Introduction to Abrasive Machining and Finishing processes

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Lecture - 12
Surface Integrity in Abrasive Process

Now, we are going to study about the Surface Integrity and what the Surface Integrity is and what it deals about and at the same time, how the Surface Integrity in Abrasive Processes and other things we will see in the current lecture.

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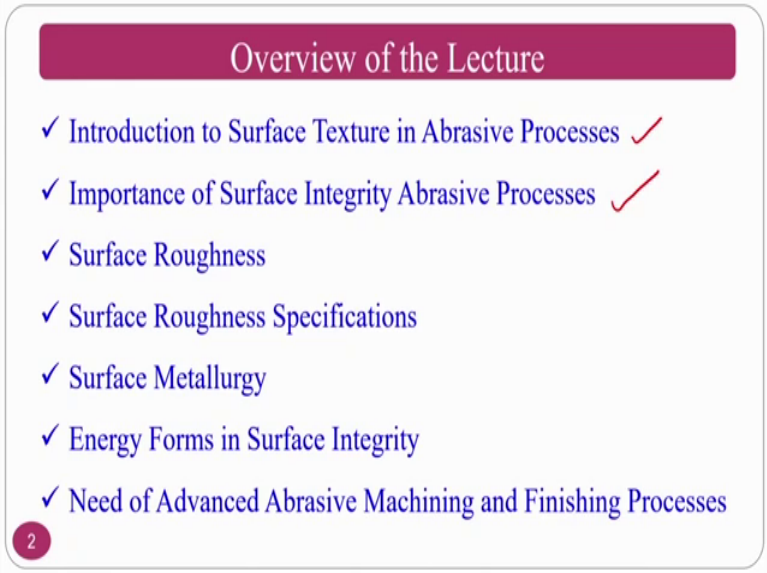

Overview of the lecture, we will see the Introduction to Surface Texture in Abrasive Processes; The Surface Integrity in Abrasive Processes; Surface Roughness; Roughness Specifications; Surface Metallurgy; Energy Forms and Need of Advanced Abrasive Machining and Finishing Processes.

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So, as you see the Grinding Process which you are familiar about this particular process. This is one of the conventional grained, conventional abrasive finishing process or conventional abrasive machining process you can say. So, it is not only doing the surface roughness, but also it is generating lot of heat because of which it can vary Surface Roughness and Surface Metallurgy ok. Because of high temperature, what is happening is it will burn the surface sometimes; at the same time it will degrade the surface.

Suppose, parent material grain structure is x size; you may get more size or less size or the size of the grains will alter because of the temperature that is generated during the process. That is why we will all use that cutting fluids and other fluids in the grinding process. If you are not going to use, there is lot of problem. If we you are going to use, there are some other problems which you have seen in the previous classes.

Now, I am going to teach you about the surface roughness aspects as well as surface metallurgical aspects in this particular class. But most often as a mechanical engineer, you deal with surface roughness and how the surface roughness representation will be done and other things, you will see in this particular class ok.

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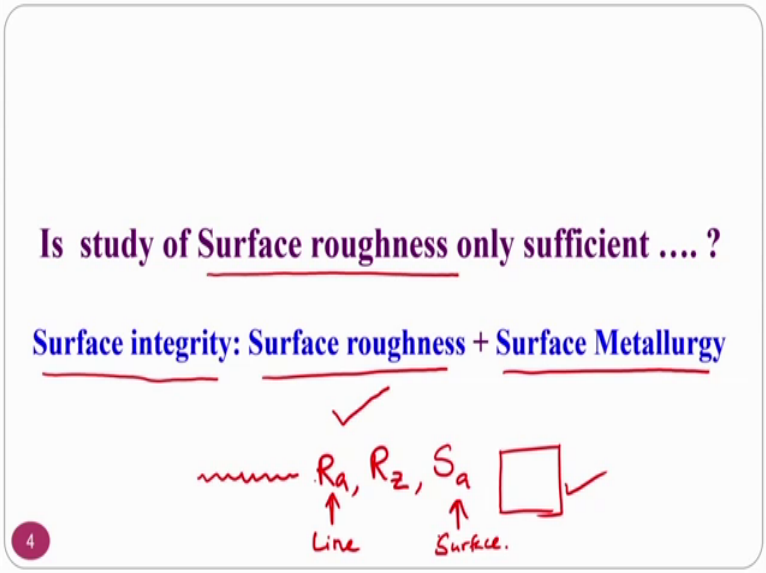

Is the Surface Roughness only sufficient? It is the question because if you see the previous slide, where the surface grinder is grinding the picture, where the lot of spark is generated ok. For that purpose, you always look at the Surface integrity that is nothing but the Surface Roughness plus Surface Metallurgy. These are the two things that one has to take care. But as an a mechanical engineer, we deal mostly with the surface roughness like R a.

R a surface roughness value, R z maximum peak to minimum value and the S a surface roughness value; that means, that this tells R a tells about a line. Normally, S a tells about a surface ok. So, I mean to say, S a will deal in a particular surface; what is average roughness in this particular surface. It will deal about in a line; what is the value in the particular line that is the difference between these things.

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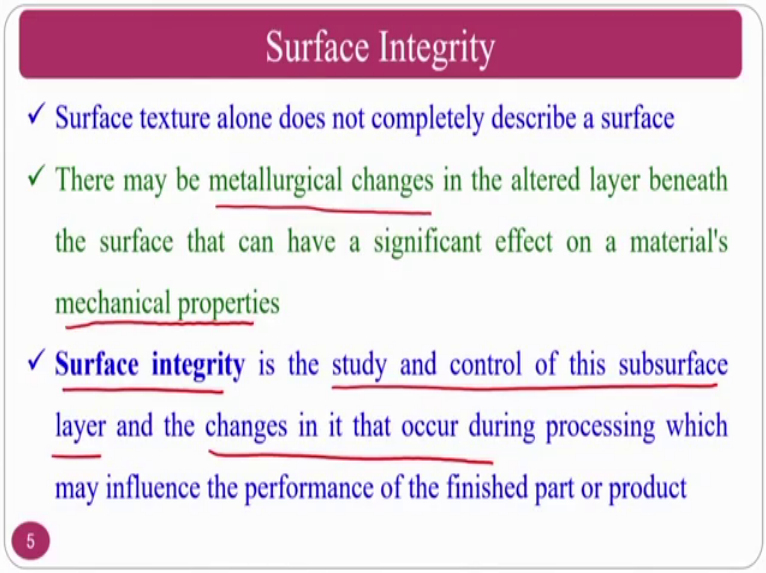

The Surface Integrity, the surface texture alone does not completely describe the surface because the surface will have roughnesses; surface will have chips that is nothing but the burns; surface will have the burnt surface. Surface will have many things in a mechanical system because of lot of kinetic energy, mechanical energy and other things are involved in this one.

So, there may be a metallurgical changes in the alter layer beneath the surface that can have significant effect on the mechanical properties. Assume that the surface roughness is very smooth, but if the surface is burnt whenever you put this particular component in a practical application because of the burnt surface metallurgical changes happens and these metallurgical changes will lead to the failure of the component.

Even though, surface roughness is very very good. The component fails because of the cracks formation because of the other things formation during the practical application. So, the Surface Integrity, that is why surface integrity came into picture. It is sturdy and the control of this subsurface layer and the changes in that occur during the processing which may influence the performance of the finished product; that means, surface roughness will occurred the complete one. It also have metallurgical aspects, how the grain structure is varying; how is there any burning surfaces there are something.

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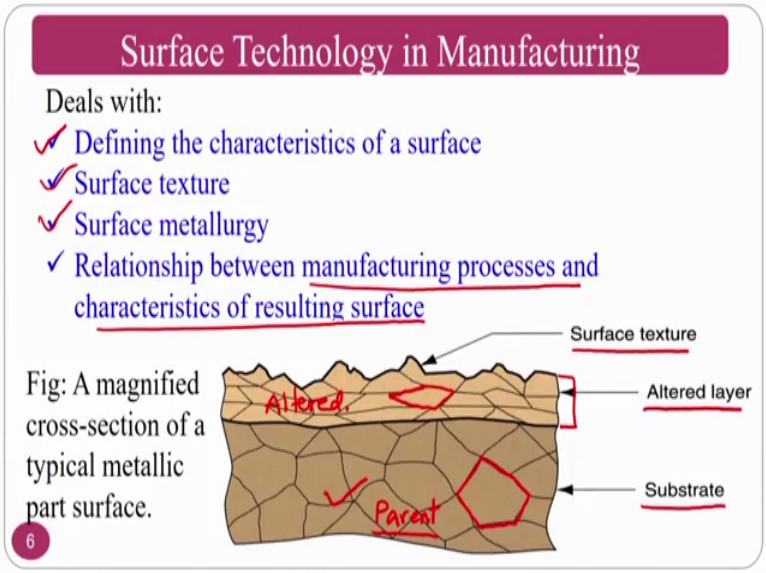

So, that means that the surface integrity has to be taken care that means, that not only you have to see the surface roughness, you have to see the metallurgical aspects also. This surface technology or the surface integrity defines the normally defines the characteristics of the surface, the Surface texture, Surface metallurgy and the relationship between the manufacturing process and the characteristics of resulting surface ok.

If you see your surface, the surface will have a Surface texture, Altered layer that is nothing but the layer on the top surface and the Subsurface ok. So, if the surface roughness is to a customer, but there is a altered surface. This much surface is altered with respect to the grains that are there.

If you see here particular grain structure or the grain size is this much, but if you see the same thing in the altered surface, it is elongated and it is compressed because of lot of mechanical forces and other things ok. That means that in a component, I want this particular surface that is the parent surface. This is called Parental surface; Parent material and this is a changed or a Altered surface ok. So, whenever I want to put a particular component, I want purely as a customer, I want parent material to be involved with respect to the interacting surfaces. But because of the manufacturing process that are involved; you may alter the process may altered the surface.

That is why we have to take care about the surface roughness as well as surface metallurgy and this altered surface will have a different morphology, different metallurgy and the surface roughness also.

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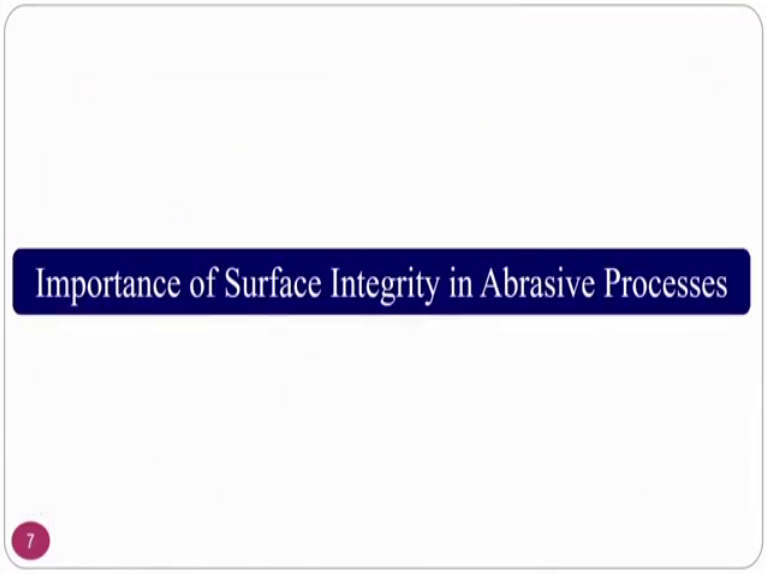

So, that is why the importance of surface integrity in abrasive processes which we are going to study because of the altered layer and the same times the surface roughness also ok.

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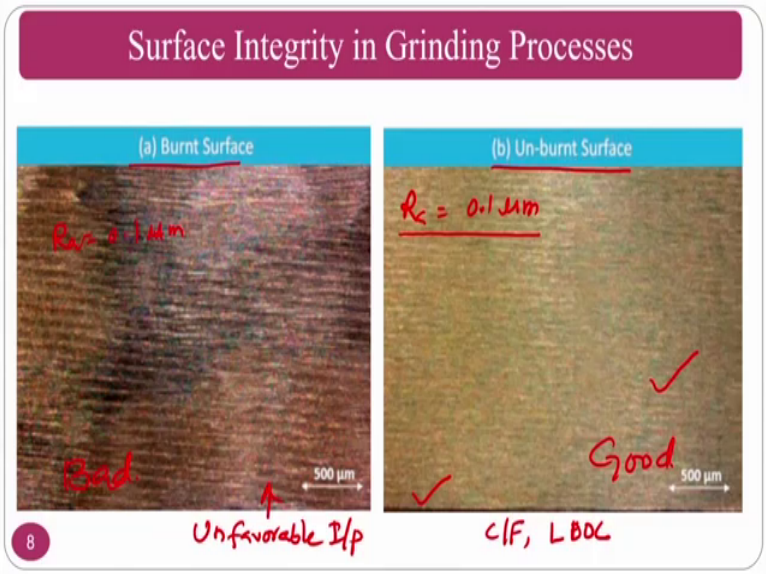

Surface integrity in the grinding process if you see Burnt Surface and the Un-burnt Surface, if at all you want to see the same surface; if you are giving a good input conditions, you are going to end up with a un burnt surfaces; otherwise, you are going to end up with a burnt surface. If you see this one, if you see this one, the completely the surface is burnt because of unfavourable conditions or unfavourable input conditions that you (Refer Time: 08:08). This burnt surface is because of unfavourable input conditions that you have or the operator has given during the operation, during the grinding process ok.

So, Unfavourable input conditions leads to this particular process and if you are going to give proper cutting fluid and cutting fluid is given low feed, low depth of cut and other things are given here; that is why the surface and the surface is Un-burnt. That is that is why this surface is good from the practical point of view ok. This surface is good, but this surface is not good.

Even though, what I mean to say here is if the surface roughness is same because assume that your R a value here is 0.1 micrometer; here also R a is 0.1 micrometer; still the surface if you put both the surface components assume that I have a 2 components, wherein surface is one burnt surface or un burnt surface, if you are going to put this practically; what will happen? Un-burnt will give more life, but are burnt will give less life because of its metallurgical changes. That is why you have to see at the metallurgical aspect.

Not only the morphological aspect. That is why that is what I want to convey for those people who works on surface roughness in a grinding or advanced machine processes and other processes because, students will always reports about the Ra value. They will say that we have achieved 0.1 micron or 0.01 micron and other things. But sometimes the paper lags in the research paper. It may alter the surface metallurgical aspects. So, people always should mention the roughness value as well as if possible if the facilities are available, you also give the element analysis and surface morphological analysis using ISCM and EDAX analysis or EDS analysis; using the elemental analysis also you have to give ok.

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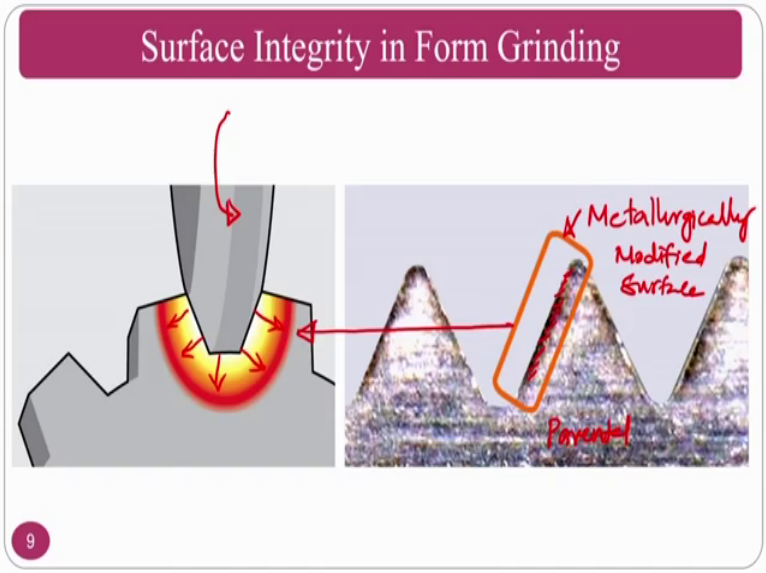

So, keep in mind whenever you report a research paper, the surface integrity in the form grinding basically if you see the form grinding like assume that we are going to do the Gears cutting and other things. What is going to happen here is if you see the surface here, normally a this is the parental surface and this is Metallurgically changed surface, Modified Surface ok.

So, whenever you put this particular component in a practical usage, what will happen? This particular surface will damage because the microstructure is different and morphology is different because of this, this particular surface may damage as early as possible because of the crack formation, because of the other formations and others things.

This particular layer is formed because of the temperature that is generated during the this particular process whenever you are giving a motion like this, this temperature is generating because of the temperature generation; what is happening? The microstructure is changing. If the microstructure is changing; what will happen? Metallurgical changes will occur to this particular component and because of this; it may fail during a practical application process.

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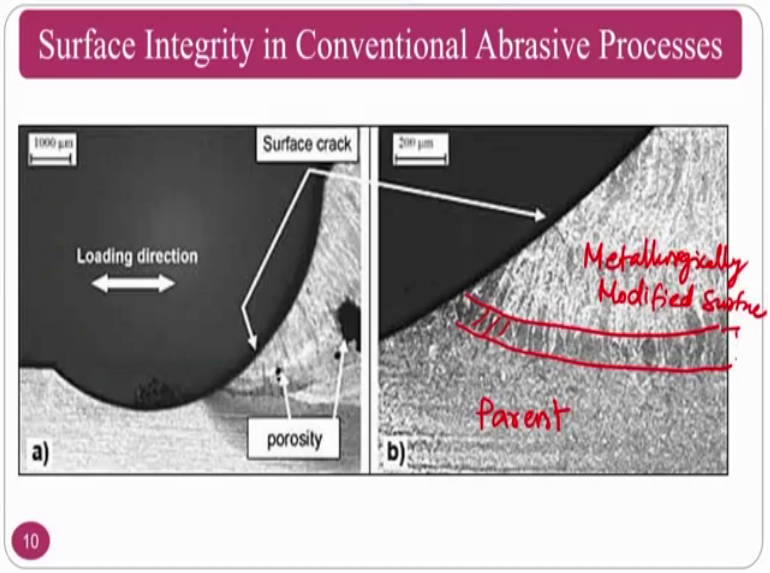

You can also see the surface integrity in terms of other manufacturing processes. This is the Parent material, Parent elemental structure and you can see here clearly the because of the heat and other things, this is metallurgically changed. Called Modified surface, Metallurgically Modified surface and this is the surface, wherein there is a gradual change between a metallurgically modified layer as well as the parent material.

Sometimes, people call it as a conversion layer because the microstructure which is there in a metallurgically modified surface and the parent material gradually changes between the microstructure of that two parent material because of which the gradual conversion takes place and this is called a conversion layer in some of the textbooks ok.

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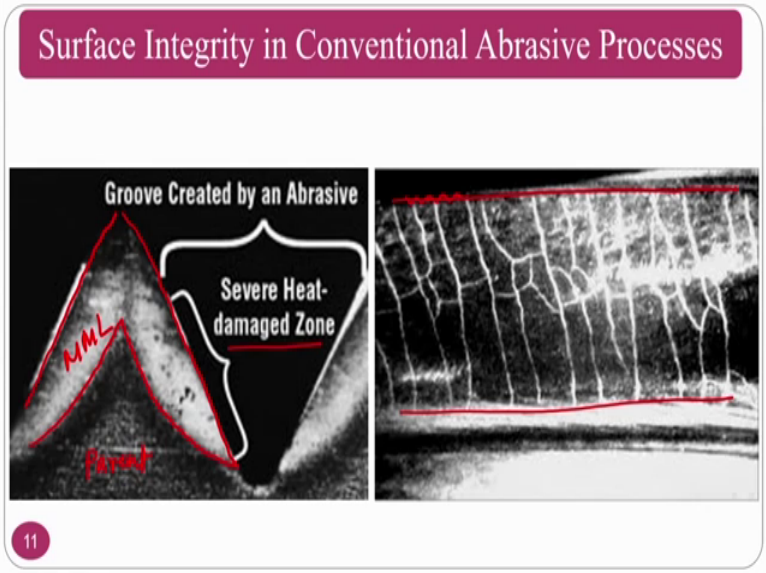

You can see, the group created by an Abrasive because of this you can you have seen the previous slides, where a structures are formed like grain structures are formed severe heat damaged zone is there and you can see, the metallurgically changed layer here ok. This is the parent material and this is a metallurgically modified layer.

So, this is how the metallurgical layer forms because of the heat generation. This layer not only loses its mechanical strength and because of the metallurgical change, but also can create the cracks. You can see here the lot of cracks are generated on the surface and if a never you put this particular component in the practical application, what will happen?

This fractured surface will be brittle enough and it will brittle fracture will takes place and the failure of the component will takes, the failure of the component will takes place. That is why you should be very careful about the surface integrity, not only the roughness. If you see the roughness, this is perfectly flat surface or you do may not get very bad surface.

Here, you have the surface roughness is very good, but you have to think about the surface metallurgical aspects. That is why mechanical engineers, we should also look into the metallurgical aspects and the crack formation, is there any micro structural change is there; is there any elemental change is there? Like that one has to; then, only the people get a good publication in a reputed journals.

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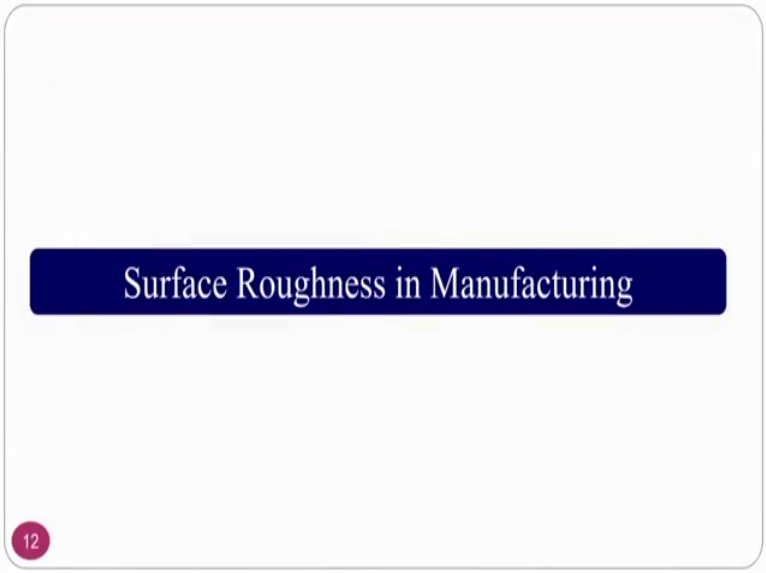

This as a mechanical engineers, what we normally deal with this surface roughness aspects ok. So, till now we have seen the some of the importance of surface integrity and other things. Now, we move on to our bread and butter that is the surface roughness and how it will be measured and how it will be represented and other things, we will see in this particular session.

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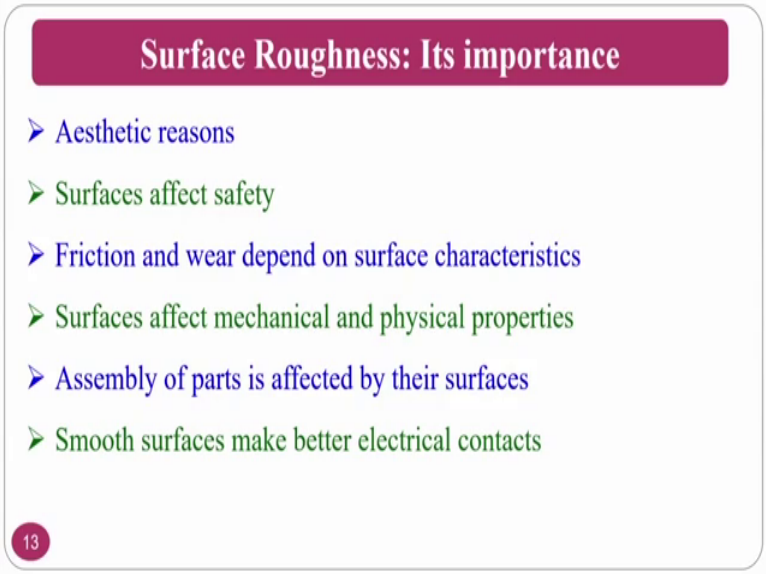

Surface Roughness importance, basically it will give us pl that is nothing but very beautiful look. It will be shining or a mirror surface, it will give and the surfaces affect

safety. Normally, if the surface roughness is very smooth; what will happen? It will be very easy to handle and it may not hurt the fingers or other parts where you are interacting with the particular component or where the operator is handling in that component.

Friction and wear depend on the surface characteristics. If the surface roughness is very high; what will happen? The friction wear and other things will be very high. So, the friction losses will be very high; that means that if you have a nano surface roughness, you will get low wear as well as low friction. The surface effects mechanical and physical properties. Normally, whenever you are putting in the a particular application, the mechanical performance or the physical performance of that particular component will be better if the surface roughness is very good.

Assembly of parts is affected by the surface; that means, that if the surface roughness is good; that means, that your surface finish is good, surface roughness values are low; what will happen? The assembly of components will be very easy. The smooth surfaces make better electrical contacts whenever you need to go for electrical contacts proper.

If your electrical contacts are improper; what will happen? The sparking will takes place and there may be a loss in electrical connections. If you have a very good surface roughness, that means that low surface roughness; so, you will have your electrical contacts will be better and proper connection will be happen. If you see there are 2 surfaces that are one is the Nominal surface.

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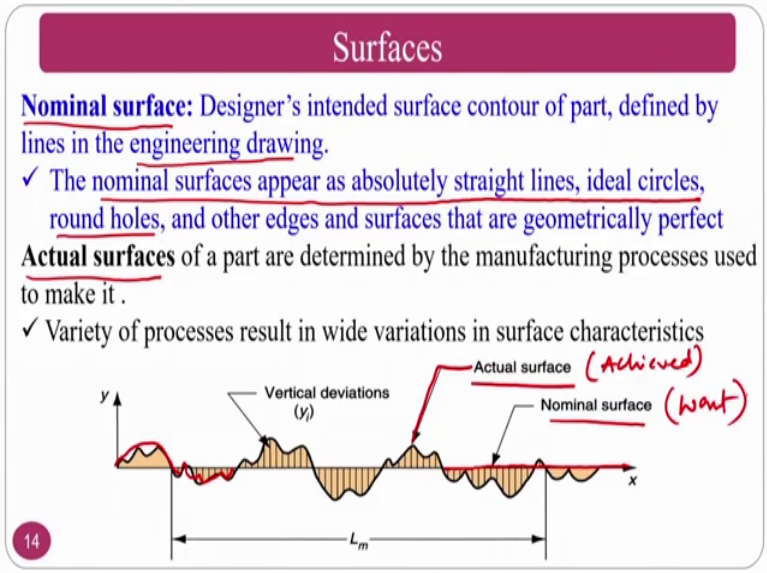

The nominal surface appears to be absolutely straight lines, ideal circles, round holes, and other thing that is nothing but it is the designer's expectation or something. If you see in the particular picture, this straight line shows me the nominal surface; that means, that I want a straight line perfectly, if I do any particular process. Assume that I am want to do a surface grinding process and in the surface grinding I should get a surface roughness very very smooth like a straight line that is what the nominal surfaces tells. But actual surface, if you see the actual part is determined by the manufacturing process and used to make it.

That means, that you intended is nothing but the nominal surface and you whatever you are achieved is nothing but the actual surface. I am intended because I wish to have a nominal surface, but due to the practical constraints of the particular process, you will get certain actual surface where your surface is like whatever is shown here. This is the actual surface and this straight line is a nominal surface. What I want is a nominal surface; what I achieved is a Actual surface; that is the difference between what I expect and what I achieved. I can say instead of want, I can say it what I.

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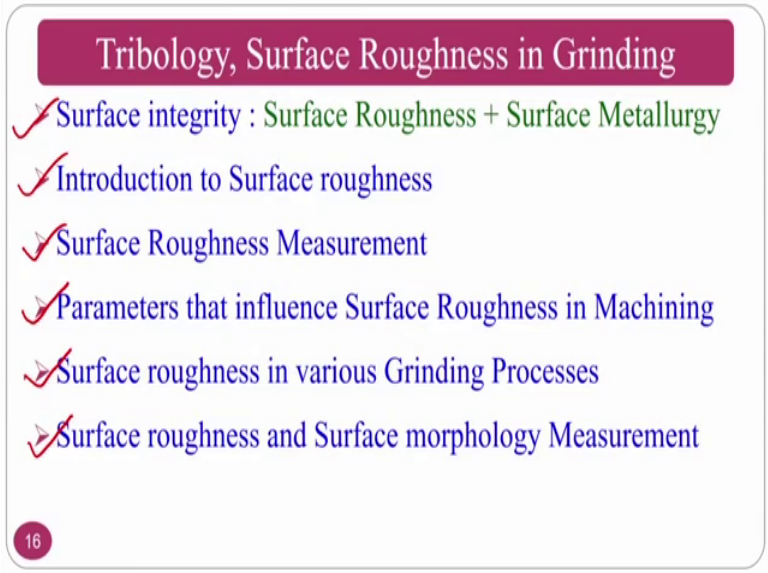

So, the surface roughness in manufacturing process; what I am going to deal here is Surface Integrity which you have seen; the Surface Introduction and other things; Surface Roughness Measurement; Parameter that are going to deal in this point; the Surface Roughness in various Grinding Process and Surface Roughness and surface morphology measurements.

How do you do and other things, we will see in this particular surface roughness section ok. Surface roughness section is one of the most important section as per the abrasive process is concerned because the abrasive processes are random processes because the abrasive size is random, shape is random and cutting edges are random. So, sometimes by the sieving nature or we were sieve, your size may have slight variation.

Assume that my size is 220. So, you may get plus or minus 2 or approximately 3 or something. But the surface cutting edges are random or the same time shapes are random that is why the surface roughness that you are going to achieve is random. If you are going to use proper lubrication and cutting fluids you will get very good surface. But surface roughness what you want and what you achieve is slightly different. For that purpose you have to go through this particular section which is most important from the point of Surface Roughness in a abrasive processes ok.

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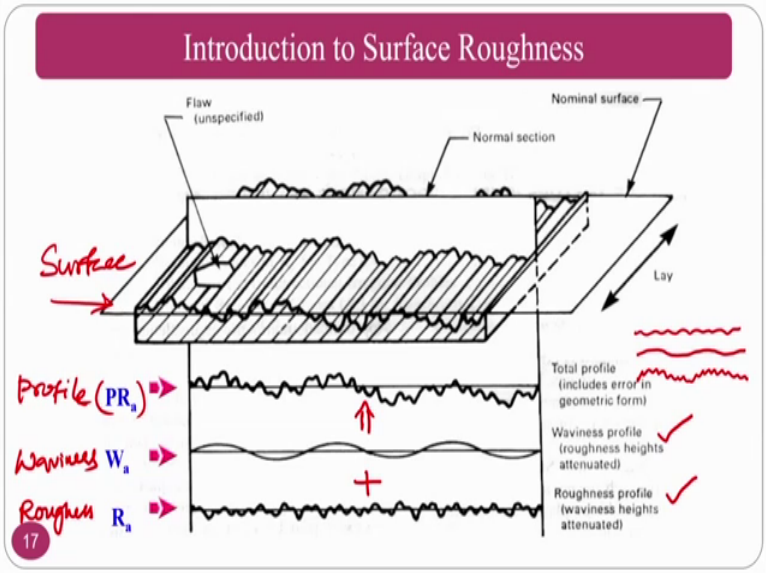

If you see this particular surface, the surface rough will have 3 things. This is the surface ok. So, the surface will have profile. This is called a Profile and PR a represents profile roughness. This is called Waviness and this is called Roughness ok. Waviness profile and roughness profile; if you club the roughness profile and waviness profiles, you are going to get the profile roughness.

Hope you got it. This is my surface roughness and this is my waviness. If you club these 2, what I am going to get is profile roughness. So, originally what you see is a profile roughness, wherein rough surfaces are what we want. That means that we always deal with this particular surface. The waviness is also important so that you can divide the roughness and waviness and other things whenever you want to measure the profile roughness, roughness and waviness you have options in the surface profile emitters. You just choose those sections.

So, that it will give the all the values. Cut-off length is one of the most important because what we are measuring is a roughness. If you are not choosing the cut off length properly, what will happen? Your surface roughnesses values may be slightly vary. Why this will vary? Depend on the cut off length that we will see in this particular slide.

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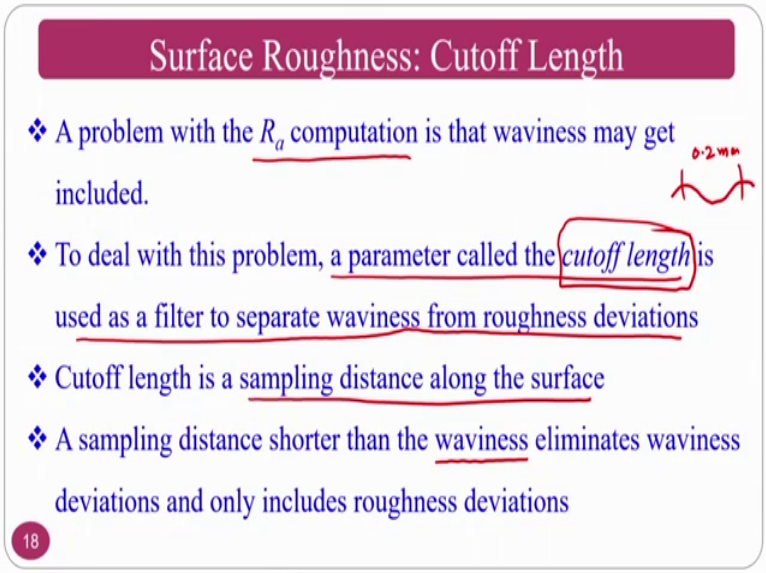

A problem with Ra computation is that waviness may get included; that means, that as a manufacturing engineer, assume that your requirement is to know only the surface roughness value; which you do not want the waviness value. So, in that circumstances, if you are not going to choose the cut off value of a particular roughness surface that you are going to measure; then, it may include the waviness also. To deal with these problem parameters called cut off length is used to filter the separate waviness from the roughness deviation; that means that there is one concept or there is one particular thing that you have to give that is nothing but the cut off length.

You have to give a cut off length whenever you do measure ok. What it will be? The cut off length is nothing but the sampling distance along the surface and sampling distance shorter than the waviness, that means you have to give the cut off length most of the times less than the waviness of that surface ok. So, if you can give a cut off length as minimum as possible; what will happen? So, it will eliminate the waviness; if you are intended to take waviness, then you can give the big size cut off length otherwise you have to give very minimal or small cut off length.

So, that it will eliminate the waviness, that means that assumed that my waviness is this much as the distance I can say like a 0.2 mm or something. If we want to remove this one, you just give the cut off length less than that particular value 0.22 mm; so, that the

waviness will not be included in the roughness that is what the some of the textbooks explains.

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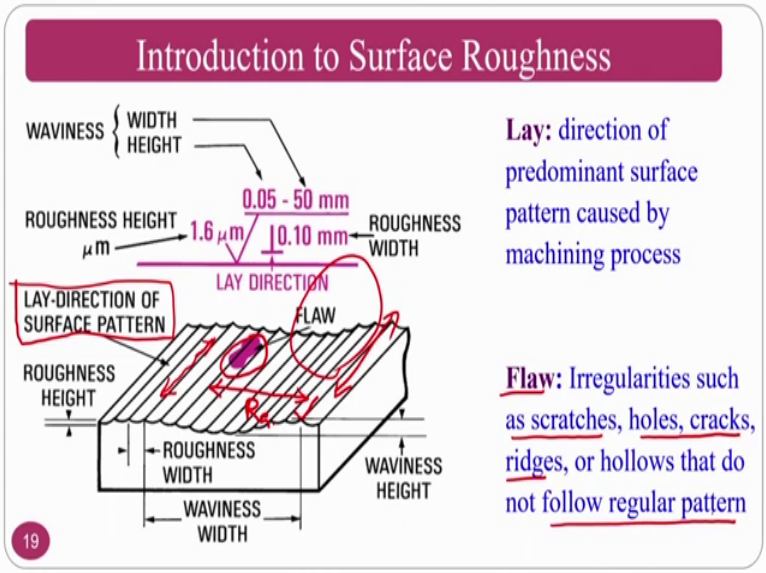

If you see the surface, how the surface is mentioned other things; you have seen the similar picture in the previous slide. So, this is the surface, where I am going to deal with the Lay. Lay is nothing but the direction of surface pattern ok. In this particular thing, the surface is generated by the grinding process assume that the grinding wheel is rotated like this if the surface pattern is generated. That is nothing but the lay is the predominant direction of the surface roughness; how the surface roughness is formed and in that circumstances you have to measure the surface roughness in perpendicular direction to the formed surface.

That means that, this is the direction of your surface roughness measurement; so, that you will get a good value of surface roughness or the original value of surface roughness. Sometimes, some people will measure the roughness in this direction also ok. So, some people claim that this also good, but practically what I feel is that you how to measure like this perpendicular to the Lay direction, then you will get a original surface.

The Flaw; Flaw is nothing but this one whatever is there, Irregularity such as such as scratches, holes, cracks, ridges and the hollow from the regular pattern that means that these are the some of the problems because of the grinding process, problems because of the material defects during the material processing itself.

Assume that I am purchasing a block from a some company; if there is a material defects, these type of flaws will come. Assume that there is a inclusive. So, it will stay there. So, that is a Flaw. If there is a hole which is say blow hole during the casting process. So, that is a Flaw. If you are grinding, then there is a deep hole will come and other things ok.

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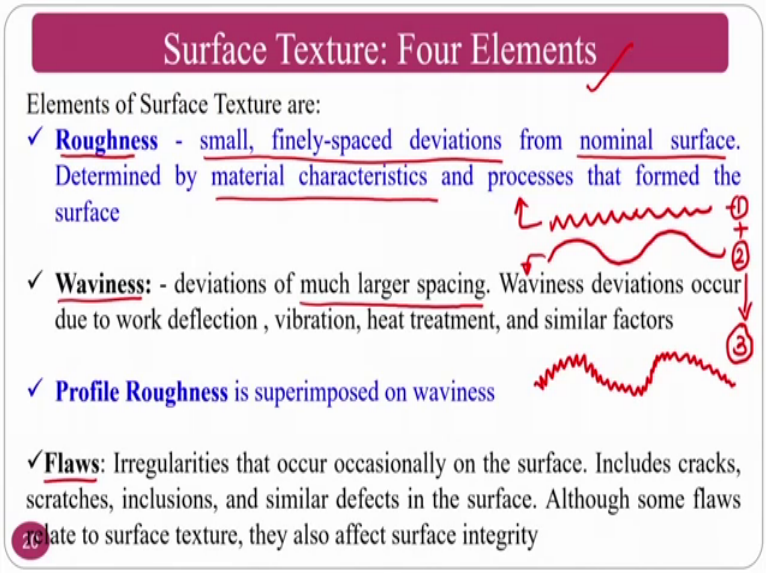

So, what are the things that we have to see the 4 elements. One is we have seen already. So, roughness is nothing but the small finely spaced deviations. This is nothing but the surface roughness from the nominal surface. This is a small finely spaced deviation from the normal surface determined by the material characteristics and process formed by the surface. Waviness as we have seen; it is a deviation from the larger spacing. It is nothing but this is a surface roughness and this is the waviness ok. So, if you can clearly see that this is a small and finely spaced deviation.

But much larger spacing is nothing but waviness. This is the waviness and the profile roughness, if you superimpose surface roughness as well as the waviness, what will happen? You are going to get a Profile Roughness. I am just superimposing the roughness as well as waviness. These two, 1 and 2 if I am clubbing; then, I am getting 3 that is nothing but Profile Roughness.

Whatever Flaws, we have seen these are the ridges or holes that are formed. In the previous slide also we have seen. So, what I want to repeat it here is these are the 4

elements that it determine the surface structure basically roughness, waviness and profile roughness as well as the flaws. These 4 elements will determine the surface structure; that means, in terms of surface roughness only, not in terms of the surface metallurgy.

So, if you consider surface metallurgy, then the things will become more and more complicated and you have to make it very complicated so that you can understand more and you can understand deeply and other things. Because, if you are concentrating only on surface roughness, sometimes you may miss metallurgical aspects; so, if you are concentrating only on mathematical aspects you may miss the mechanical aspect like surface roughness. So, if you are a mechanical engineer and try to collaborate with metallurgical people and come up with a good paper in terms of advances in this particular area ok.

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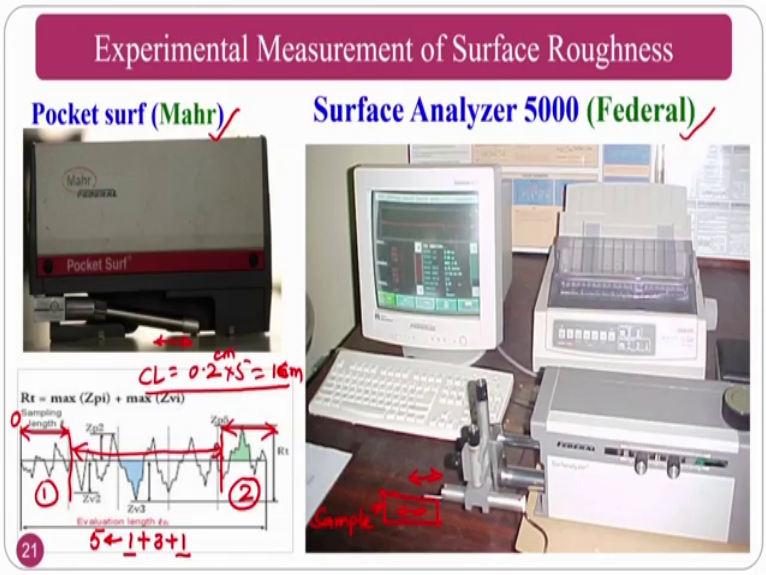

So, these are the surfaces normally if you see here, Pocket surf. This is the one of the experimental methods that normally people will use. At the same time, surface analyzer big one also you can use. This is the what we have used during our experimentation and if you see here, if you are going to place a sample work piece sample here.

This is the sample and this is the contact type of surface for profile meter, then it will move on this particular surface which will reciprocate on this particular surface and it will give you particular value. For the same time, as I said the cut off length and other

things. If you are see in the cut off mean what will happen? If you give a cut off length of 0.2 mm or something; what will happen?

It divides into 5 segments of 0.5 assume that I am going to give cut off length equal to 0.2, then 0.2 multiplied by 5, it will give certain distance and this particular distance it is going to divide is a complete length of travel ok. 1 mm is a assume that this is a 0.2 centimetres if you going to give, this is the 1 centimetre it will give. That means that the maximum length that you can move is 1 centimetre. The first segment and the last segment, it will not consider because this is the acceleration phase and this is the deceleration phase ok.

So, that is why my probe that is a mechanical probe will accelerate from 0 to some its uniform velocity in the zone 1 and zone 2. It will decelerate from that velocity to 0. That is why it would not consider in these 2 regions that and it will give me the original value in these 3 regions. So, that is the beauty about the contact surface profilometers. However, nowadays people are moving towards non contact type of surface profile emitters because this particular thing will give only a R a value and a straight line value. So, if at all people want or the customers want their surfaces to be examined in a neat and clean way, for that purpose people are moving towards the optical type of surface profilometer, where you can measure the surface roughness in a better way.

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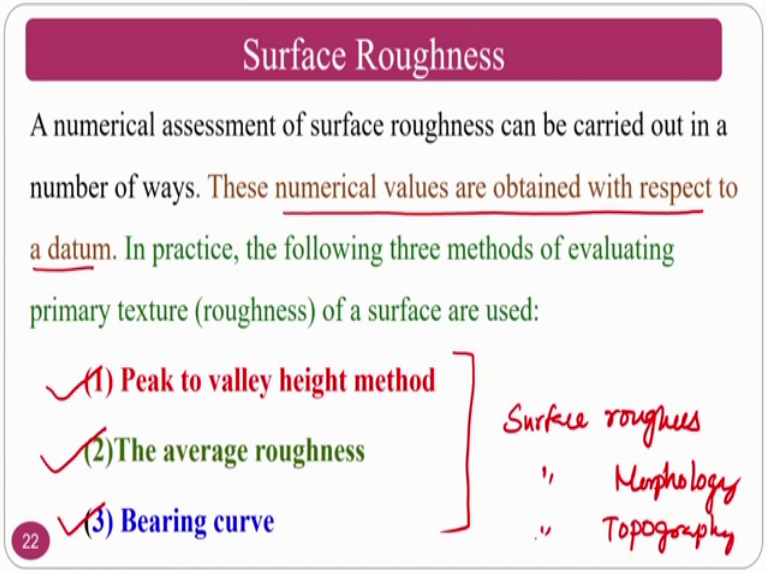

Though, so the surface roughness normally the numerical assessment of surface roughness can be carried out in number of ways. These numerical values are obtained with respect to a datum and in practice the following 3 are the methods. One is Peak to valley height method; the average roughness method and Bearing curve. These are the 3 methods normally people express the surface roughness and surface morphology basically ok. This will explain the Surface Roughness; indirectly Surface Morphology or some people they call it as Topography also ok.

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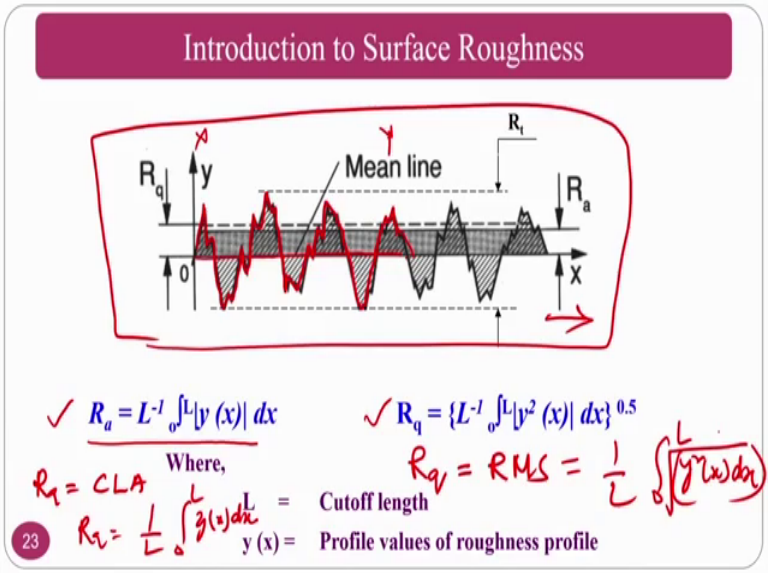

If you see the introduction to the surface, normally there is 2 ways to measure the surface roughness value. Normally, the people likes to go for R a value and the people some of the people will go for R q value also. That means, that R a is nothing but the average surface roughness value; that means, that centre line average value. This is called R a is known as CLA, Centre Line Average Value. How you can measure? Normally assume that I have this particular surface. So, what will happen? This particular surface is there which I do not know any value.

So, whenever the surface profilometer I am assuming it as a contact type of surface profilometer and if the contact surface profilometer moves on this particular surface; what will happen? It will only measure the Surface Topography and it will give certain value; how it will give certain value? That processor I am going to explain you here. This is the surface which I am going to draw and the surface profilometer moved all the nooks

and corners, assume that it is moved to each and nook and corner; what it do is once it move from x to y assume that this is the y.

What will happen? It move what is the where is a peak, where is the if now the surface profilometer knows where is a peak where is a valley ok. It will draw an imaginary line, make sure that the area above the curve equal to area below the curve. So, if it is not matching, then there will be a trial and errors things will takes place in the software and it finds the average curve, wherein the area above the curve equivalent to are below the curve. Once it use the area above the curve equivalent to area below the curve.

Now, you can calculate all the values. Ra equal to 1 by L 0 to L y of x into dx ok. So, way of the x into dx along the x axis change in length you can calculate and you can do. This is called Centre line average value. In terms of Rq that is nothing but RMS value that is root means square value 1 by L 0 to L and this is under root basically. So, the only difference that you are going to get here is whenever the surface roughness is higher, your RMS value will be slightly higher compared to your Ra.

Because as per the equation is concerned you are doing the square, then you are doing the under root. So, it has to come near to your CLA value, but whenever the values or the surface roughness is higher and higher these squared terms will increase the value and if at all for a same surface what I mean to say is that 1.5 with the surface roughness.

In CLA, if it is 1.5 in RMS value anomaly it will be like 1.5, 1, 1.505 or something slight variation will takes place in terms of root mean square value compared to Ra value. This is the only difference that you can find, but the equations are in front of you, you can see and you can try also some of the values and other things.

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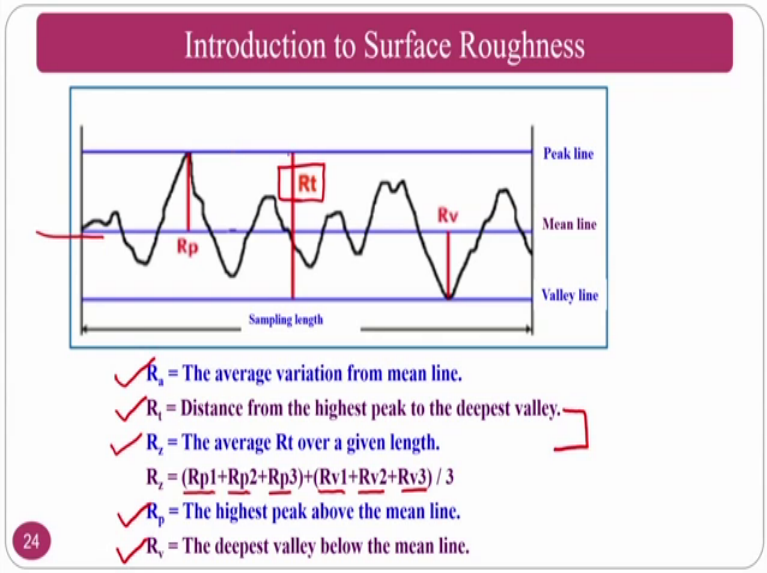

Other values if you see R p and other things Ra the average variation from the mean line that is nothing but the centre line average value that we have seen in the previous one. R t is the distance from the highest peak to the deepest value. That is nothing but this is the R t and R s R z is the average R t over a given length. That is nothing but R p 1 R p 2 R p 3 plus R v 1 R v 2 R v 3 by 3; that means, that maximum peak to minimum valley you are taking at multiple locations and you are doing the average value. And R p is nothing but the highest peak, R v is nothing but the lowest or the deepest valley.

If you are going to measure the R z that is nothing but average of 3 biggest peaks and 3 deepest valleys you are doing certain average value and you are giving that is recommend R z. So, people sometimes may confuse between R t and R z. So, R t is nothing but the maximum peak to minimum valley and R z is nothing but you take on a average line; 3 big peaks and 3 deepest valleys average it and you are going to take. So, approximately here also this values are slightly variant; but within you can say that there is a slight variation in the particular values.

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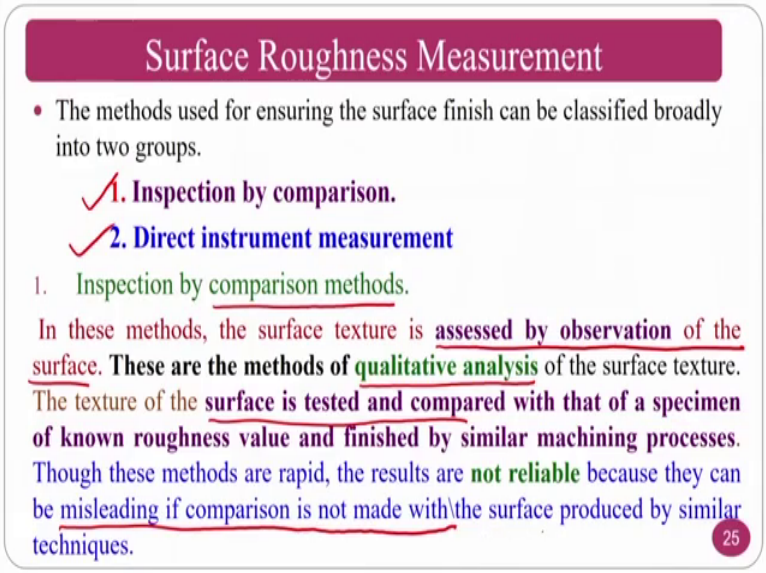

So, surface roughness measurement, if you see the surface roughness measurement, you can do by the inspection by the comparison or direct instrumentation measurements. Inspection by the comparison method, these methods of surface texture is assisted by the observation of the surface. Normally this is the qualitative measurement or one can do the observe you can observe using laser, you can observe using the other mechanisms and the assessing the values or assessing the quality of the product and other things.

These methods are qualitative analysis. Normally, whenever you see this surface is very good; oh this surface is burnt; if this surface is not good like that qualitatively. Qualitatively, Ram is a good boy is a qualitative statement. Ram is a 99 percent good boy that is a quantitative statement. So, you cannot say a quantitative statement by the inspection method; you can say the particular surface is very good. You cannot say particular surface by seeing that it is 1 micron because you do not have that capability or your eyes do not have that ability, only you can say a qualitative statement.

That is what this Inspection by; Inspection by comparison method. The texture of the surface is tested and compared with that of specimen known to roughness value and finished by a similar process; that means, that you have a masterpiece, just you look at it and you look at this one. Ok, that qualitatively you can match your experience with respect to that particular process. Just you match it and you can say that ok, this process

is got the achievable surface roughness and other things. So, you are just saying by the qualitative.

Though these methods are rapid, these results are not reliable because they can be misleading in comparison not made by the surface produced by similar techniques; that means, that sometimes this may be misleading because this comparison not made by the surface produced by similar techniques. Assume that I have a one grinding surface; another one is lapping surface. Your master is a lapping surface and if you are comparing with respect to the grinding surface.

So, sometimes the values or sometimes your comparison by inspection may be misleading. So, one should be very careful about the inspection method. So, only thing is that you if you have a masterpiece of lapping, you have to check with the lapping surface. If you have a masterpiece with the grinding, you one has to compare the grinding surfaces.

Assume that I am going to a the shop floor and I have a grinding samples which I have to inspect or I have to compare by inspection method. So, I need to have a master which is done by that particular machine using the grinding process. If I have a grinding master, I have a samples of 10 which are grounded or the then, by the grinding process then just I will see this one, I will see this one. Ok, Ok.

Then, I can compare it that is what I mean to say is if at all a person is going to compare the grinding surfaces you should have in his view about the grinding surface masterpiece so that we can compare. If it is a lapped surface, if you are going to measure or inspect the grinding; then, it cannot be. So, this may lead to a misleading of the inspection. First, we will see inspection by comparison.

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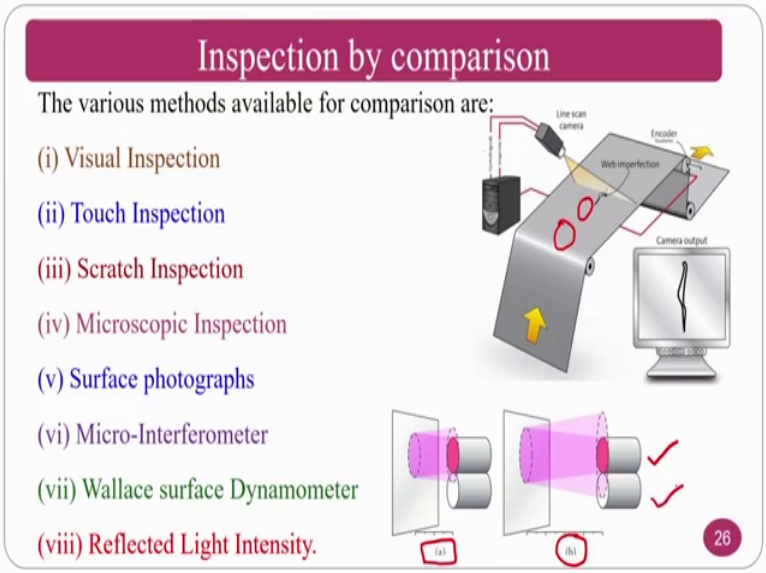

And the various methods available for comparison or like a Vision Inspection; that means, that you can visually see or the experience people see visually and they will compare with a master. Assume that I have a milling master and that the surface produced by a milling and the surfaces are that is to be supplied to the customer just you can compared by Visual Inspection method.

And the Touch Inspection, you can see that the whether surface roughness is proper or not just you can see by touching the surface and other things. And the Scratch Inspection, you can do the scratch testing and other and you can see later you can see by the inspection by visual or touch screen other things. The Microscopic Inspection, you can use this optical microscope and you can see the quality of the surface. You can see the surface morphology of the and you can tell the whether the product is right or product is wrong or product is acceptable or product is not acceptable and other things.

And the surface photographs like it is also look like the surface morphology only and you can see the surface how the top layer of the surface looks like and other things. The Micro-Interferometer and the other things are wireless surface dynamometer and you can see using the forces and other things also. Suppose, if a tall I want to see the surface of that particular component, you can also see by these things and reflected light intensity and these are the methods if we can see here these are the 2 things that you can visually

see in a camera based line scan camera based and other things parts are transferred like this and this can be inspected by using the line scan camera and other things.

At the same time, you can do this particular method also by you have a master and you can compare with respect to other thing. These are all will give you whether the product is acceptable or not acceptable. This is the master assume that this is the master and this is your component that is produced. So, if my requirement is as per the master is as per the master then you can see the other thing and you can compare the qualitatively. But you cannot compare quantitatively.

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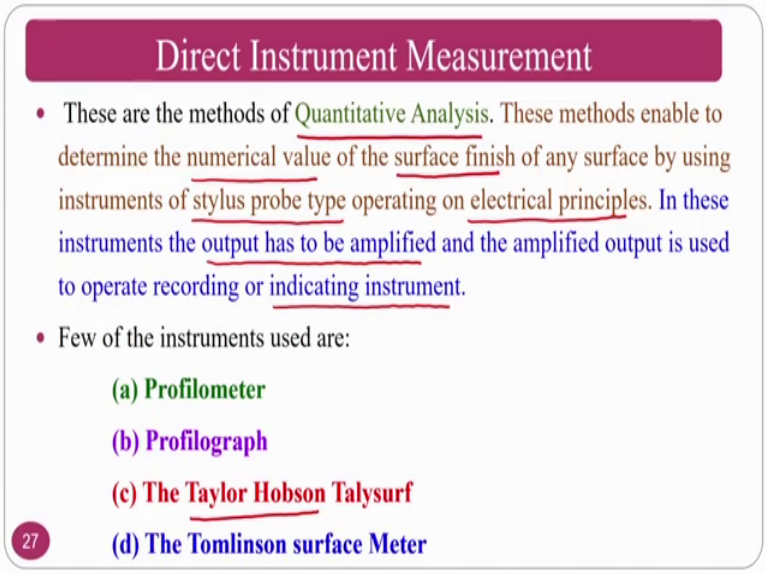

For that quantitative comparison, you have to go for direct instrument measurement ok. There are various methods to do the quantitative analysis; that means, whether the surface is 1 micron 2 micron or the 10 micron or something, but you have to specify the surface roughness of that particular component. These methods enable to determine the numerical value of the surface finish and; that means, that the surface roughness of any surface by using the instrument of stylus probe type on electrical principles. These are the one of the methods that we can use is the probing method.

You have a probe; that means, that you have a these type of probe will be there and you will see it will reciprocate that you have seen in the previous slides at the same time, I will show you for better understanding in the upcoming slides also. And these instruments output has been amplified and the amplified output is operate to record or

indicating the instrument. Normally, what these thing? The probe will reciprocate on the surface and it will give you certain values and these are values are amplified and gives the original surface roughness value. ok.

Few instruments that are used to measure the surface roughness using the direct instrument method is the profilometer that is Surface Profilometer and the Profilographs are there. At the same thing, there is a one equipment that is many equipments are there; one of the company that produces is a Taylor Hobson company and you can see how you can measure the surface roughness. Then, the Tomlinson surface Meter also. These are the some of the methods that are available to measure the value of a surface roughness of that particular surface which is there on the component.

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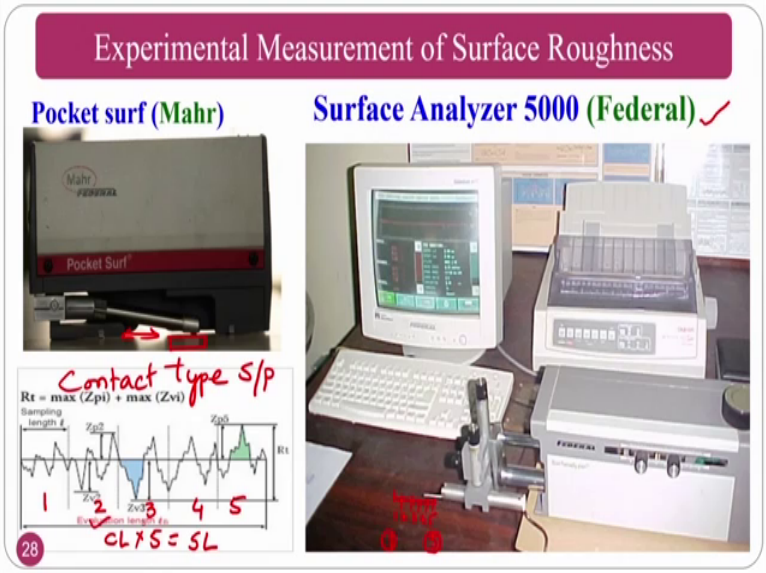

The Experimental method if you see as this is already saw by you in the previous slides. Again to understand for better understanding; for better understanding, I am showing again. If you can see the Pocket Surf and this is the Taylor surface analyser 5000. This is some made by the Federal. These are all we measure by the contact type. These are all contact type: surface profilometers.

So, what it will do is you have a surface, on top of the surface your probe will reciprocate and it will give you the surface roughness value. Similarly here also you have the probe on which just you put a you place the work piece. Assume that in this piece just

you place the work piece and it will reciprocate and will give you the value. How it will do?

If you see here, you have to specify the cut off length as I said in the previous slides the cut off lengths should be less than your waviness of particular sector, then your waviness will not be included here in the surface roughness value. At the same time, you have to specify cut off length; normally what it will do is your cut off length multiplied by 5 times will give you your complete scanning length ok.

SL stands for Scanning Length; CL stands for cut off Length and 5 normally it will consider. Why? Because sector 1, sector 2, sector 3, sector 4, sector 5; so, sector 1 will be my probe that is the contact surface profilometer, assume that I will just explain you from the point of this one. So, I have a surface here and this is divided into 5 sectors. So, sector 1, sector 2, sector 3, sector 4, sector 5 so, 1, 2, 3, 4, 5. So, assume that starting from the 5. What is happening?

It is at the static level that is the velocity of that probe is; so, 5 to 4, it will start accelerating; 4, 3, 2 it will be uniform. Again, it has to come from 2 to 1 in their circumstances it has to deserve rate to 0 ok. In that circumstances sector 1 and sector 5 will be counted for inertial effects and the surface roughness value that is it is going to give you is sector 2 sector 3 and sector 4 which is at the middle.

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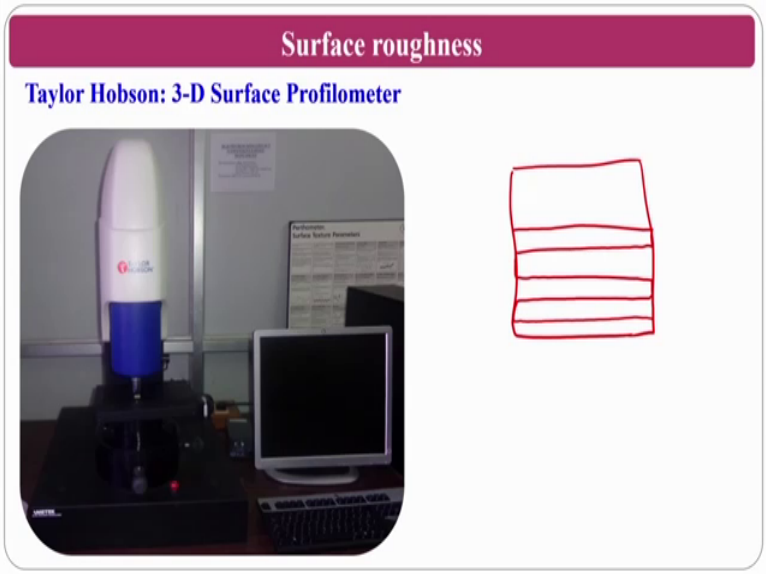

The Surface Roughness, the basic drawback of that surface profilometer is initial sector and final sector. It is acceleration and deceleration problems will be there. For that purpose at the same time, it cannot give you a surface roughness of a particular surface; assume that I want to measure a this particular Surface Roughness. I mean to say I want to make a complete area of surface roughness that cannot be do. That can be done only by doing like this, a multiple segments. And it can give only average, it will take a lot of time.

For that purpose, the scientist came up with a non contact type surface profilometer. Those non type of surface profilometers give you area surface roughness; at the same time, line surface roughness and other things and there is no problem of acceleration and deceleration. So, the 2 drawbacks of acceleration deceleration in the contact type; at the same time, it cannot give you a area surface roughness ok. It can give you a line surface roughness; if we can go on a line and it can give. For to measure in a area and other things you have to go for a non contact type surface profilometer.

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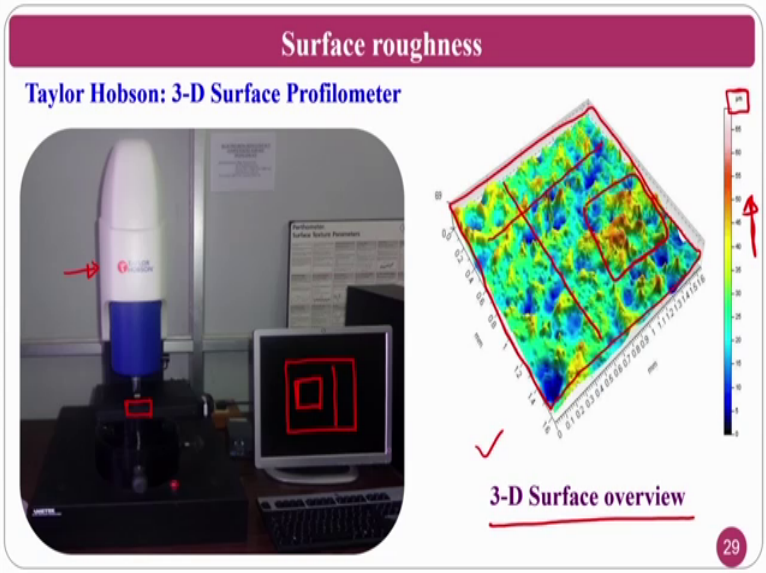

And this is the Taylor Hobson, it is manufactured by the Taylor Hobson is which is one of the big companies in the area of surface profilometers and this will give normally if you have a IPs and you just place your component here, this is IPs and you can see your surface roughness on the screen. And you can measure a line average surface roughness

or assume that I want to measure the area surface roughness in this sector or I want to measure a lines; you can measure whatever you want ok.

As per your requirement, you can measure. Whenever you do the scan, normally you will get a 3-D view like this particular figure and in this particular surface, assume that you want to measure only this area surface roughness, you can measure or you can measure complete area also. That also possibility is there or if you want to you can measure a line scan also ok; you can draw a line and you can measure the surface roughness value ok. In this particular or you can go in this particular line also ok. As a as you want you can measure any directional surface roughness ok. For that purpose, you need to get a 3-D surface profile that it will give.

Once, you have this 3-D profile you can use the area or line or a segmental area of a complete surface or whatever you want, you can measure in this particular surface. That is the beauty about a non contact types of a surface profilometer and you can also see a scale here. The surface roughness in terms of micrometers ok; this is a very rough surface that is why you are seeing a high peak, several peaks and other things. Normally, the surface normally what you can achieve this type of surfaces is in electrical discharge machining process ok.

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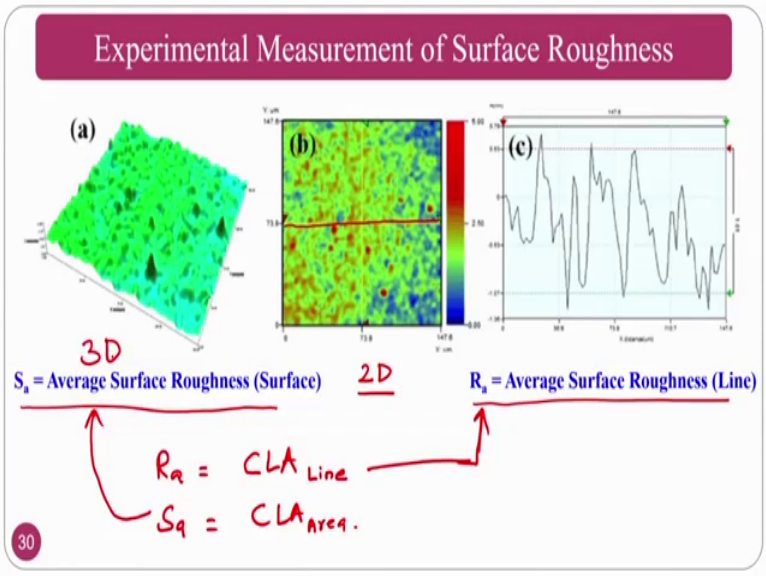

So, experimental method, if you as I said. So, this is the 3-D surface where you can measure the surface roughness an average of an area, whenever you want to take you can

take. a is a 3-D profile. This is a 3-D profile and if we can generate 2-D profile and then, you just go and take the top view of that one this is you can get a 2-D and, at the same time, if you what all I want to measure a surface roughness of a particular along a line that you just draw a line using that software. So, you will get a lines surface roughness that is the difference between the average value and S a.

So, R a is nothing but line, it average surface roughness that is nothing, but CLA, Centre Line Average value of a line basically. S a equal to Centre Line Average value of a area ok; that is a difference. This is refers to this one and this refers to this one. So, this is how you can get the 2-D profile as well as a 3-D profile using a non contact surface profilometer.

Thank you.