equal to the target value, but in case because of some random errors even if the value is not equal to the target value; it should be well within the range of the target value to be both accurate as well as precise.

So, this is the basic concept of variability; there will be inherent process variability in each and every process because of some random causes, but that variability or the inherent process variability must be well within the limits and it must not go beyond the control limits. As we have seen in our previous session that there are control charts which help us to calculate the upper and the lower control limit beyond which the variability is not acceptable.

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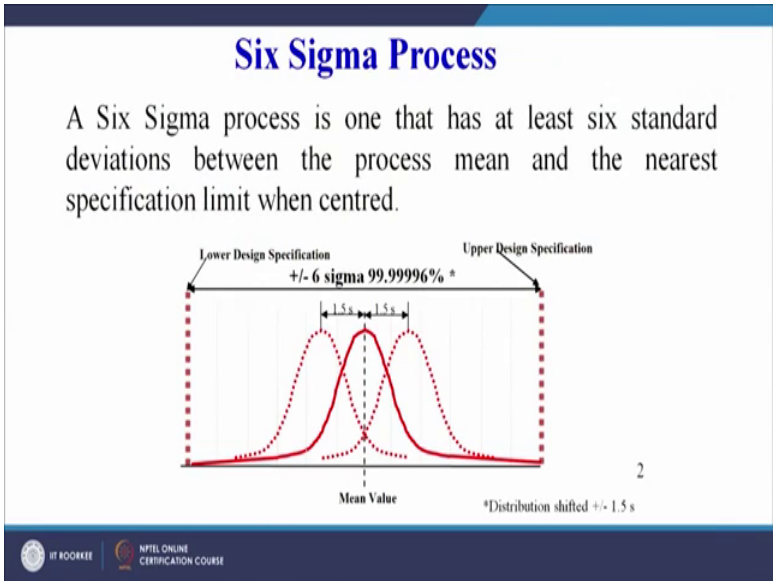

Now, six sigma process we can see here a six sigma process is one that has at least six standard deviations between the process mean and the nearest specification limit when centered. So, this is our mean value here; so, we have three sigma deviation this side and three sigma deviation on the this side upper design specification this is a lower design

specification. And the this dotted lines are 1.5 sigma; so, 1 sigma the 1.5 sigma in both side in six sigma we have plus minus 6 sigma deviation. So, maybe we can see the example here.

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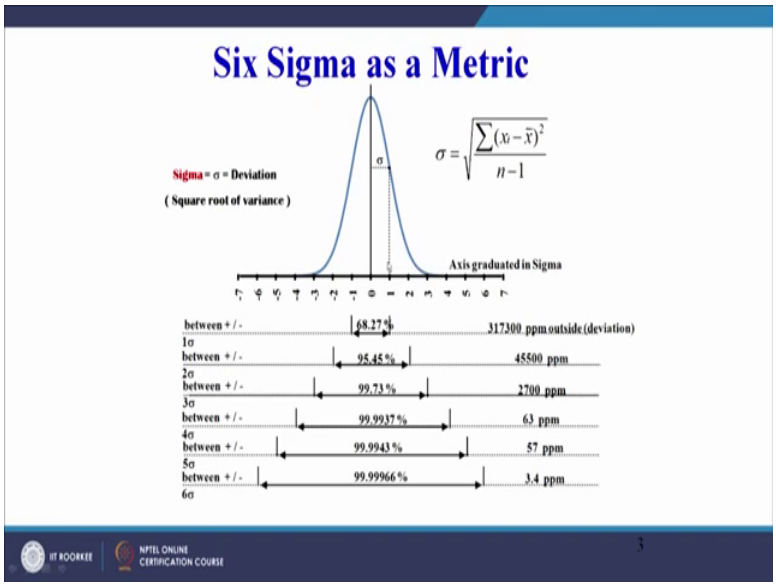

The percentage we can see in case of six sigma 99.99966 percent is explained and maybe only 3.4 parts per million are outside the explanation range or we can say our control range.

So, in if to explain it in a much simpler manner suppose a company is producing one million parts. So, only 3.4 parts are expected to be defective rest all will be under the acceptable limits that is the six sigma limits as we can see in this diagram. Whereas, we can see the variability the deviation 68.25 percent are explained we can say with accuracy and the rest can be defective for this we can see 95.4 percent this is 1 sigma limit, 2 sigma limit, 3 sigma limit, 4 sigma, 5 sigma and 6 sigma.

So, usually the industry standard is 3 sigma in which 99.993 percent accuracy level is there and only 63 parts per million are we can say maybe this is one sigma is 68.22 sigma is 99.45; 3 sigma is 99.73; 4 sigma is 99.9937; only 63 parts per million will be defective rest all will be as per the design specifications within the acceptable limit.

So, we can see that as we are increasing our specification limits or as we are increasing the sigma level that is we; we are able to get the lesser number of parts with deviations.

This is representing a long non-linear decrease here we can see 1 sigma limits this many number of 317300 parts will be may be out of the control limits, in 2 sigma we see 45500, 3 sigma which is the industry average usually the industries focus on 2 sigma limits 2700 parts; 4 sigma 63 parts only, 4 sigma 57 parts only and if we go to the six sigma only 3.4 parts per million will be with deviation.

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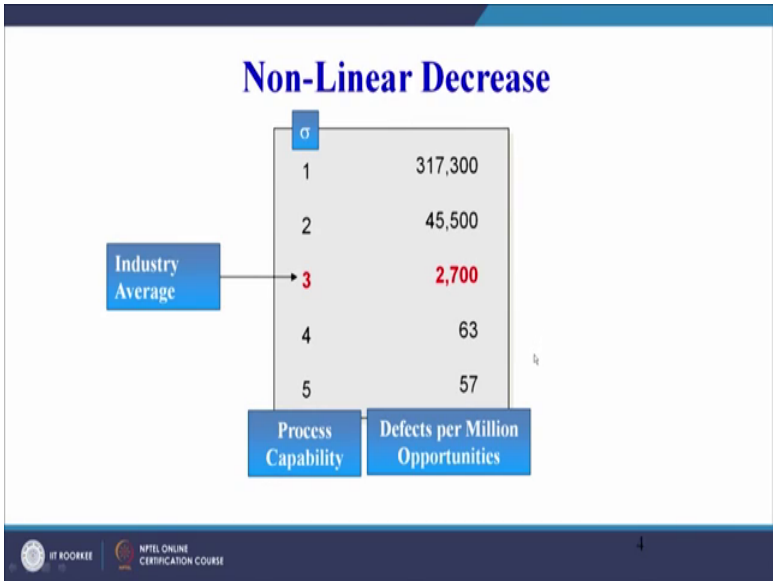

So, the this is representing the process capability in terms of the sigma and this is a defects per million opportunities DMO

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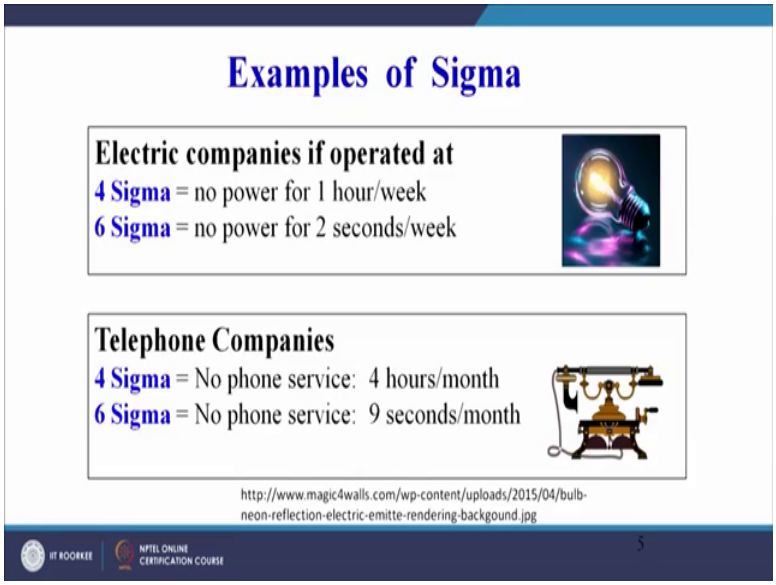

Now, examples of sigma we can see electrical companies if they operate at 4 sigma limits; no power for 1 hour per week. If they operate at six sigma we can say no power for 2 seconds per week. So, we can see how the quality has improved by considering the six sigma as our target.

Similarly, the telephone companies if we follow 4 sigma no phone service 4 hours in a month whereas, if we follow 6 sigma no phone service only nine seconds in a month.

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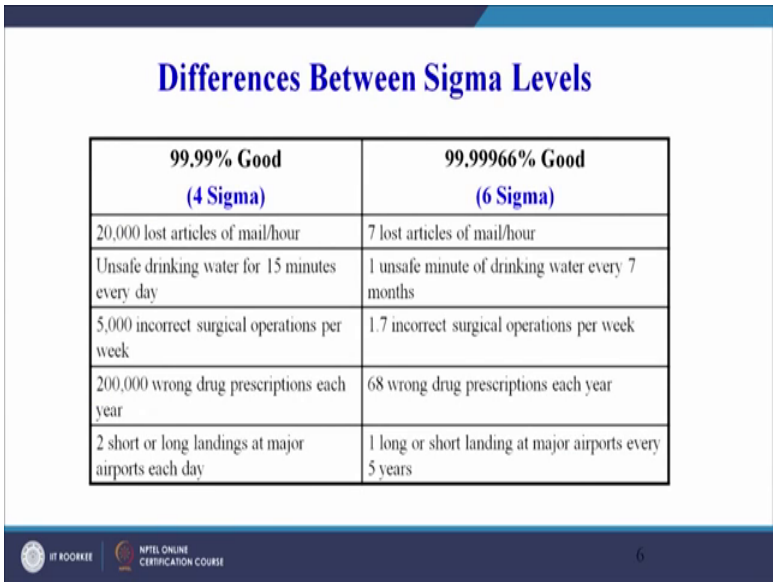

So, this explains the non-linear decrease as we have seen here in the non-linear decrease which is explained here.

Now, difference between sigma levels you can see in 4 sigma; 99.99 percent is good and in 6 sigma 99.99966 percent is good. So, we can see that different examples are taken just to explain the concept of 6 sigma 20000 lost articles of mail per hour whereas, if we follow 6 sigma limits; 7 lost articles of mail per hour.

So, we can see what is the change we can call it a c change if we are able to achieve our target of 6 sigma. Then unsafe drinking water for 15 minutes every day if we follow 4 sigma limits, but if we follow 6 sigma; once one unsafe minute of drinking water every 7 months, you can see the change in quality by following a very strict regime of 6 sigma. So, one unsafe minute of drinking water every 7 months which is linearly changing if we say 15 minutes every day as per the 4 sigma limits.

Similarly, plot 2 lakh wrong drug prescriptions each year whereas, if 6 sigma limits are used 68 wrong drug presic pre prescriptions each year or every year. So, we can see the difference that can be created by following a very strict you can say quality control over the products that we are producing.

Now, history of six sigma we can be I think we have understood the concept of six sigma.

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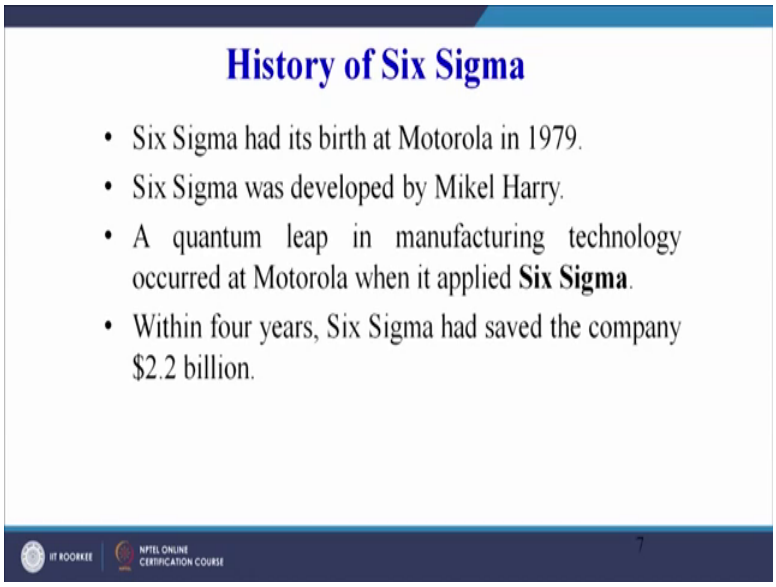

Now six sigma was implemented in Motorola in 1979 was developed by Michael Harry, a quantum leap in manufacturing technology occurred at Motorola when it applied the concept of six sigma within 4 years six sigma had saved the company dollar 2.2 billion. So, your defects when they will decrease automatically your profits will increase because a rework scrap and reuse or maybe kind of the waste wastage will be reduced. And therefore, it will automatically lead to productivity as well as increase in the profit of the company.

Now, what is six sigma? I think the examples have fairly explained that more focus is on ensuring that the process is done in such a way the operations are done in such a way that the defectives are minimized.

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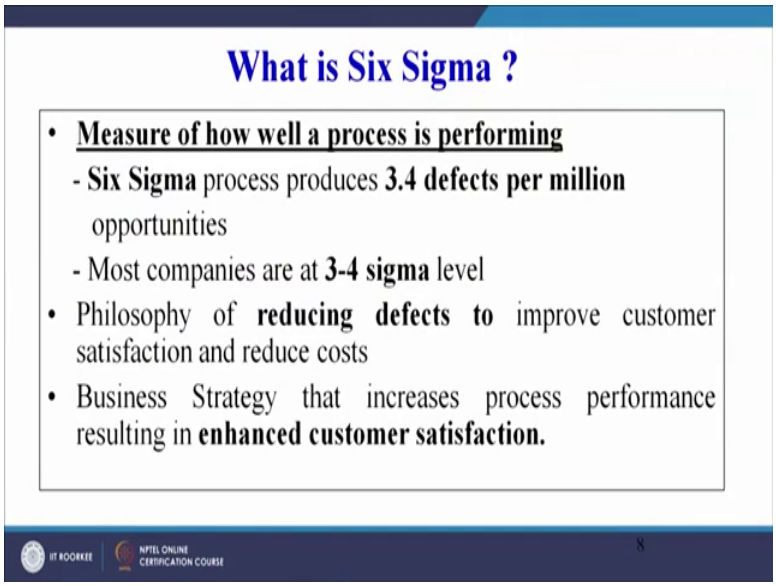

So, measure of how well a process is performing is what is six sigma. Six sigma process produces 3.4 defects per million opportunities. So, we can see it tries to minimize the defective items being produced by the production line. Most companies are at three or 4 sigma level only; so, that is something which is be the current practice, but slowly and steadily with the development of the technology companies are trying to focus on the six sigma level also.

Philosophy of reducing defects to improve customer satisfaction and reduce the costs. So, business strategy that increases process performance resulting in enhanced customer satisfaction. So, if the defects in the product will be less the customer will automatically be satisfied. And when the process is managed in such a way that the defects that are occurring in the process are reduced to a minimum value reduce to maybe 0 value only the customer will always be satisfied,

For example, suppose we buy a refrigerator and we are using it for the last 15 years and there is no defect in the refrigerator the customer will always become a loyal customer of that company because it has outlived the designed life of the component or the product. And the product is still functioning satisfactorily without any defect. So, that is maybe the customer loyalty or satisfaction which will occur if the product is not defective. So, that is basically the target of the companies to produce products which are good quality which are without any defect.

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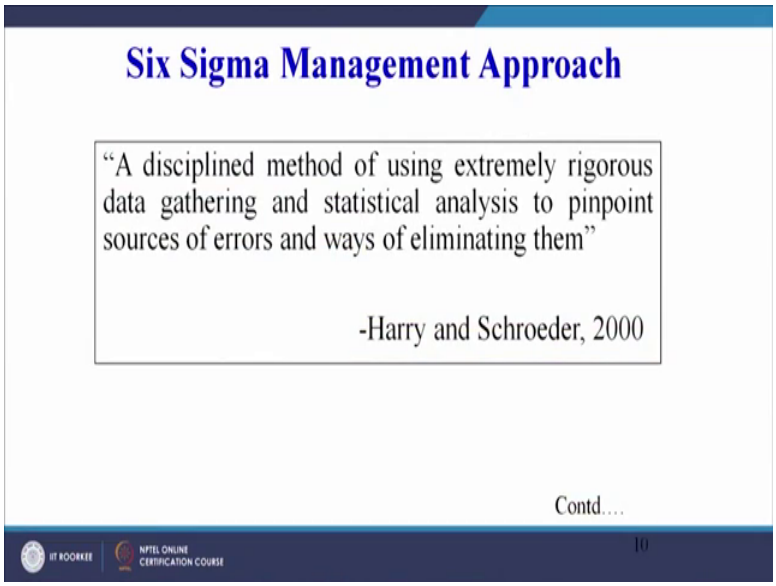

Now, let us see just a simple definition of six sigma a disciplined method of using extremely rigorous data gathering and statistical analysis to pinpoint sources of error and ways of eliminating them; So, we can see that it is a systematic or disciplined method of using extremely rigorous data gathering and statistical analysis.

So, maybe we will try to analyze our processes statistically or the data derived from the processes statistically to find out what are the sources of error and then in a way using the creative skills using the technical knowhow using the advancements in the technology to eliminate the sources of errors. So, that the process produces the products which are without any defect.

So, if the process produces all the products maybe over a year's time or 2 years time without any defect I think we are we will be able to achieve the six sigma level of accuracy. The six sigma is both a philosophy and a goal now focus on continuous improvement through customer satisfaction.

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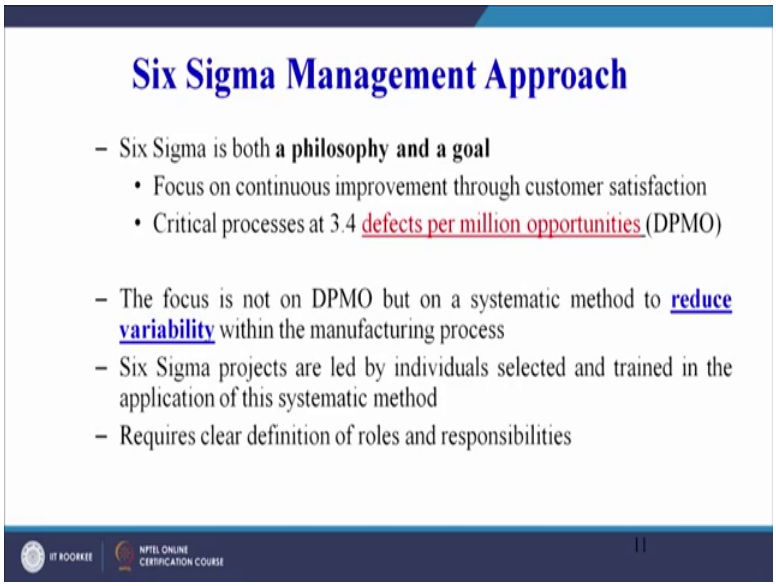

And if you remember in our concept of total quality management also we have discussed that continuous improvement is the key word. Suppose today we are at one may be at one level of our sigma next time or maybe over 6 months we can plan to have a rigorous review of our processes of our operations of the manufacturing techniques that we are using and try to continuously improve and minimize the defects that are occurring during the process. So, that our customers are satisfied and the defects are minimized.

The focus is not on the defects per million opportunities that is DPMO the as per the six sigma; I think this has been discussed today earlier also the critical processes at 3.4 defects per million opportunities that is the six sigma target. So, the focus is not actually on the DPMO that is defects per million opportunities, but on the systematic method to reduce variability within the manufacturing processes.

So, our target will be to modify to develop, to design, to invent our system in such a way that the variability in the product specifications is minimized to a 0 level in case of ideal scenario or is minimized to acceptable variability or deviation level. So, that we are able to produce the products with the good quality within the allowed deviation that is as per the random variation which is mostly there or sometimes we call it as the inherent process variability also, but that inherent process variability must be within the limits of acceptable range.

And therefore all products if are acceptable then we will be able to achieve this target of producing 3.4 million sorry 3.4 defects per million opportunities; So, six sigma projects are led by individuals selected and trained in the applications of this systematic method; this requires clear definition of rules and responsibilities.

Now, the essential six sigma tools and methods are in different presentations different books, we will find that there are approaches standard approaches of how to approach the six sigma level.

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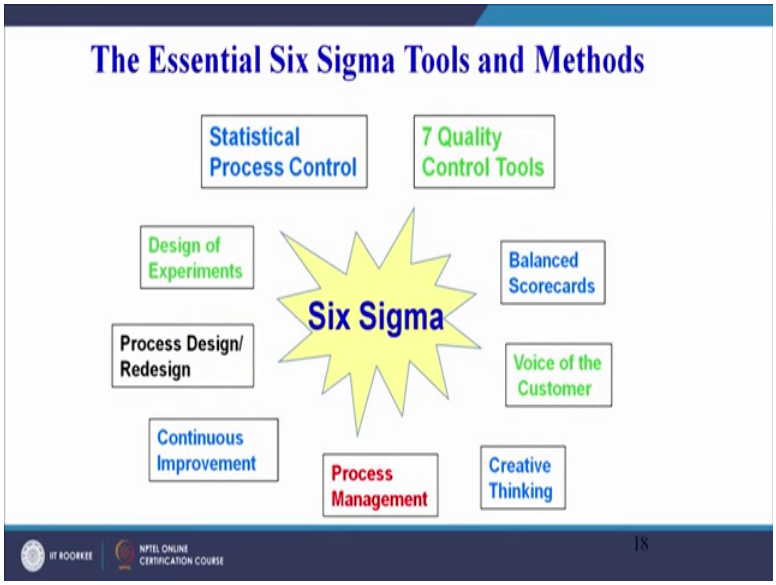

So, one may be think that we have already seen in our previous session the statistical process control, design of experiments, process design and redesign, continuous improvement today also we have seen process management, creative thinking as I have already discussed that. We have to think creatively we have to reinvent our systems in such a way that the defects are reduced to a minimum value voice of customer we have to look up to the customer for his advice for his requirement for his needs which can be direct or implied needs accordingly we have to change our process.

So, that we are able to satisfy our customer then 7 quality control tools which can be used there are number of presentations available on 7 QC tools which can be seen and which can be referred to by the learner. So, six sigma basically is a management approach which will focus on improving the quality of the products being manufactured in the company.

Now, what will be the organizational structure for a six sigma team?

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A typical six sigma strict structure in manufacturing organization is there will be a quality leader or a manager. The quality leaders responsibility is to represent the needs of the customer and to improve the operational effectiveness of the organization. So, the important part is the two things one is we have to take the feedback take the inputs from the customer, another thing is we have to manage our operations in such a way that we are able to deliver to the customer what he actually wants and he is satisfied with what he gets for the money he spends.

So, therefore, two important things are there our system and the need and requirement of the customer and both have to be addressed in order to produce a good quality product which is accepted by the customer and that is the responsibility of the quality leader or the manager

Similarly, there is master black belt MBB. So, the master black belts are typically assigned to specific area of functions of a business or organization. So, they will try to see and look for the causes or the sources of error and use their creative thinking to come up with solutions which will help to reduce those sources of error in order to improve the overall quality of the product. Then the black belt black belts lead quality projects and work full time until they are complete.

And green belt green belts are employees trained in six sigma who spend a portion of their time in completing the projects, but maintain their regular work role and responsibility. So, maybe in six sigma once you undergo the training, you may be a green belt or a black belt or a master black belt that depends upon your level of training and the kind of projects that you can handle or will be assigned.

Now, what are the benefits of six sigma project? We have tried to see that we have to focus on our system, on our operations, on our manufacturing processes try to look for the sources of error try to use the creative thinking to find out the sources of error and then eliminate these sources of error. And finally, design the process in such a way that the products being produced by our process are of good quality.

Now, what will be the benefits if we do that I think instead of reading the points on the screen all of you will be able to answer by now that if we give quality to the customer what will be the advantages.

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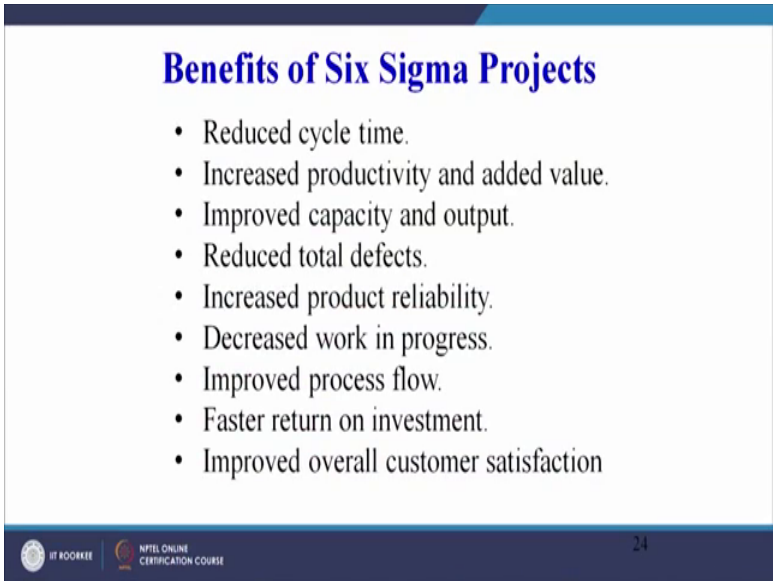

The advantages will be that the rework will be reduced, customer will be satisfied; we will get loyal customers our inventory levels will be reduced, our rework will be reduced the profitability of the company will improve, the productivity of the company will improve, the employee morale will be improved.

So, whatever without looking at the slides we can just try to figure out that what will be the advantages if we are able to produce a good quality product without any defective products coming why to talk of a million we can talk of multi millions also that there is no defective in multimillion products that we are producing.

Currently six sigma limits specify 3.4 defectives per million, but we can talk of even higher ranges where we say that even in 2 million or 5 million we are not we are not finding any defective item. How that is possible? That is possible if our systems are so, developed; so, designed that they are error free human intervention is minimum and the system is so, designed self regulating system that even if there is a problem it regulates itself without affecting the quality of the final product.

So, if just for your sake I will read these points here the benefits of six sigma; reduced cycle time, increased productivity and added value improved capacity and output. Because there are if when there are no defects fully we can utilize our capacity reduced total defects increased product reliability because if there are no defects product will be reliable; I have taken an example to this effect in today's session also. Decreased working process, improved process flow, faster return on investment improved overall customer satisfaction.

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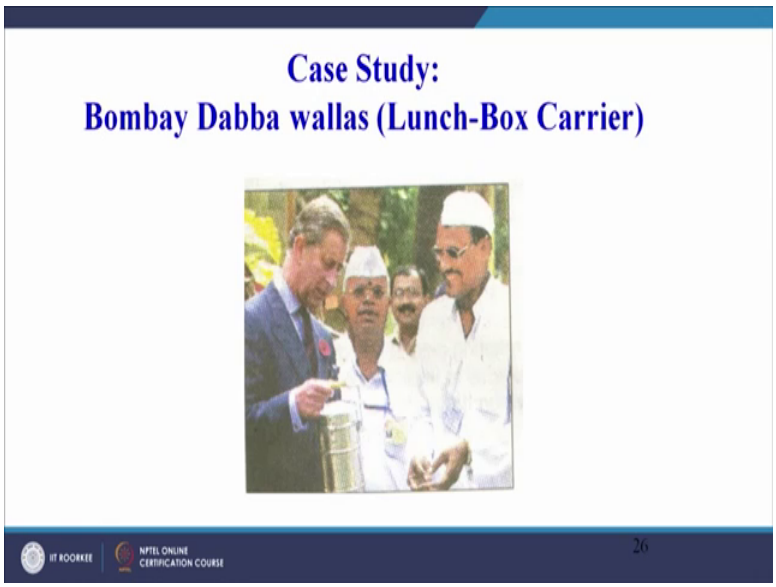

And let us take a very simple example case study of Bombay Dabba Wallas Lunchbox Carrier who supply lunch to the office going people in their offices only and then collect back the used boxes lunch boxes. So, just one this is a last slide.

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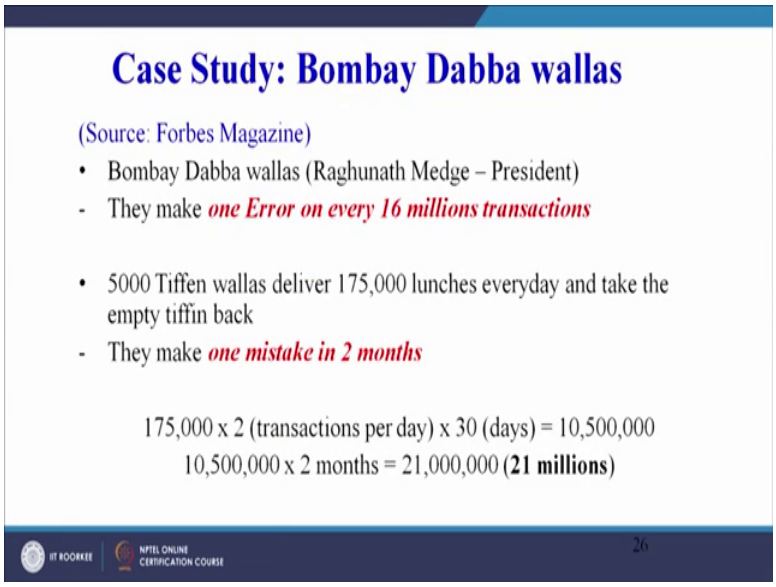

We can see this is a sources Forbes magazine Bombay Dabba Wallas; the president is Shri Raghunath Medge; they make 1 error on every 16 million transactions. So, you can see we are accepting 3.4 million per sorry 3.4 defectives per million, but here we see 1 error for every 16 million transactions. So, 5000 tiffin wallas deliver 175000 lunches every day and take the empty tiffin back.

So, they make 1 mistake in 2 months. So, we can see 175000 lunches every day into 2 transactions they have to first deliver at the right address and then collect the used tiffin back from the right address; so, two transactions for every delivery. So, 175000 lunches into 2 into 30 days is equal to we can see 10 lakh that is approximately no no it is more than 10 lakh.

So, we can see for two months it is coming out to be 21 millions and in 21 millions they make only one mistake. So, we can see the level of accuracy, the level of maybe hitting the target value again and again without any mistake that is what has been achieved by the Bombay Dabba Wallas.

So, we can see the same concept or same maybe methodology may be applied in the shop floor operations also. And the number of defective items can be reduced it is possible to reduce them if we use a systematic approach of managing our operations. So, the target of this week the discussion of this week was focused on quality and we have taken five important sessions to explain the concept of quality to explain the concept of total quality management; then we have discussed total productive maintenance and then we have seen statistical quality control and today we have seen six sigma.

So, these two and a half hours of discussion if you focus and if you work on these topics on your own try to go into the depth of these topics, you will be able to see that yes the quality of the product can be improved by systematic planning and control.

So, with this we end the discussion for this week.

Thank you.