Production and Operation Management
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Lecture 46
Six Sigma

Welcome friends. In our last few sessions we are focusing on statistical quality control and particularly if we discuss the last session where we focused on process capability analysis. So, we discuss that sometime our processes are matching with respect to their capability with the specifications given for production purpose.

But sometimes it is possible that processes are less capable and we have a very stringent specifications. And in that particular case we need to see how to improve the process capabilities. In our earlier discussions, we discussed about various types of quality control tools. And we also discussed that the Japanese system of manufacturing says continuous improvement kaizen so that you can continuously improve your process capabilities.

The idea of improving the process capability is very simple, which we discussed in the previous session that how can we minimize the variations in our processes. If we can minimize the variations in our processes that is a single point address towards the improvement of process capability.

So, reducing variation means improving the process capability. A very important concept came in this direction about the process capability improvement and that has become a very popular concept across the globe and it is now being applied not only in manufacturing industry, but whatever type of service organization you talk, whether it is health care, whether it is postal, whether it is restaurant, whether it is airline, whether it is banking, everywhere you will find the application of this concept.

And this concept is known as six sigma. We have already introduced the meaning of sigma, sigma is the standard deviation that how much you are deviating from the mean values. Now, in our previous session we have discussed the concept of central limit theorem. Now, in the central limit theorem, we discussed that the samples, whatever sample you are taking from the process, the mean of those samples are normally arranged.

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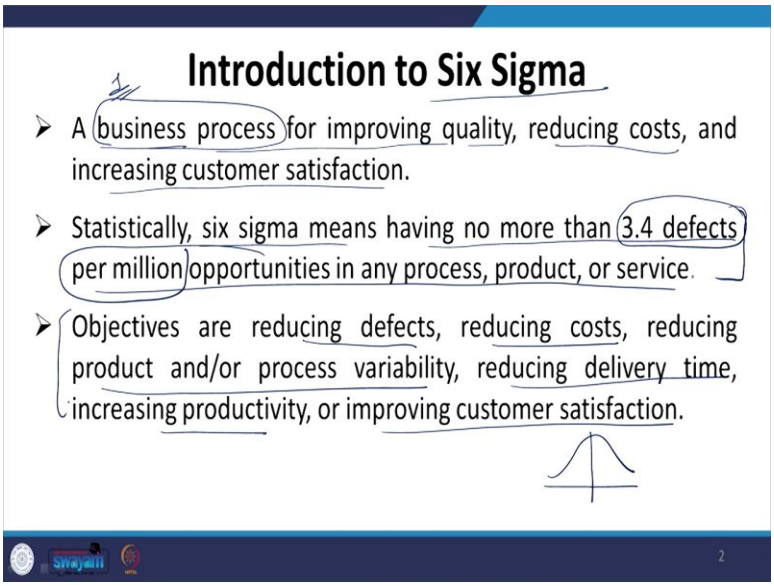

That means whenever you have some mean of a sample, they will follow the normal distribution curve. And this is the essence of our six sigma discussion. Now, when we are discussing the six sigma, it is important to know that many a times, now a days the meaning of entire quality management is only around the six sigma. It has become such a popular topic.

So, we will go to some theoretical aspect also to discuss this six sigma. It is more practical in nature, how to implement the six sigma and how to measure the success in terms of six sigma that is more important. But at the same time some philosophically issues, some theoretical issues behind the six sigma are equally important. So, let us start our discussion with those concepts which are behind six sigma.

So, a business process for improving quality, reducing cost and increasing customer satisfaction use six sigma. So, all these three things can be simultaneously fulfilled because the idea of six sigma is reducing variation. So, if you are able to deliver consistently same level of quality, it will increase the customer satisfaction.

If you are able to consistently reduce the wastage in your production process that will reduce the cost of your production process. Again, it will help in either getting more profit or reducing the cost and that will help in improving the customer satisfaction. So, when you are continuously if

nowadays, let us see it is the time of E-commerce and you are placing an order on some E-commerce site and you know that you click the order button and the products will be delivered at your door step within 17 hours and all the time products are delivered at your doorstep on the 17th hour.

That means you can plan your movement whether to remain in house, or you can go outside for other shopping activities. Accordingly, you know that around 6, 16 to 18 hour the packet will be delivered to my house. So, you can plan your movement accordingly and that obviously increases your satisfaction level. So, six sigma is a very important business process. So, the first important point is that it is a business process.

The second important thing is, statistically six sigma means having no more than 3.4 defects per million opportunity in any process products or service. So, we will discuss this very point in more detail in our coming slides, but you can remember this particular value that 3.4 defects per million, 3.4 defects per million that is the level of reduction of defects.

So, almost you can say almost zero defect are available in case of six sigma quality levels. So, that is almost negligible number of defects in your production system. Now, objectives are reducing defects, reducing cost, reducing product or process variability, reducing delivery time, increasing productivity or improving customer satisfaction.

So, all those things which you desire in your organization that, how I can improve the quality? How I can reduce the lead time? How I can reduce the wastage? How I can reduce the cost? How I can improve my competitiveness? How I can improve my productivity? All these things are simultaneously possible if you understand the meaning of six sigma and if you are able implement this six sigma in right spirit. The right is spirit is very important. So, almost all those things which we want to have in our organization are possible with the implementation of six sigma.

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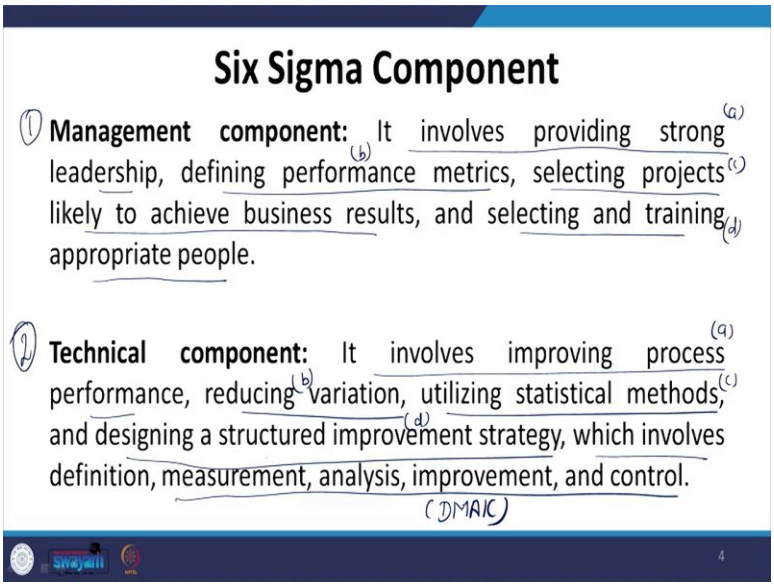

Now, what is the six sigma component? It has two components. The management component and technical component. In the management component, it involves providing strong leadership, defining performance criteria, selecting projects which can likely to achieve business results and selecting and training appropriate people.

These are the different type of managerial actions which are required six sigma implementation process that means one is leadership the top management commitment that we have already discussed. If you remember in our TQM class. The second is, how are you going to measure your performance? That is the second important level. The third is, because six sigma is implemented in organizations in project modes.

So, you need to identify those projects which are likely to achieve business results. And the fourth is you need to identify and provides a specific training to those resources those men power in your organization who are responsible for six sigma implementation. And some of you may be knowing that there are different levels of training. So, finally you achieve the black belt training level in the six sigma.

So, there are different levels of training, so you may have the green belt and then you can go to finally black belt level. So, proper training is also very important, proper certification that is also

very important for the proper implementation of six sigma philosophy. Then there are certain technical issues also, so these are the managerial issues then there are certain technical issues.

What are those technical issues? It involves improving processes performance. So, you have to improve the process performance. That is number one, reducing variation. How to improve the process capability so that you can reduce the variations. Then third is, utilization of statistical methods because six sigma is highly influenced by statistical calculations.

Therefore, this term of sigma in the name itself that six standard deviation, sigma is the name given for standard deviation. So, that is so how use the statistical methods and designing a structured improvement strategy. We will see in few minutes that there is a very systematic process of implementation of six sigma which is known as DMAIC and for implementation of the DMAIC you require sustained structured innovation strategy.

Unless until you know how to improve this particular activity. You will not be able to implement six sigma. So, the structured innovation system, structured innovation approach is required for improving your current processes. Then which involves definition, measurement, analysis, improvement and control that is nothing but DMAIC. So, this DMAIC is that structured innovative strategy for implementation of six sigma. So, these are the two important approaches management approach and technical by combining both these management and technical approach. You will be able to achieve this six sigma.

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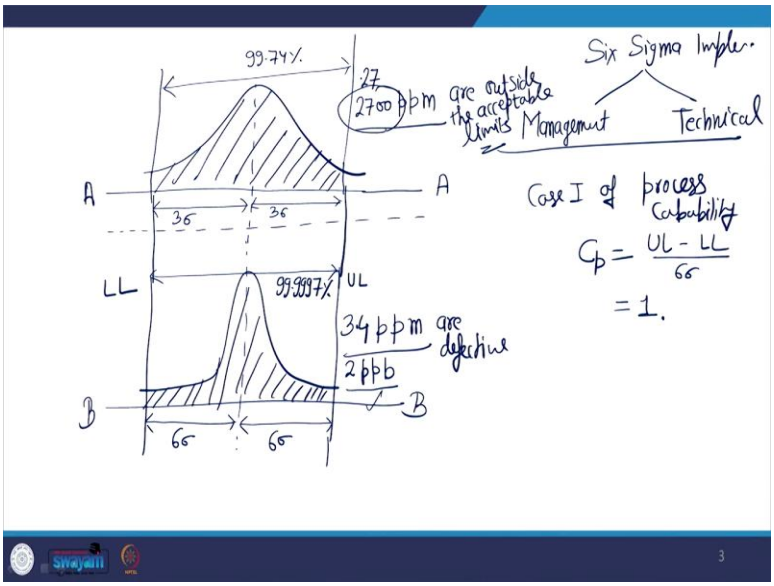

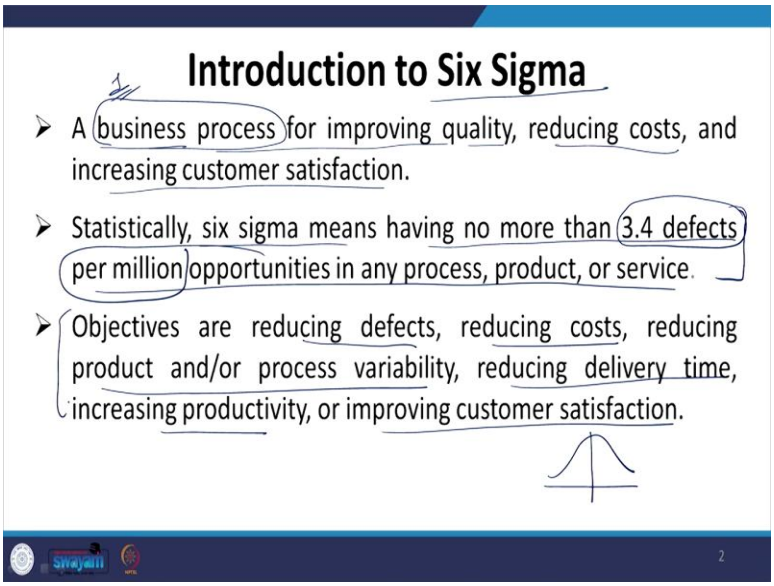

So, six sigma implementation and it has it has components from both these management and technical side. Now, before we move further to discuss the implementation of six sigma. Let us put some time for understanding the philosophy of six sigma. That how we are able to get this 3.4 defects per million kind of things in our process. What we are doing? So, our numbers have reduced so drastically that almost we have reached the situation of zero defect. So, for that purpose, let us understand the philosophy of six sigma. Here I am making a graph and these are my product specification.

This is upper limit. This is lower limit. Now, I am making the process, in this process, my process mean this is situation A, in situation A the process mean is exactly the mean of specification and this is 3 sigma. This is also 3 Sigma. Now, the area under this curve, area under this normal curve which is having upper limit and lower limit exactly at six sigma level.

So, if you remember this is case 1 of process capability, where we calculated the value of process capability index and that is upper limit minus lower limit divided by 6 sigma and you see the upper limits and lower limits are already apart by six sigma. So, process capability in this case is coming 1. So, process capability is just touching the six sigma level.

And we know that six sigma is taking, how much area? 99.74 percent area is under this six sigma. So, you know that 0.27 parts per 100 unit are defective or you can say 2700 parts per million are outside the acceptable limits. So, this system is producing 2700 parts per million, which are outside the acceptable limits.

So, that looks a every huge number that out of 1 million, out of 1 million 2700 parts are defective. So, that is very very stressful information for us. So, this is the A. Now, I am drawing another axis be B, B. This B, B is also having the same mean. It also has the same mean, but now what is done that I have done some improvement activities. I have done some improvement activities and as a result of that improvement activities, my process variability has reduced, my most of the values, most of the output of this process are around the mean values. So, my spread is now reduced.

So, the shape of my curve is like this. And what I have done that I have targeted my improvement in such a manner that the process variability just becomes the half of my previous case. So, so in the earlier case in A A case this much one side of mean was 3 sigma, but now my process variability has been half. So, the same area is now taking care of six sigma.

So, this is plus minus six sigma on either side of mean value and most of the values you are seeing are around the mean value and the total area is in this particular case the total area under this curve is 9.9997 percent. And therefore you will have you will have this is 9.99974 and therefore we have already discussed that you will get only 3.4 defects per million.

So, only 3.4 parts per million are defective or you can also translate this into more useful number that it 2 parts per billion, 2 parts per billion numbers are defective in case of a six sigma activity.

So, that is how you have used the same specification, the upper limit and lower limit but now you have increased your area of acceptance.

So, earlier only 99.74 percent area was under the acceptance limit. Now, my 99.9997 percent area is under the acceptance limit. So, therefore, I am able to accept more number of parts and I am rejecting only 2 parts per billion, which is practically zero kind of thing. So, therefore, the six sigma offers this direct economic advantage that how because of increasing the area under acceptance region I am able to improve my performance and I am able to have the rejection of just 2 parts per billion.

So, even when you compare these two situations, you will see that six sigma is having either 3.4 parts per million. So, if I am saying that if I am making 1 million cars, if I am making 1 million cars. So, in this diagram A A you may have 2700 defective cars out of 1 million cars, you may have 2700 defective cars.

But in case your organization is six sigma complied organization in that case in 1 million, you will have just 3.4 cars as defectives or out of 1 billion you will have only 2 cars which are defective. So, you can see that how drastically the numbers have changed just by increasing the sigma level.

The numbers have change drastically from 2700 parts per million to 3.4 parts per million or 2 parts per billion. So, that is the philosophy behind the implementation of six sigma and therefore all the organization because of this numeric advantage. We have come from 2700 per parts million to 3.4 parts per million and that is the beauty of six sigma activity.

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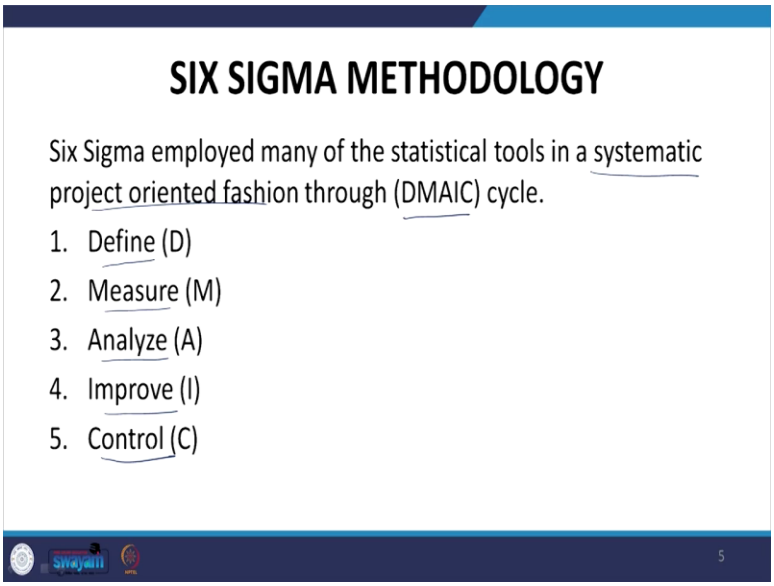

Now, the six sigma methodology how are we going to implement the six sigma and for that purpose as I told you already that we will do it in a very systematic fashion and that systematic fashion is coming from this particular acronym that is the DMAIC. That consist of, define, measure, analyse, improve and control. So, DMAIC this is the most powerful framework for the implementation of six sigma. It looks very simple, define, measure, analyse these things are okay.

You can define the problem, you can do some checklist for measuring those particular parameters. And then you can analyse the results also, using the quality control tools such as Pareto diagram or Fishbone diagram et cetera. You can analyse the results also. But improve and control, I consider this two are the most difficult things you have to be very very innovative in developing solutions to solve the problems.

Because problem are there since long. So, it is a very important challenging task that how do you motivate people for making some improvement in their work practices. And then you also want to have control because it was believed that if control is not there people will not work. So, many of us understand this particular point that how in India particularly that pushing every time is very important and that is about the improvement of your work and it has to go consistently.

Though it is done in a project mode you have some kind of project activity in which six sigma is implemented. But we need to have in our organizations continues availability of the projects. So,

that every time whenever an opportunity is there, you can take a project in any place not only in your campus any place and you see that how we are going to improve the processes. So, that is about six sigma mythology.

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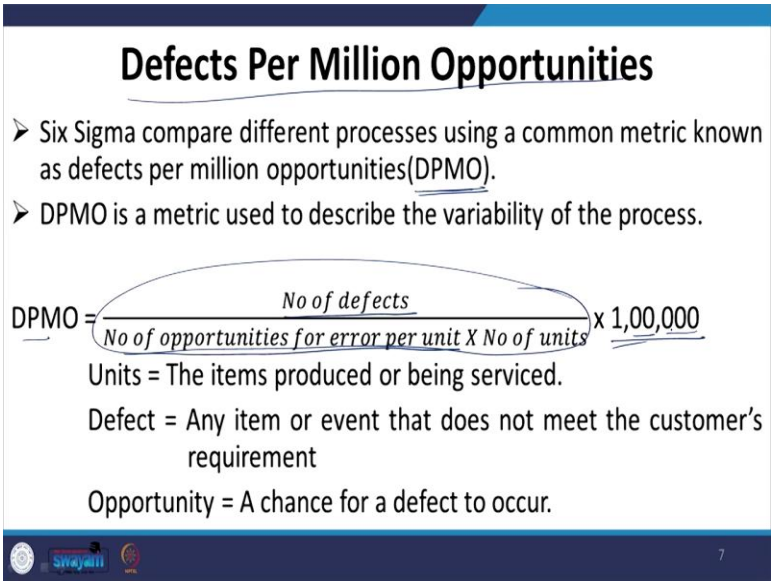

Now, another important thing which we discuss that we need to have a proper measurement criteria for measuring the six sigma levels. And that proper measurement criteria is known as defects per million opportunities, which is abbreviated as DPMO. DPMO is defects per million opportunities. So, first you should be careful in identifying that how many opportunities of defects are there, like this pen example I give you again and again.

In this particular pen how many opportunities of defects are there, let us say something is to be printed here on this pen something is to be printed here. But because of pressure of the work the vendor missed printing of that particular statement at the cap of this pen. And similarly, many such examples are possible where you may create defects. Because there are multiple opportunities of defects in a single item and some of you may do 1 defect, may do 2 defects, may do 3 defects.

So, one product may have multiple opportunities of defect. So, this is similar to our C chart, if you remember in case of attributes in those particular cases where more than one type of defects are possible you are not answering only in terms of yes or no, but more than one type of categories are possible for the customers.

So, that case not going to help us and here we will see that how we are going to combine all those different categories under one umbrella term and that umbrella term is DPMO defects per million opportunity. Now, the DPMO calculation involves three important things, one is total number of defects. How many total number of defects are there?

Then number of opportunities for error per unit in a particular product in a particular unit how many opportunities of defects are there? So, like I am wearing the shirt there may be some four 5 opportunities of defect maybe these buttons are not properly stitched, maybe the fitting is not appropriate, maybe the colours are not appropriate, maybe the collar is not properly designed. So, these all are the opportunities of defect. So, number of opportunities for error per unit into number of units.

So, this is the formula, but to convert this formula in terms of our standard terms that whether it is 3.4 million per opportunity or 2 parts per billion. Let us understand and therefore we are multiplying this with 1 million. So, this is the formula for the calculation of defects per million opportunities.

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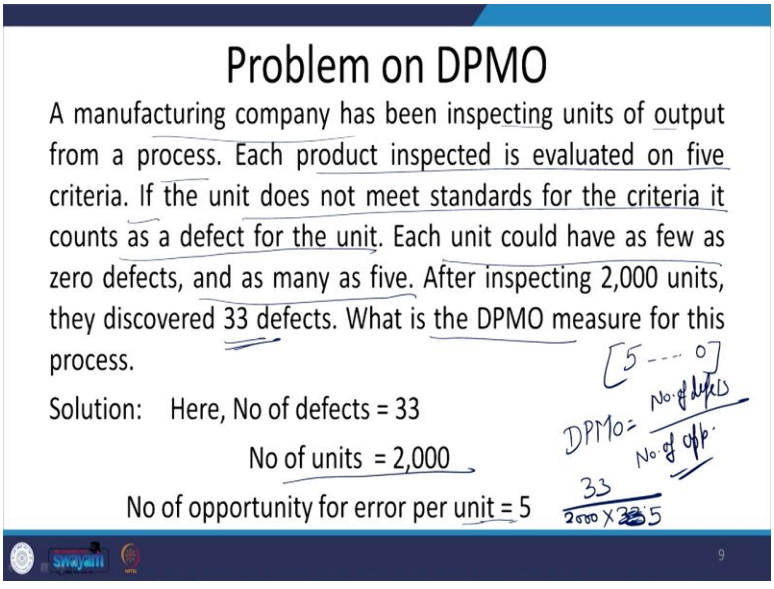

Now, we will see one numerical or you can say one calculation on DPMO formula, and that will give us that, how are we using this formula for determining whether the process is in six sigma limits or going beyond the six sigma limits. If your DPMO is coming within the limit that is 3.4

parts per million that we say that the process is in six sigma limits. But if DPMO calculation comes more than 3.4, then we will say that no, it is not, it is giving more defect to the therefore this is still not six sigma. So, that is how you continuously improve also.

Let us see this example, a manufacturing company has been inspecting units of output from a process. Each product inspected is evaluated on five criteria. If the unit does not meet standards for the criteria it counts as a defect for the unit. Each unit could have as few as zero defects and as many as five. So, number of defects vary from 0 to 5. After inspecting 2000 units, number of units inspected are 2000, they discovered 33 defects. What is the DPMO measure for this particular process?

So, DPMO as we have already discussed. Number of defects divided by number of opportunities and number of opportunities are total number of pieces and how many defects are possible in a particular product, particular plant and therefore 33 divided by number of units, you inspected 2000 units and each unit may have up to 33 defects. And number of opportunities per unit. These are 5, sorry this is 5. So, 2000 into 5, that is in the denominator.

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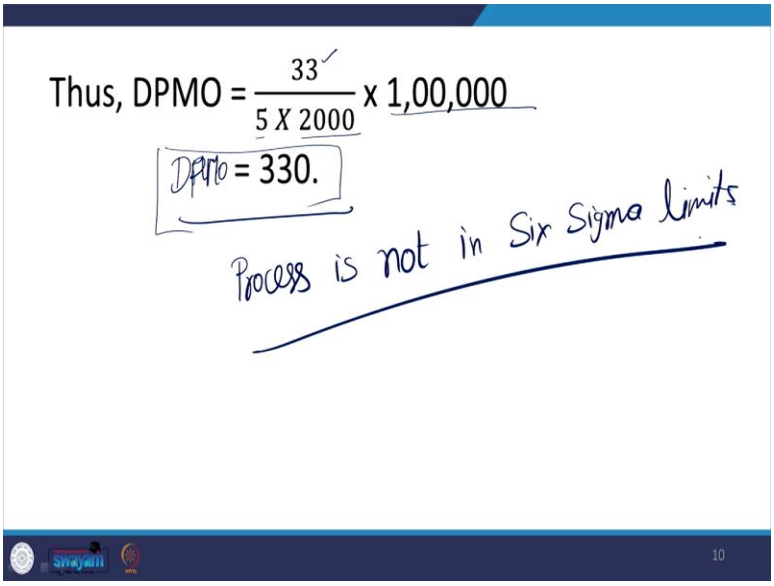

So, the calculation says that DPMO is 33 that is the total number of defects, the possibility of defect in a particular product that is 5. The total number of products you inspected that is 2000 and this is 1 million.

So, this DPMO calculation is coming 330, which is not acceptable because it has to come within 3.4. Here the DPMO is coming 330 which is much higher than the DPMO level came theoretically that is 3.4. So, process is not in six sigma limits, this process is not in six sigma limits. Because the value of DPMO is sufficiently high. If this value of DPMO comes to be 1, 2, 3 or in some minus values. If product is of that type, then it is saying that it is a six sigma process.

But right now DPMO is coming 330 and that therefore we will say that the process is not in six sigma, with this we have understood the various meanings of six sigma aspects. We discussed the philosophy of six sigma, we discussed how to calculate sigma and then we also discussed that how to take projects of six sigma with the help of DMAIC, DMAIC concept that without defining, measuring, analysing, improving and controlling six sigma implementation is not possible. So, with this we come to end of this session. Thank you very much.