Six Sigma
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Lecture – 04
Six Sigma Principles and Focus Areas Part - 1

Hello friends, I welcome you to the journey of Six Sigma. And this is lecture 4, Six Sigma Principles and Focus Areas Part 1; and something in detail related to fundamentals of six sigma principles will be discussed in part 2 – lecture 5. Before we proceed to this particular lecture, let us just have a small recap.

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So far we have talked about pursuit of quality. Why quality is important, why today organizations they are continuously striving for better and better quality standards and benchmarks. Importance of quality, how the company they really perceive the quality, and try to justify their business competitiveness and sustainability through the dimension quality. There are various dimensions of quality, and we cannot say that quality is only unidimensional perspective; it is a multidimensional, multi attribute perspective. And we have talked about various perspectives of the quality like reliability, safety, aesthetics and many others in the previous lecture.

We have also seen the various definitions offered by quality gurus; the renowned personalities in the domain of quality like Crosby, Deming, Juran, Ishikawa and many

more. We have gone through a systematic journey of history of continuous improvement in various milestones in quality. So, since last 80 years or 90 years, companies, organizations, they are striving for better and better quality, and we have seen the various milestones. Then we talked about evolution of Six Sigma at Motorola. And the problem Motorola has faced, and as a solution they discovered something called Six Sigma a systematic approach for implementing DMAIC, and improving the quality of various processes by reducing variability.

We have also seen the variation in six sigma. Variation is the enemy. And if you can have better control over the variations, then automatically your processes will improve; and in turn you can say that you are improving on the sigma level. And then we have seen that what is lean-six sigma, and what kind of synergistic effect in terms of waste reduction through lean as well as variability reduction through six sigma an organization can achieve.

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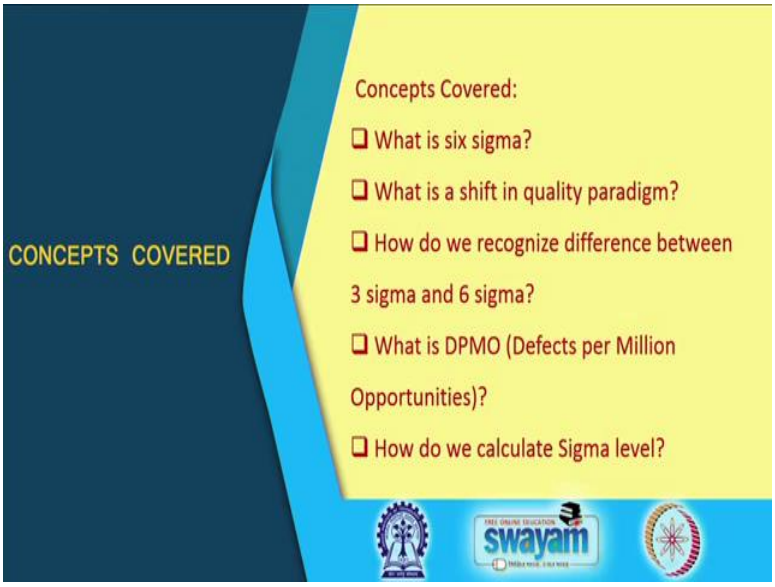

Now, in this particular say lecture 4, we will focus on the couple of concepts like what is six sigma? What is the shift in quality paradigm? How do we recognize difference between 3 sigma and 6 Sigma? What is DPMO – Defects Per Million Opportunities? And how do we really calculate sigma level in practice?

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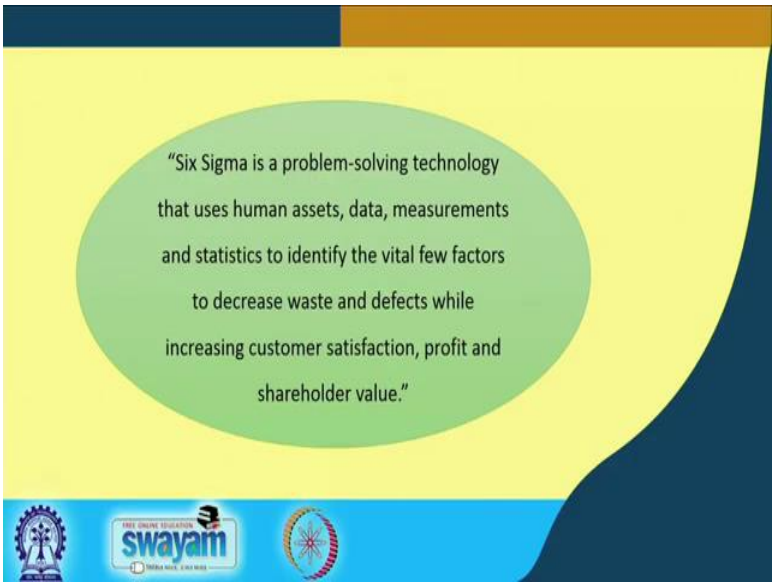

So, six sigma is a problem-solving technology as I mentioned it is a philosophy, it is a compass of tools and techniques for analyzing the situation, reducing the variability. And typically this uses the data, assets, measurements, assets maybe human assets, physical assets; and typically statistics to identify the vital few factors which are really causing the problem and focus is on decreasing the waste and variability.

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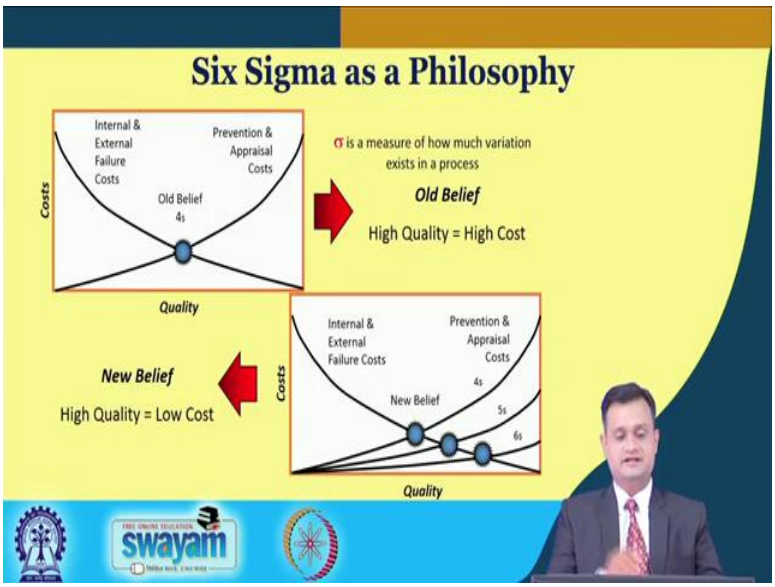

Now, if you see this diagram, then the idea would be say pretty much clear that when we look at the old belief, people use to believe that high quality means high cost; if you want

better quality, you have to spend more; but this is now no more a fact, we believe that high quality means low cost. You can even you can read couple of good books from Crosby like Quality is Free, the Quality without tears. And you will find that higher quality, basically helps you to reduce your appraisal cost by spending little more on prevention, and higher quality is at low cost.

So, if you see this second diagram with the new belief, then when we move our process from 4s to 5s to 6s, you will see that every time your prevention and appraisal cost typically depicted by this particular curve is shifting at the lower end. And with respect to quality you are able to achieve better tradeoff between internal and external cost, and the prevention and appraisal cost. So, as you are reducing the variability, improving your processes as you are advancing to higher sigma level; your total cost comes down.

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So, to achieve Six Sigma a process must not produce anything more than 3.4 defects per million opportunity. So, you can see that such a stringent target we are trying to achieve through a systematic process of DMAIC as a part of six sigma. And this means that Six Sigma concept means, 99.99966 percent probability that 3.4 defects per million opportunity can only occur. So, this is exactly where the companies they are trying to set the benchmark by achieving extremely low defect rate. Hence reducing scrap, rework and another way I will say that producing better and better A grade quality products which can exchange better value to the customers.

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So, as we mentioned couple of times that Six Sigma is typically a tool box of quality and management tools for problem resolution. Organized process for structured analysis of the data. Business philosophy for continuous improvement, and it is used to reduce the product and process variability. And typically, the use of statistics is emphasized to see that we do not only bring the improvement once, but we can also sustain the improvements.

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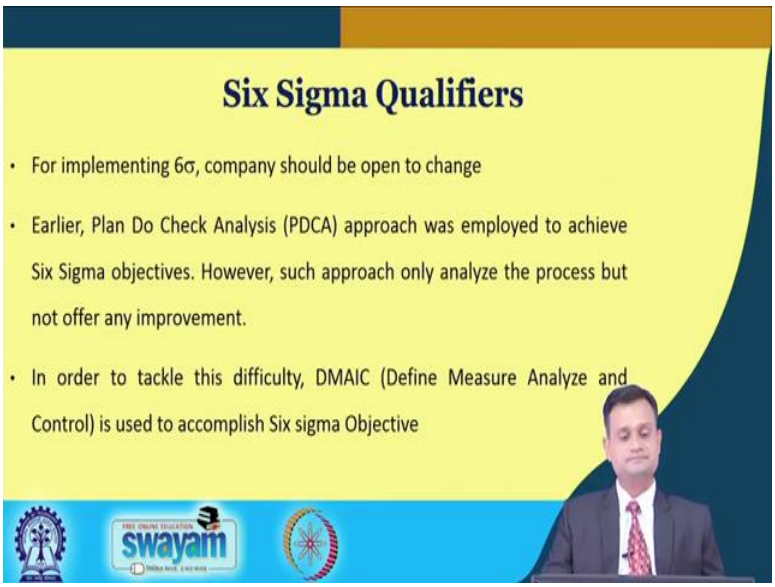

There are certain Six Sigma qualifiers we cannot just implement the Six Sigma without setting a prerequisite in the organization. So, typically for implementing Six Sigma, the

most important thing that company should be open to change; you must have open minded top management, you must have workers with very least resistance to change, and you must have a culture of arguing, accepting, debating and working continuously towards better and better quality standards.

So, previously if you see, then Plan Do Check and Analyze this was the approach which was well known, companies they have used to achieve the sigma level, improvement in the sigma level or Six Sigma. But this approach was not very much workable typically, because it was not focusing much on the improvement part and more on the analyze part. So, then subsequently this DMAIC approach was developed typically with Define Measure Analyze Improve and Control, and this is typically used as the central approach in achieving the Six Sigma for the given process or the function in the organization.

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So, how quality is measured in Six Sigma? So, fundamental definition is quality is DEFECT. So, if you can get rid of defect, minimize defect, you are improving on quality. So, anything which dissatisfies the customer is not acceptable as a part of say customer requirement, as a part of product design, this is not acceptable. And we should try to see that defect rate in terms of wrong customer requirement, assessment or producing the products which is not meeting the specification should be avoided.

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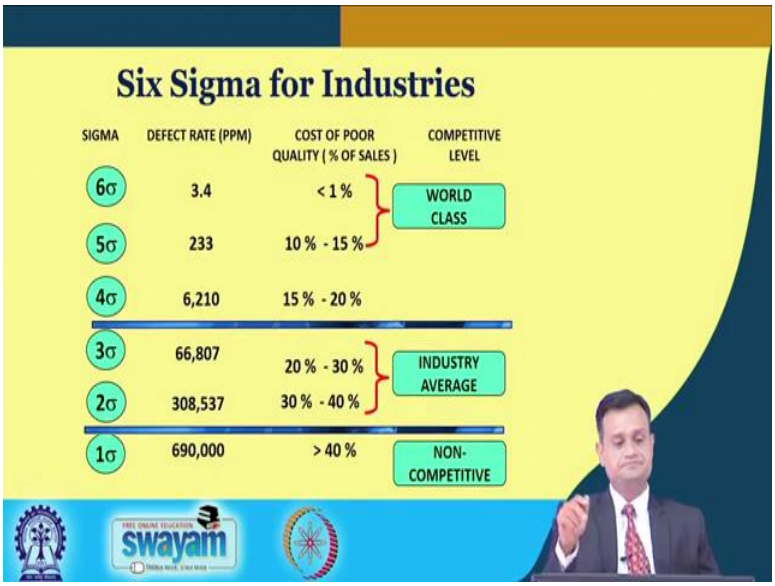

Now, if you see this Six Sigma for industries, then you will really be surprised to see that if you are 1 sigma then your PPM defect rate parts per million is almost 690000 its huge and more than 40 percent, cost is associated with poor quality. So, if you are living with this standard, it is better to close the business; because you are highly non-competitive and your business cannot survive. If a little bit say improve upon sigma 2 sigma, then it will say be 308537, but still caused because of poor quality is in percentage 30 to 40 percent. 3 sigma again it is high 20 to 30 percent typically this is called as industry average, but I will not say this is the excellence or the ultimate quality level which a world-class companies looking for.

So, now if we go further, and let us say strive through DMAIC improvement in the sigma level, then 4 sigma means 6210 defects parts per million 15 to 20 percent. 5 sigma further reduction and 6 sigma is at the top which is only 3.4 parts per million defective less than 1 percent defect or less than 1 percent say cost of poor quality because of defects. So, this is something where world-class standard companies are trying to achieve and it is very much possible through a systematic approach of Six Sigma.

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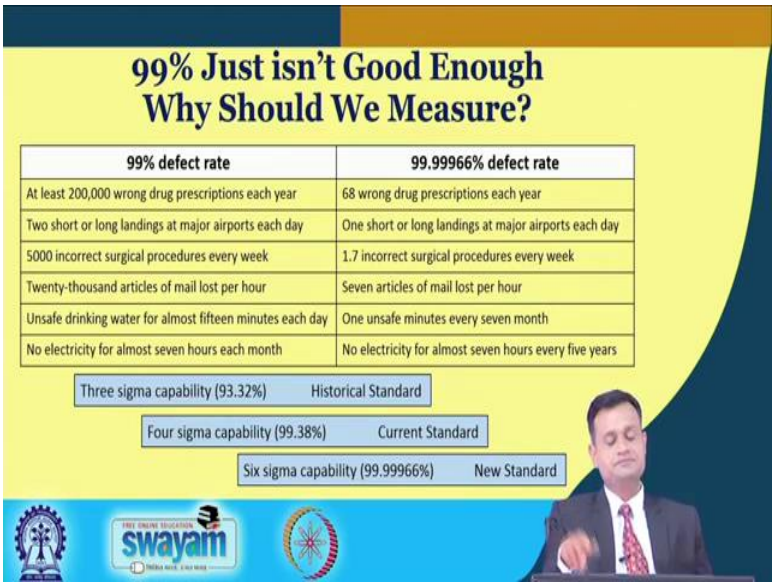

Now, just to bring more insights into this concept of Six Sigma, and just to sensitize you that what happens if you are operating let us say at 99 percent defect rate, and if you are operating at 99.9996 percent defect rate, you may say that there is hardly much difference; 99 percent and 99.99966 percent more or less same, but let us just try to evaluate it, and what could be the consequences.

So, if you see at least when 2 lakh wrong drug prescription each year, if you are operating at 99 percent defect rate; and if you increase your sigma level means achieve the better quality, then only 68 wrong drug prescription each year. Huge difference and you do not think in terms of only the drug prescription, but there is a loss of human health and societal cost by writing wrong prescriptions in such a high number. Let us see another thing. Too short or long landing at major airport each day, even one accident can cause death of hundreds of the people; here too short or long landing at major airports each day. Just see this goes half, one short or long landing at major airport each day.

Another example, 5000 incorrect surgical procedures every year; if you are operating just at little lower standard, then 5000 incorrect surgical procedures. You look at the Six Sigma, 1.7 incorrect surgical procedure every week. So, there is a huge difference and you really get excited, you really get say fascinated to opt for Six Sigma journey when you see such a huge difference typically in the critical processes.

Similarly, we can say that twenty-thousand articles of mail lost per hour; here it is seven articles of mail lost per hour. Similar way unsafe drinking water for almost fifteen minutes each day, and if you are at Six Sigma one unsafe minute every month, every seven month and this is such a low defect rate. So, likewise electricity also I have compared, and you can see that three sigma is 93.32 percent, four sigma is 99.38 percent and Six Sigma is 99.9996 percent.

So, basically we are trying to see that how you can move in your journey from 2 sigma to 3 sigma to 4 sigma and then 6 sigma. So, please remember that it is a journey, and Six Sigma is not like a wrapper which you can put on the chocolate and you will get something outstanding quality. If your processes are at 2 sigma or 3 sigma, you should set the realistic benchmark, realistic milestone, and then strive for achieving that higher sigma level again from that you investigate; identify the root causes and once again move to the higher sigma level.

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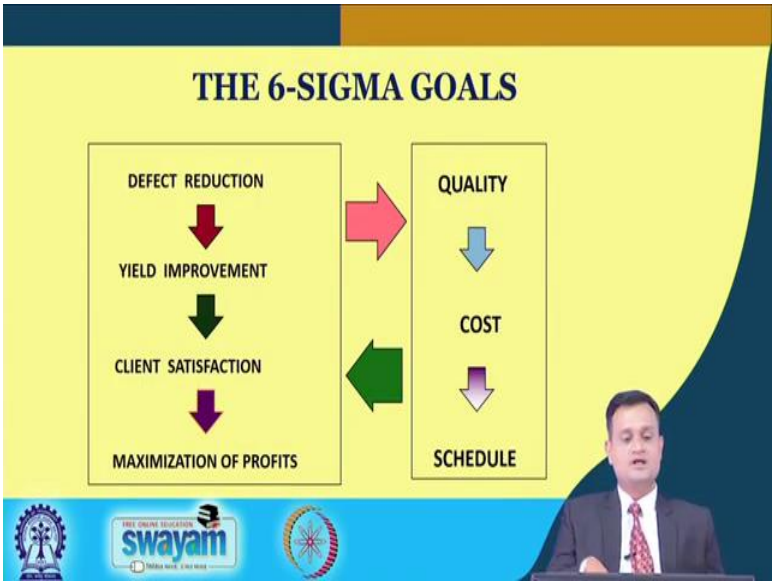

So, typically there are Six Sigma goals like defect reduction, yield improvement. The moment you will reduce the defect your resources will be saved, and your raw material utilization will also improve, manpower utilization will improve, your yield will improve. Client satisfaction obviously, when I am providing A grade products or services with very less defect rate, I have a better control over cost as well as the quality and my customer

satisfaction enhances, and obviously as a result of these your company can improve the profits, maximize the profits, enhance the sustainability.

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So, typically we say in Six Sigma that identify core processes; so you define your mission and vision statement, your strategy, classify core processes and enabling processes, prioritize focus based on strategy. Second is establish process control system, so you can map your key processes, determine voice of customer, voice of business, voice of employee requirement, establish indicators, subsequently identify performance gap.

You are operating in an industry, maybe let us say petroleum, maybe in service or maybe let us say manufacturing typically, you have your competitors assessment and use this to identify the performance gaps. Apply MAIC that is Measure Analyze Improve and Control, and this will help you not only to investigate the root causes, identify the reasons to address them, it will also help you to set the appropriate measure, control and sustain your proposed improvements.

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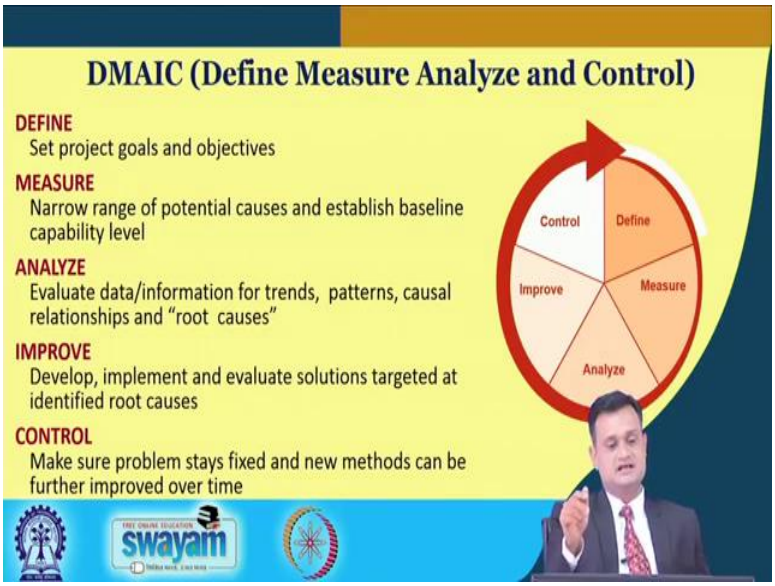

So, typically this keeps on rotating in the form of DMAIC - Define Measure Analyze Improve and Control. So, define means set project goals and objective. Measure means narrow range of potential causes and establish baseline capability level. Analyze evaluate data information of trends, patterns, causal relationship, root causes I am I am trying to dig out, so that is the analysis part. Improve, so develop implement, evaluate solutions targeted at identified root causes. And control that we make sure problem stays fixed and new methods can further improve over time.

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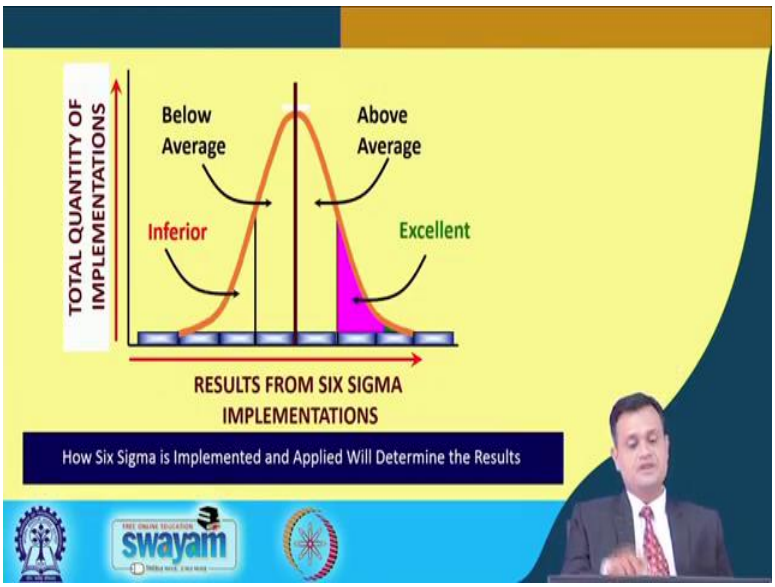

So, typically just see that when you are implementing Six Sigma. And if I just try to visualize the Six Sigma implementation in the form of let us say normal distribution, then the colour which you see here; this is your pink colour, this is the excellent region and it means that if your Six Sigma can result into sum in percentage monetary or maybe in terms of defect rate this particular result, then your implementation is successful and subsequently the benefits can be sustained.

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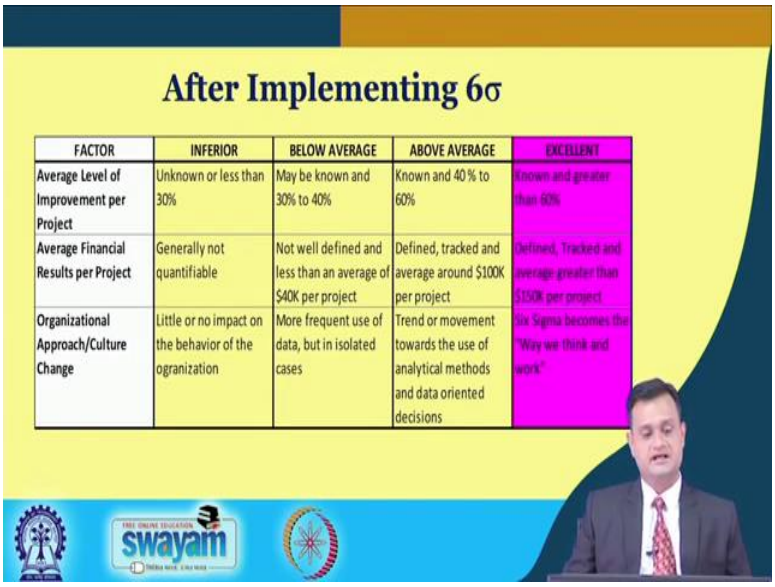

Now, just see that when I say after implementing Six Sigma, how do we analyze it. So, average level of improvement per project; suppose it is unknown or less than 30 percent typically your column 1, it is said inferior. Suppose, it is known and 30 percent to 40 percent, it is still below average. If it is 40 to 60 percent, it is above average; and it would be excellent if it is known and greater than 60 percent.

So, I am investing huge amount of time, resources, money, top management is committing, so it is necessary for me to see that Six Sigma can really give me tangible benefit in terms of profitability, in terms of reduction in cost. And if this improvement is more than 60 percent, then I am successful in my implementation. Similar way, you can see the financial part that generally not quantifiable if your implementation is not adequate, if it is inferior. Below average not well defined or it is less than 40 K dollar 40000 dollar, then it is below average. And if it is around 100 K 100000 dollar per project, then I will say that my Six

Sigma implementation is yielding above average result. And if it is more than 150 K dollar, then it is excellent.

So, similar way you can see another intangible aspect that is organizational approach and cultural change. So, Six Sigma remember is a methodology, it is a philosophy basically it not only helps you to improve the quality of the processes by reducing variability, but it continuously put the organization under a process of improvement, refinement in terms of its attitude, organizational culture, their passion for quality, learning through team and this component is extremely important to realize in order to see the benefit long lasting as well as implementation of Six Sigma with a greater is in other processes also.

So, if you can see that there is little impact on organizational culture, than my Six Sigma implementation is inferior. If I can say more frequent use of data, but in isolated case still it is below average. Above average trend or movement towards use of analytical methods, people are motivated they want to use the analytical approach logical approach, discuss with each other work in team. And finally, I will say that my Six Sigma implementation is bringing excellence result, if it becomes a way of thinking and passion for the work.

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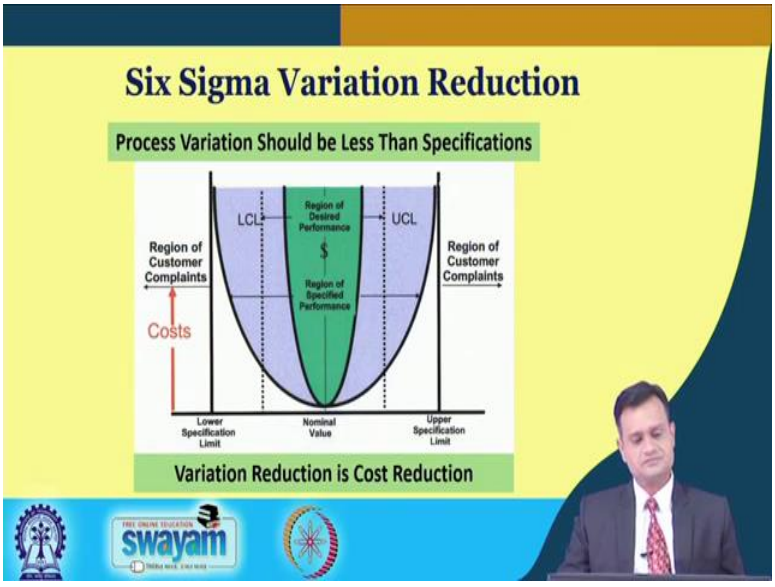

So, we can very well see through this diagram that what is the variation reduction and how Six Sigma basically helps us to achieve this. So, you can see that there is a region of consumer complaint, and the moment you go out of your specification limit; either upper specification or lower specification, you will find that your products or services are not

performing well. Suppose, I commit as a say a restaurant to deliver my order within 30 minutes; and if it is delivered in 1 hour, the food is now no more say delicious to consume, it has become cold, then my customer would not like if I am crossing this specification limit.

So, you have specification limit and you are operating with a particular say bell shaped, inverse bell shaped curve. And you can see that if the variability is high, then there is a possibility then your process may get shifted and you will be producing more defects; means producing product or services not meeting the customer expectation, but you can see the green region, and you will see that if I can bring my variability very close to nominal value, then basically I am producing A grade services and products.

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So, Six Sigma is a system for improving profitability. And just see that one sigma improvement from your present status can yield 20 percent margin improvement. 12 to 18 percent increase in capacity. You can better utilize the capacity, 12 percent reduction in number of employees, please do not miss understand that Six Sigma should be used as a strategy to give layouts to the people; we want to utilize the people for better purpose, I do not want my people simply to waste the time on rework or say inspection, but rather they can be utilized in better function where their competency can really bring value for the company. 10 to 30 percent reduction in capital, and these are some of the public results which really motivates the companies opt for Six Sigma.

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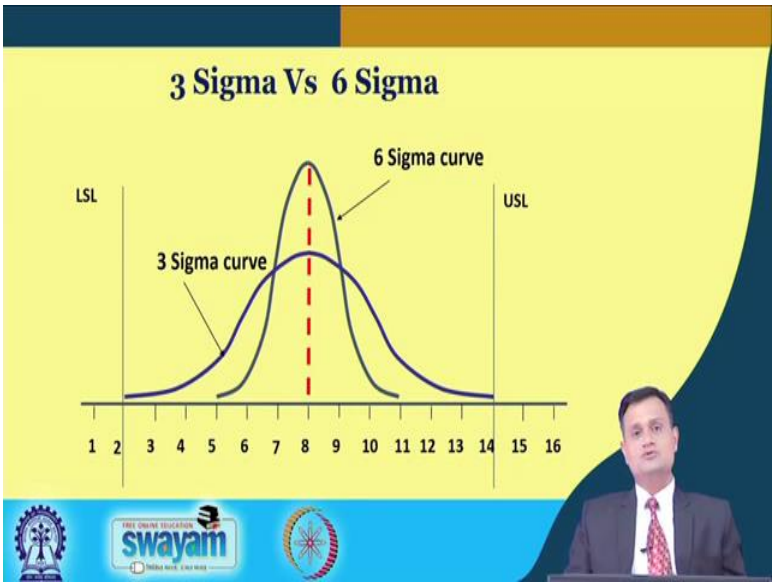

Now, this is something very very important that 3 Sigma and 6 Sigma. And please remember this slide throughout the course, many a time student they make a mistake when we ask that what is the difference between 3 sigma and 6 Sigma; they will say 3 sigma means small, 6 Sigma means large, this is a big cross wrong. Please understand 6 Sigma is about reducing variability and making your process is more centric to mean value, target value, when you achieve these you can see here that 6 Sigma curve is more centric towards the mean value, variability is lock where as 3 sigma is widely spread it.

Now, if you see this both the process is three sigma and 6 Sigma, then they both are within the specification limit lower specification and upper specification, but you can just see if there is a small shift in 3 sigma process, immediately you will start producing defective products or services; whether it is crossing lower specification or upper specification, but in case of 6 Sigma there is a huge band available. Even if there is a shift because of certain reason, maybe beyond your control, even if there is a shift in mean you will find that your processes are well within the specification limit, and probability of producing defective items is very very less.

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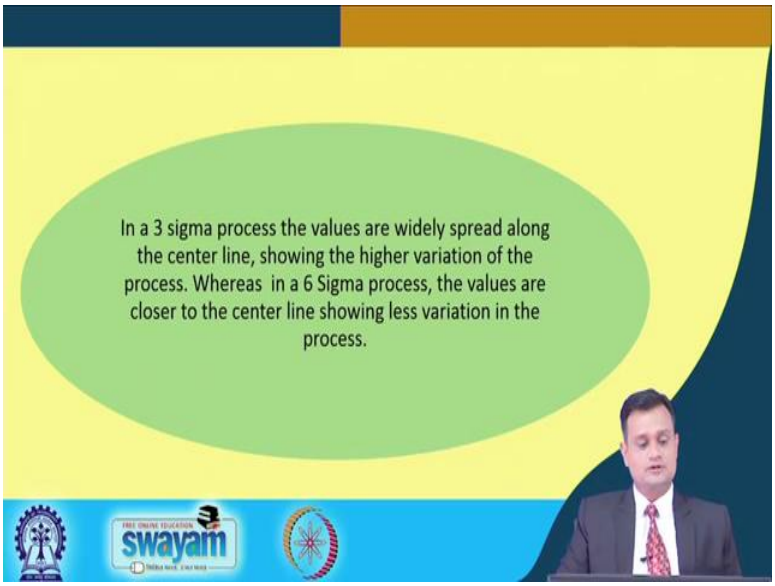

So, 3 sigma process the values are widely spread along the centre line, as I have shown. And the higher variation of the process is typically a problem, this we are able to reduce in case of 6 Sigma.

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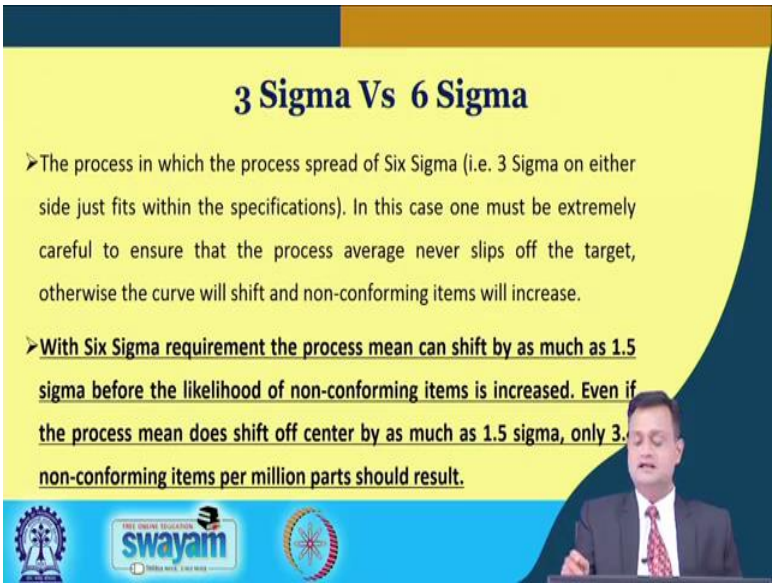

So, this is exactly what I explained. And you can see the remark put in underline that even if there is a shift of 1 sigma 1.5 sigma, then also I would and if I am operating with 6 Sigma, I would not be producing say defective products, but this become very much evident in case of say 3 sigma. In 6 Sigma, the defectives produced with 1.5 sigma shift is

just 3.4 non-conforming items per million, and this is almost close to 0; and this shows that we can achieve almost 0 defect through 6 Sigma.

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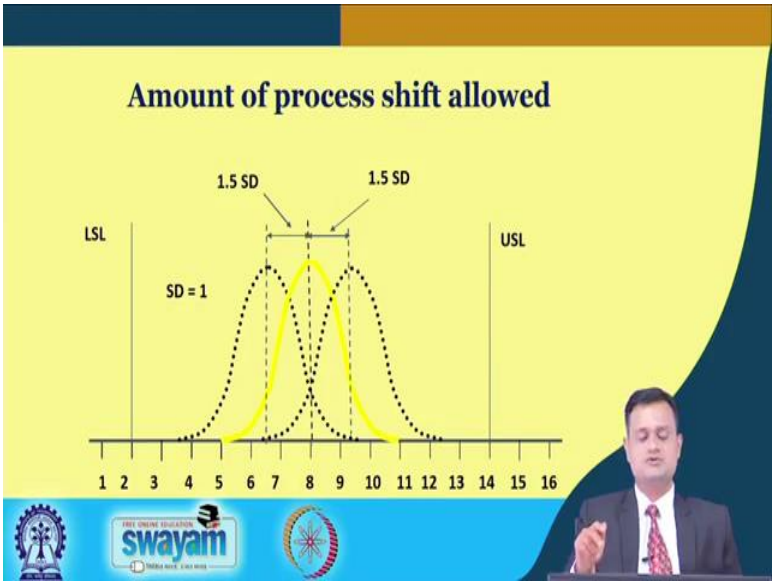

So, this is exactly explained that your process may shift towards right or left with 1.5 sigma and still you are well within the specification limit, and you are producing the A grade products and services.

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So, in 1989 Bill Smith defined Six Sigma as organized common sense. So, it is a systematic approach as I am telling you repeatedly through DMAIC cycle and it is an organized

common sense to identify the root cause, identify the appropriate solution, control it and then sustain it.

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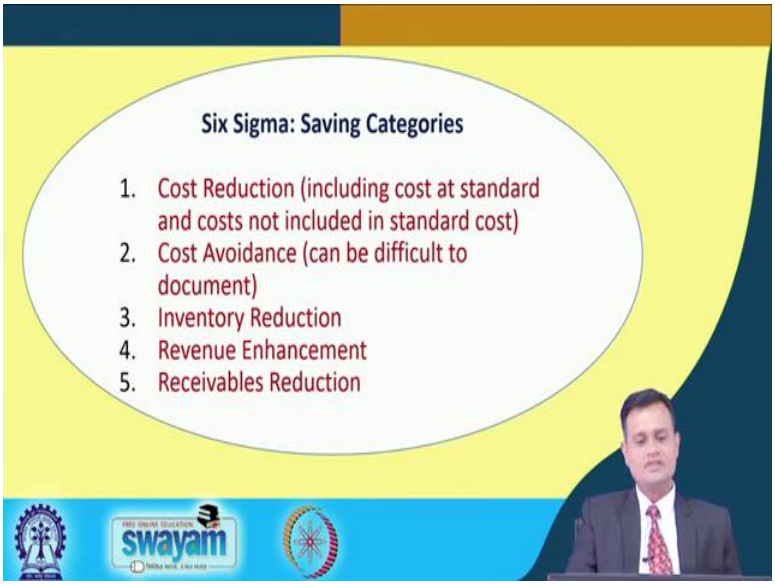

Six Sigma can bring enormous benefits in terms of cost reduction, avoidance sometimes, inventory reduction, revenue enhancement and receivable reduction.

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So, typically it is a radical change. You can drastically improve your sick let say defect, overall defect rate by improving your sigma level.

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And if you see this particular representation, then it is high accuracy, high precision; low accuracy, high precision; high accuracy, low precision; low accuracy, low precision; obviously, I would like my processes to achieve high accuracy and high precision, it means I should be close to target and my overall reading should also fall within a particular say closeness, so that I can achieve high precision high accuracy.

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There are basic matrix which we will discuss over a period of time. Sigma, capability C p and C pk, defective parts per million, defective versus defects, then DPMO role throughput yield, typical lean metrics, cost of poor quality and so on.

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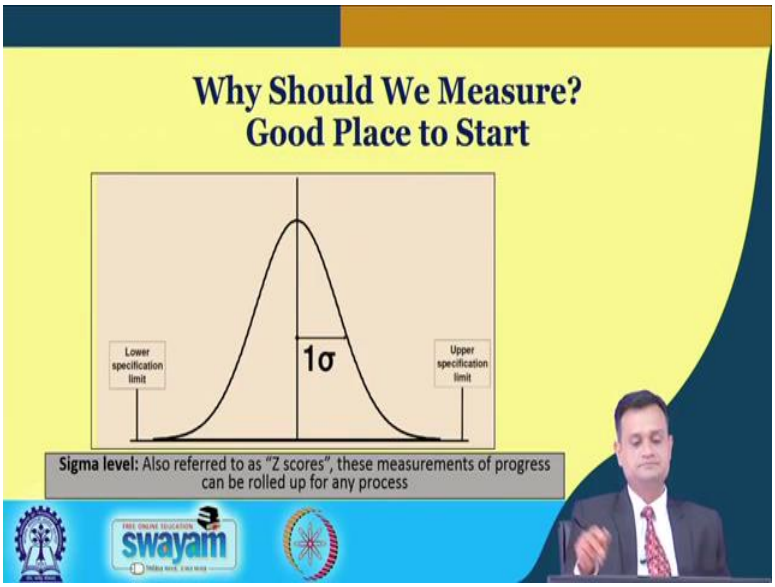

So, typically you can see that why should we measure? And good place to start. So, we typically use z score, we will see later on. And normal distribution to judge my sigma level and 1 sigma or 1.5 sigma shift, it may take place as the processes are under the operation.

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So, there are some basic terminology I would like to introduce, one is defective, another is defect. So, an item that always contains at least one defect and may contain more defect, it is typically called defective. Defect means a characteristic that makes the process output defective. And you may say that a defective is basically faulty product because of one defect or more defect.

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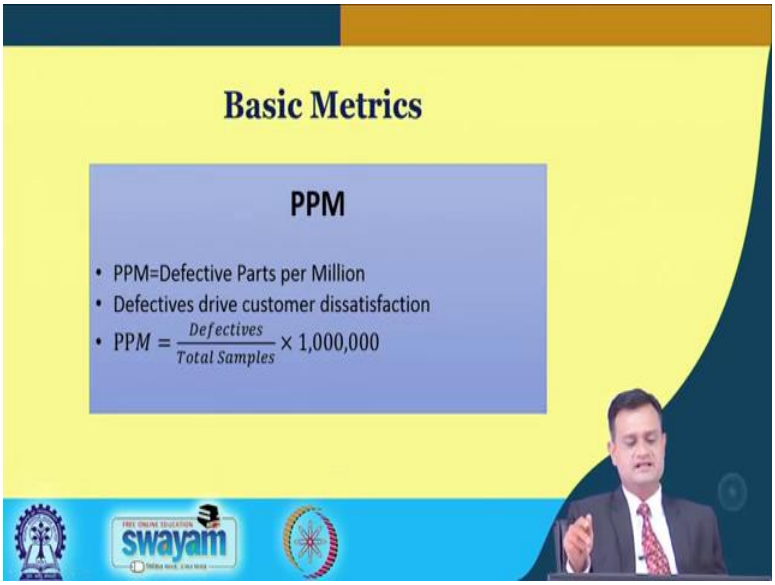

So, Six Sigma matrix and measurement let us just try to little bit focus on couple of matrix PPM is defects Parts Per Million. And I can measure PPM as defectives divided by total sample into 1000000 that is basically 10 lakh, and this is how I measure.

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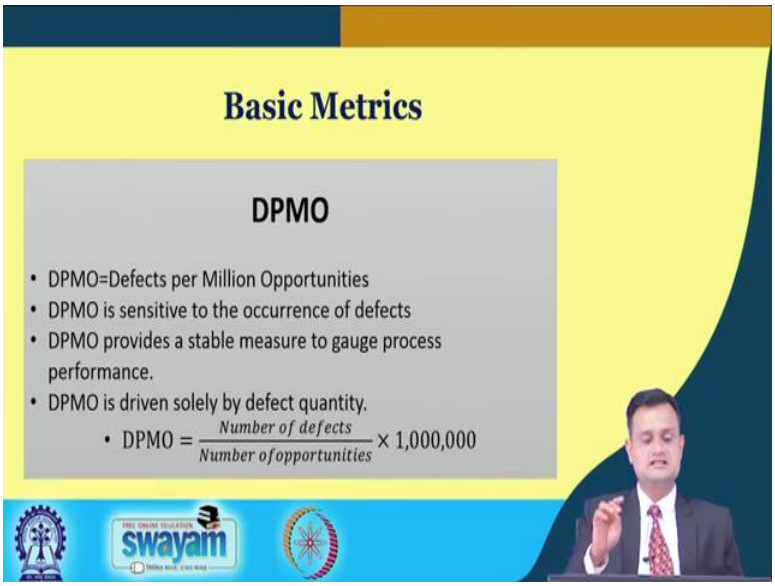

Second is DPMO. So, Defects Per Million Opportunity and this is sensitive to the occurrence of the defects. So, DPMO typically provides a stable measure to gauge process performance. And it is the ratio of number of defects divided by number of opportunity into 10 lakh, and this measure can really help us to identify the sigma level of my process.

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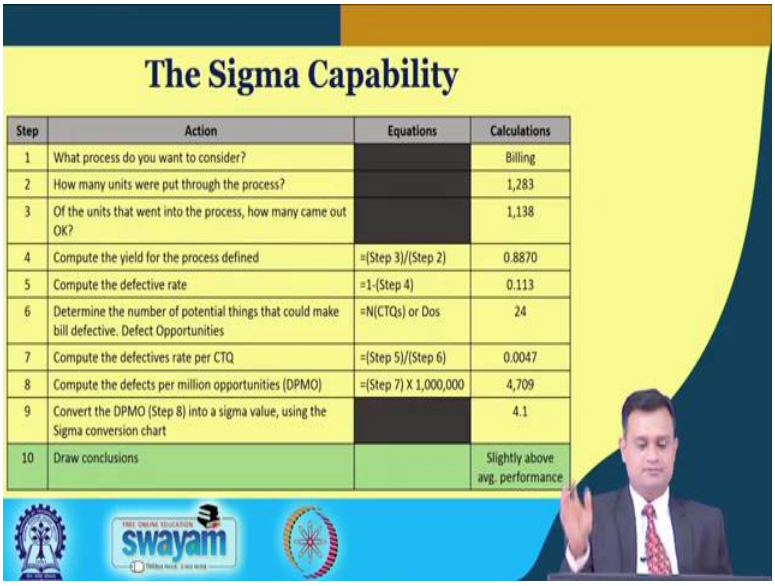

Step	Action	Equations	Calculations
1	What process do you want to consider?		Billing
2	How many units were put through the process?		1,283
3	Of the units that went into the process, how many came out OK?		1,138
4	Compute the yield for the process defined	=(Step 3)/(Step 2)	0.8870
5	Compute the defective rate	=1-(Step 4)	0.113
6	Determine the number of potential things that could make bill defective. Defect Opportunities	=N(CTQs) or Dos	24
7	Compute the defectives rate per CTQ	=(Step 5)/(Step 6)	0.0047
8	Compute the defects per million opportunities (DPMO)	=(Step 7) X 1,000,000	4,709
9	Convert the DPMO (Step 8) into a sigma value, using the Sigma conversion chart		4.1
10	Draw conclusions		Slightly above avg. performance

Let us just take a simple example, and the process here is billing, I want to figure out that what is the sigma level of this particular process. So, the question I am asking what process do you want to considered? So, the answer is billing. How many units were put through

the process? So, 1283. Of the unit that went into process, how many came out ok? So, 1138. Compute the yield for the process defined? So, I just take the ratio of step 3 then 2, so it comes out to be 0.8870. Compute the defective rate? 1 minus step 4, so 0.113.

Determine the number of potential things that could make bill defective? So, let us say my CTQ NCTQ is 24. Compute the defective rate per CTQ? So, obviously I will take the ratio of step 5 and step 6; this comes out to be 0.0047. And eight compute the defect per million opportunity? So, this would be say step 7 into 10 lakh that is 4709, and this I can relate with sigma level from a particular table I will show you, and this corresponds to 4.1.

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So, just see this table and you will get an idea. I have DPMO, let us say in the previous one I computed, my DPMO is 4709. And if you see here, then the corresponding sigma level will be somewhere in between DPMO 3000 and 6200.

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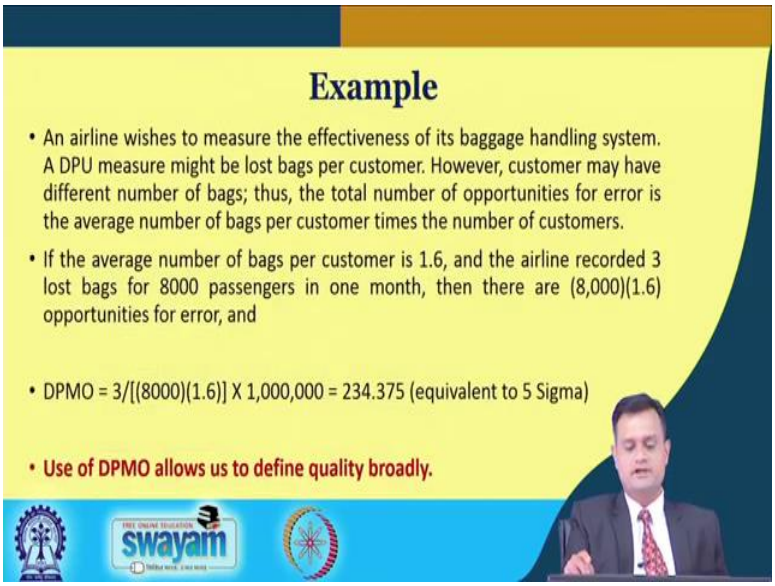

So, say it would be somewhere around say, it would be somewhere around 4.1 sigma, so this is how we compute the sigma. And I would like to add one more example, we are all aware that airlines many a times they miss handle our baggage, and there is a loss of baggage also. So, and airline wishes to measure the effectiveness of its baggage handling system. A DPU measure might be lost bags per customer, and customer may have different number of bags. So, the total number of opportunities for error is the average number of bags per customer times the number of customers.

So, let us say if the average number of bags per customer is 1.6, and the airline recorded 3 lost bags for 8000 passengers in 1 month, then there are 8000 into 1.6 opportunities for error.

$$DPMO = 3/[(8000)(1.6)]\ X\ 1{,}000{,}000 = 234.375\ (equivalent\ to\ 5\ Sigma)$$

So, knowing the present sigma level can definitely help me to strive for the higher one.

Before I close the session, I just want to float couple of questions this will help you even to have a quick brush up of the concepts we have discussed, and internalize the concepts better.

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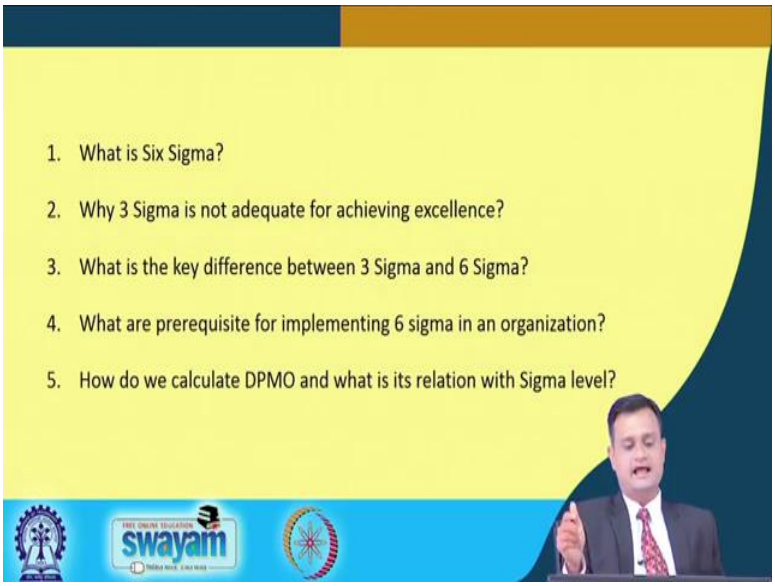

So, what is Six Sigma? Why 3 sigma is not adequate in today's competition for achieving excellence? What is the key difference between 3 sigma and 6 Sigma? Again cautioning you, please do not make a mistake. What are the prerequisite for implementing 6 Sigma is an organization? Organization cannot implement 6 Sigma just like that they must have open and deadness. How do we calculate DPMO and what is its relation with the sigma level?

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So, these are couple of things we have discussed. For greater detail you can see this references Mitra, Evans by introduction to Six Sigma and Fundamentals to Quality, Roderick and so on.

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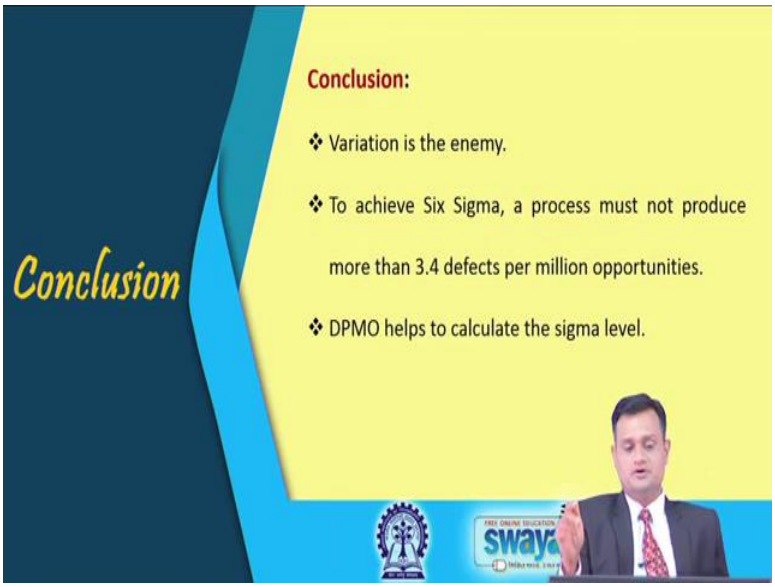

So, the conclusion is that variation is the enemy. If you want to achieve Six Sigma, a process must not produce anything more than 3.4 defects per million opportunity and DPMO helps to calculate the sigma level.

So, with this thank you very much for your patience; and interest in learning this particular course. Please revise the concepts. And we will continue with the concepts principles and focus area as part – 2 in the next lecture.