Polymer Assisted Abrasive Finishing Processes
(Surface Morphology and Surface Metallurgy)
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Lecture - 02
Surface Integrity and Surface roughness representation-Part-I

Welcome to the class and I am going to teach you about the surface integrity, in Polymer Assisted Abrasive Finishing Processes. In particular you may be thinking about only I am talking about polymer assisted abrasive finishing process no. So, it is a finishing processes where surface integrity in particular which comprises of surface morphology or surface topography, along with surface metallurgy is important. Why this is important and all those things you have to understand, before you enter into the finishing processes that are considered in polymer assisted abrasive finishing processes.

If you see the conventional finishing processes such as grinding, honing so, many what is happening is solid to solid contact will be there. So, lot of forces will be in, if you see the forces in surface grinding process, normally it will varies from 50 Newton's to 100 Newton 150 Newton so on. If it is maximum increate feed grinding and other (Refer Time: 01:32) ok.

So, whenever the grinding forces are high, there is a chance that the surface burning will takes place. So, the surface roughness may be same but, the thing is that surface metallurgy will be completely different. Now, we will see what is surface morphology or surface topography and surface metallurgy, pertaining to commonly for conventional and advanced finishing processes and why, particularly this polymer assisted abrasive finishing processes or some other advanced finishing processes are required.

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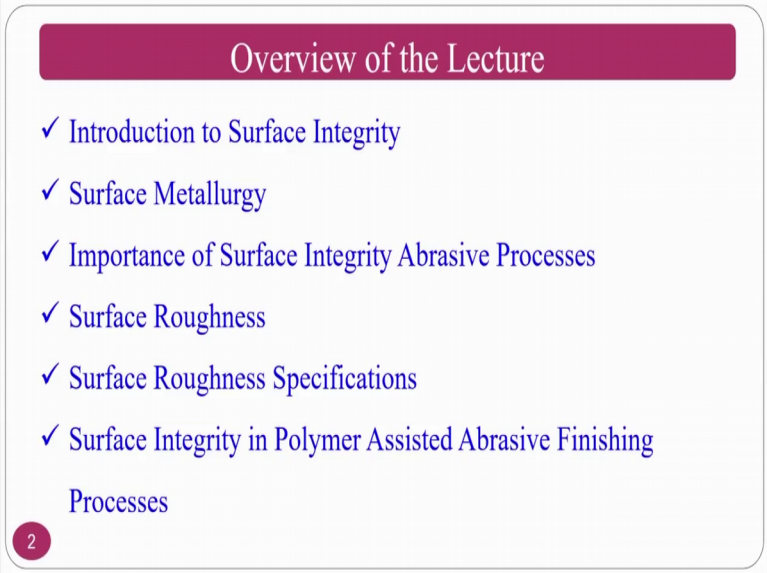

So, overview of the lecture we will see the introduction to surface integrity which means, surface roughness that is nothing but surface morphology and surface metallurgy. In particularly we will see what is the importance of surface metallurgy and importance of surface integrity in various conventional abrasive finishing processes and advanced finishing processes, then we move on to surface roughness, where we deal with various surface morphologies. How we measure the surface roughness? How to represent the surface roughness and other things and how do you specify the surface roughness?

Whether it is a machined surface, how do you represent? Whether it is a other surfaces, how do you measure? What how do you express the minimum surface roughness value, maximum surface roughness value, how do you represent the lay? Lay is nothing but predominant surface roughness directions ok. Whether it is parallel, whether it is perpendicularly, or how do you represent this whenever you are specifying to the supplier being a customer.

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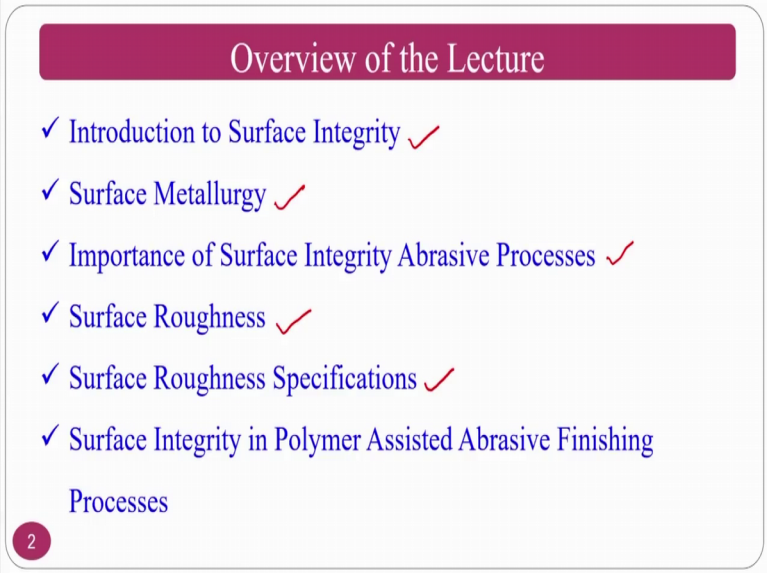

The surface integrity importance in polymer assisted abrasive finishing processes. At last, after studying all these things like what is surface morphology? What is surface metallurgy? And how do you represent all these things? How do you overcome all these things? And other things, at last you come, why this particular surface integrity is important? And how you can get a very good parent material; that means, that without disturbing surface, without giving the micro surfaces, how can you achieve the nano surface finish; without changing the parent material, that is the basic objective of all the manufacturing engineers.

What is the objective? I want to achieve the good surface finish, without disturbing the metallurgy means, it should not have the thermal layers, it should not have adverse affected layers ok. That is the motive of a manufacturing engineer, how you can achieve using this particular polymer assisted abrasive finishing processes ok.

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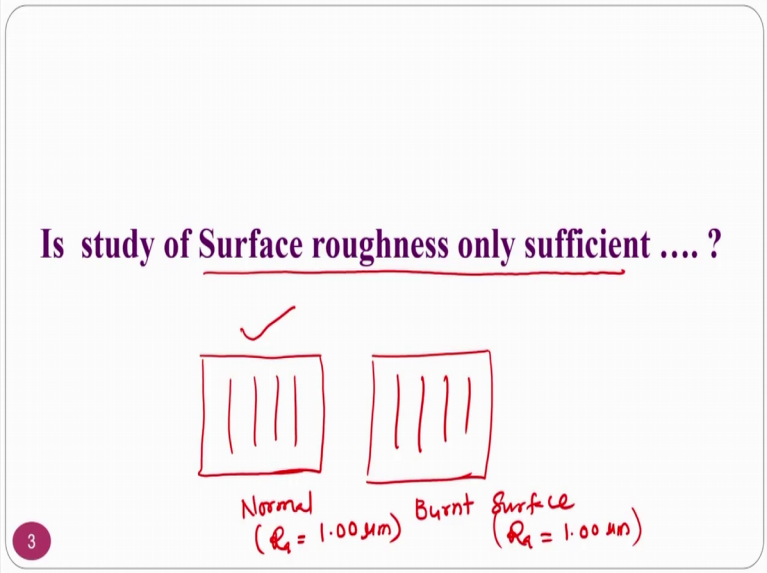

Is the study of surface roughness is only sufficient? That is the question. So, assume that I am going to get a micron surface roughness like, 1 micron. Is it sufficient? I mean to say is, if the surface is 1 micron, if it is metallurgically then there is no problem.

Assume that the bond surface, you take 2 surfaces. one both are assume that this is the grind surface, in one case it is normal surface, another one case it is burnt surface ok. But, the surface roughness value is approximately, here also R a value; normally you represent in terms of R a only, micrometres. Here surface roughness is approximately 1 micrometer ok. So, do you think both are same? No actually, whenever you represent a particular surface, being a mechanical engineering, I am sure that you bother about mostly about surface roughness that is why we also study mostly in this particular class about surface roughness only.

But, on an average this particular product is going into the market and the customer will see all aspects. He is not a mechanical engineer, he do not know what is surface roughness is, what are the other things and he will see whether drastic appeal is good, if the surface roughness is too low; that means, that the finish is very good. So, it will look good, if it is a burnt surface then he is not going to purchase. So, you should always go for, a better surface to sell to the customers that means, that the answer for this question which is mentioned is the study of surface roughness is only sufficient? No, you need to understand, you need to accord, you need to have some glans over surface metallurgical

aspects also ok.

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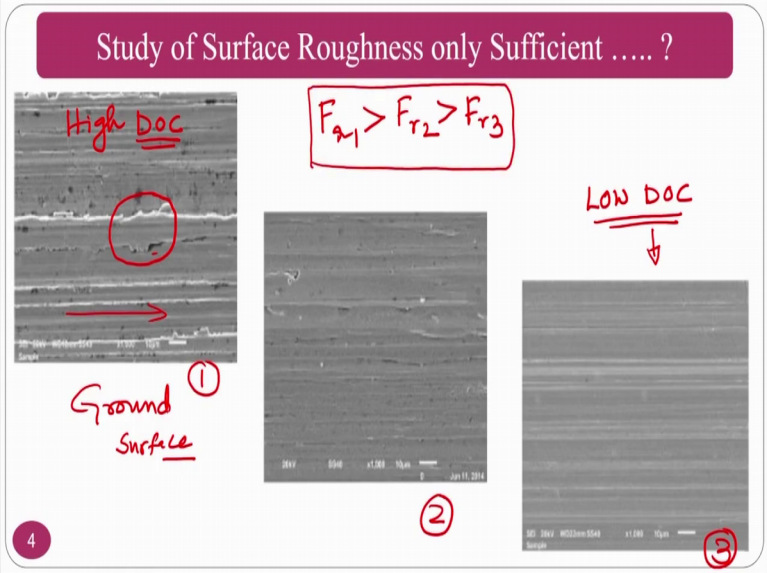

So; that means, the study of surface roughness is only important, you see the surface roughness of the ground surface, normally the grinding surface if you see here, these are the lay and you can see the plywood material and other things ok. This is grinding surface or ground surface.

If you see still more still more this, all the surfaces are grinding surfaces only. But, what is the change that you are observing. If you give the low input values like, low depth of cut and other things.

What will happen? You will get very good smooth surface; this means, low depth of cut. Most importantly it is called, low depth of cut if you give. So, the surface that you are going to get is bit smoother, if you are going to give high depth of cut and other important parameters are high, stringent then it is rough surface, plywood material you can see

You can see here the ploughing of the material, how the ploughing of the material is forming and other things. If you intermediate, medium depth of cut and other things table traverse speed, what is the rpm? These are the input parameters in the grinding, these are all will decide the forces basically, if you are depth of cut is very high, what will happen?

The enormous amount of forces will be generating and you can see the surface roughness

it is very high surface of this value. At the same time, metallurgical changes in this one also will be different ok. So, we will see about the forces here, the forces that experienced by the workpiece material, in case 1, case 2 and case 3 if you see here. So, the forces or the radial force in 1 will be much much greater than, radial force in 2, greater than in radial force 3 because, your input conditions are very high, if your input conditions are very high surface roughness is very high; that means, at the surface roughness also will sometimes have the burning surface also ok.

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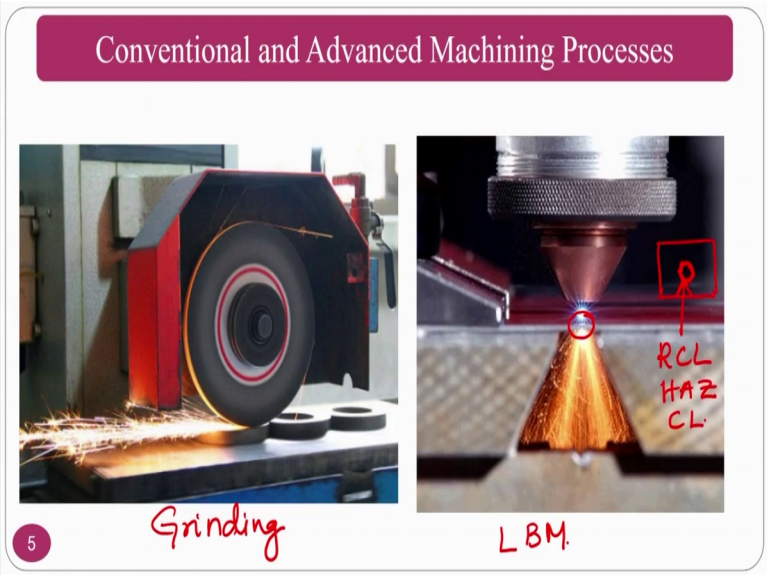

So, normally what are the advanced processes or conventional processes where you can see these type of thermal degraded layers is one is grinding process, that we have seen in the previous one, this is the grinding process, which can be called as a conventional abrasive finishing or machining process, another process where you will see the thermally degraded layers in advanced machining processes is laser beam machining process.

You can see the temperature, generation and other things. If you want to see the surface that is generated in the laser beam machine surface, where you are cutting. This is the cutting zone and if you see the surface, where you assume that you are going to cut a whole? This whole surface will be completely rough and it will gives rise to recast layer, heat affected zone and conversion layer ok. So, multiple layers will be forming and you have to remove recast layer by using the some post processing and other things.

Why I am telling these two processes here is, surface roughness even though you may get a very good surface roughness in terms of conventional abrasive machining processes like, grinding. Whenever you see this type of spark is coming, it may destroy thermally; that mean, that burning surface will takes place along with the surface roughness. Here also in laser machining also you will get a smooth surface, if you are going to use pulse laser, ultra short pulse lasers and other things. But, there will be a thermally destroyed layer; that means, that the metallurgical aspects of the surface also equally occurred along with the surface roughness; that means, that surface morphology.

So, what I mean to say is, surface morphology and surface metallurgy both are important and the combination of surface roughness and surface metallurgy is called surface integrity ok.

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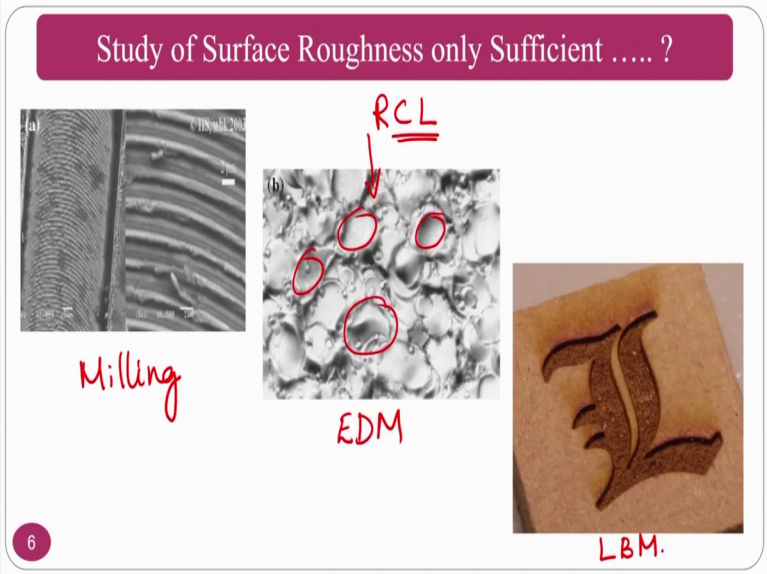

You can see here milling surface and you can see the EDM surface, than laser surface, this is electric discharge machining surface and this is laser beam machining surface. So, the metallurgical structures are completely different, in milling temperatures are very less, compared to EDM, compared to laser beam machining and other things.

You can see here, craters are forming and this craters are completely formed because of recast layer, recast layer means, you know what is casting? You just make a molten metal, then pour into a mould ok, you will get a casting here, EDM whenever there is a spark because, of the spark on the material cannot evaporate or cannot travel along with

the dielectric fluid, the material which stays there will solidify because, of the cooling effect of the dielectric fluid. Those will form again the craters; that means, that casting their liquid is converting in to a shape of the mould part here, there is no shape of the mould. But, liquid is resolidifying there, that is why it is called recast layer.

Same thing will happen in in case of the laser beam machining also ok. If you see the surface here, in the laser beam machining and if you see the parental surface, surfaces are completely different. So, it is not about the surface morphology. If you try to measure the surface roughness here and if you try to measure the surface roughness here, there may be a small variation. But, if you check the metallurgical aspects at this position and this position, it will be different, completely different ok. Just explaining with respect to the metallurgical aspect ok, this work piece may not be a metal also ok.

So, if assuming that this is a copper based alloy or then the material metallurgical aspects will be completely different, that is the importance of surface metallurgy.

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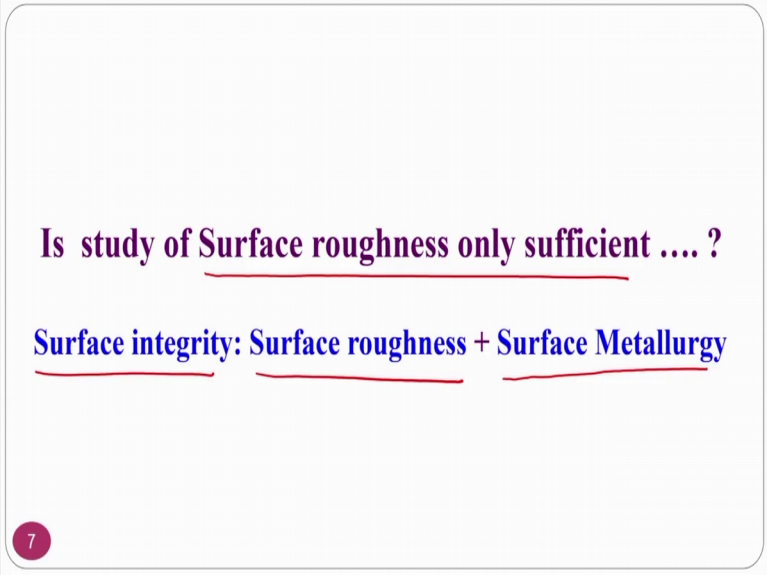

That means, is the study of surface roughness is sufficient, the question coming back again, after seeing this much problems with the surface metallurgy, we can clearly say no, that is why, people should teach or should understand the surface integrity, which comprises of surface roughness or surface morphology or surface topography, you have to merge along with the surface metallurgy and the mechanical engineers as particularly the manufacturing engineers should gain the knowledge of surface metallurgy. At least,

they should process some knowledge. So, that whenever they do the processes, they can understand what are the metallurgical changes? They can study the microstructure analysis, any grain boundaries and other things. Whenever you do the idiom process, you just make a cross section and you check the microstructure analysis. Obviously, you will see the size of the grains in the parental material e will be completely different in heat affected zone, recast layer and conversion layer and other things ok.

So, you can understand these and how to play with the input parameters. So, that the surface metallurgy will be approximately similar to parent material, that should be the aim of a manufacturing engineer or advanced manufacturing engineer.

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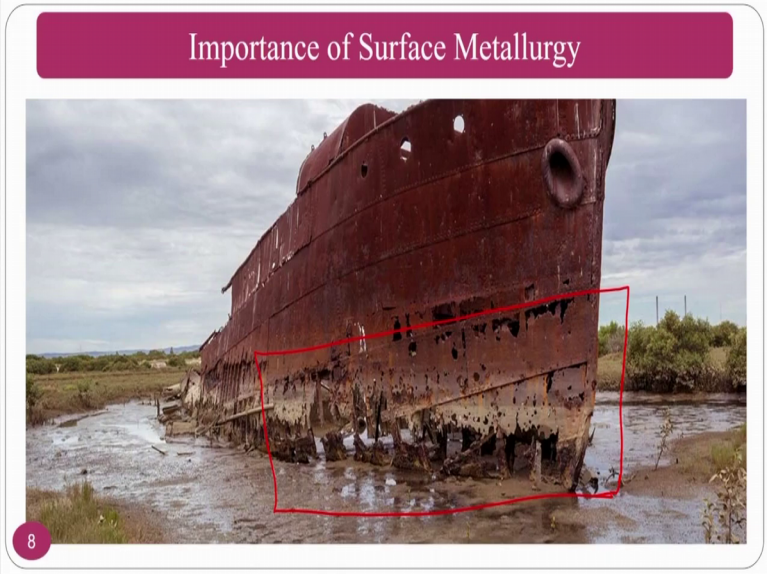

Now, surface metallurgy importance, these pictures shows you how the surface metallurgy is so important to the common products a ship, which is stationary for a long time at certain places, how this will be destroyed ok. That is why one has to collaborate with metallurgy persons or metallurgical experts, whenever you do manufacture any product,

So, this particular ship, you can see how this is gradually destroying with respect to environmental conditions, with respect to the other conditions, that are in contact ok. This is the importance of surface metallurgy, if you do not maintain surface metallurgical properties properly, this will destroy. Even though you are preparing or you are manufacturing a big structure, if you do not have proper surface metallurgical properties,

then this will happen ok. Even though you may be a good advanced manufacturing engineer, even though you are a good manufacturing person, if you do not look into the metallurgical aspects, then it is a big problem.

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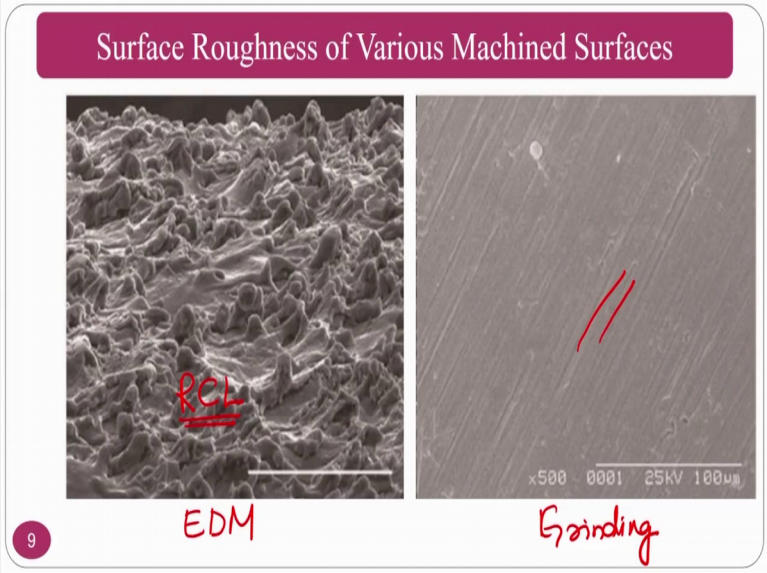

And you can see here EDM surface and at the same time a grind surface, this is the EDM surface are thermally destroyed surfaces and this is the grinding surface, or any abrasive process surface.

The surface metallurgy, will play a major role craters are forming, which is a material that is unable to go out because, of resolidification. These are all called recast layer, which are formed ok. This is nothing but, the surface roughnesses that are formed.

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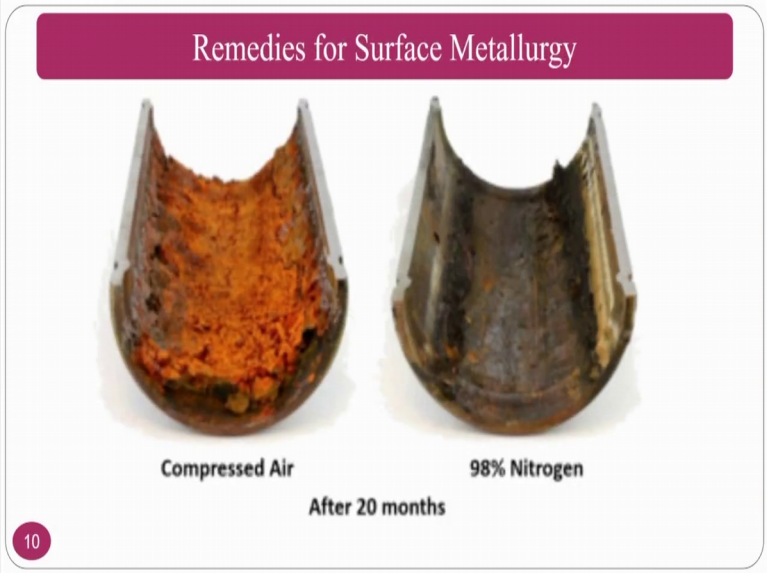

Now, we can see how to find some remedies because, as a manufacturing engineer, if I start teaching completely surface metallurgy and other things. So, I am not justifying to my manufacturing process, that is why we will see just glimpse 1 or 2 glimpse, how to find a solutions for surface metallurgy. A pipe wherein compressed base is there at the same time, you can do by the same process by having a nitrogen or some of the things like, inert gases pumping and other things, we you can protect it.

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At the same time, the better way will be coatings, surface coatings, if you can coat after

manufacturing a product that will be a best solution.

So, if you remember, there was a ship in previous 2 to 3 slides back because, of improper coatings or long term exposure of the corroded surface, which is metallurgically destroyed surface, should have done antifoul coatings and other things, if that coatings would have done. So, that ship would have been in a good shape. So, this is the coated surface; that means, that protecting coating will be there; that means, that there is a protection by the coating technology. That is one of the best technologies that you can collaborate with the metallurgies and you can manufacture a product, if there is any problems or metallurgical problems are very poor. So, you can go for their help in terms of coating and other things.

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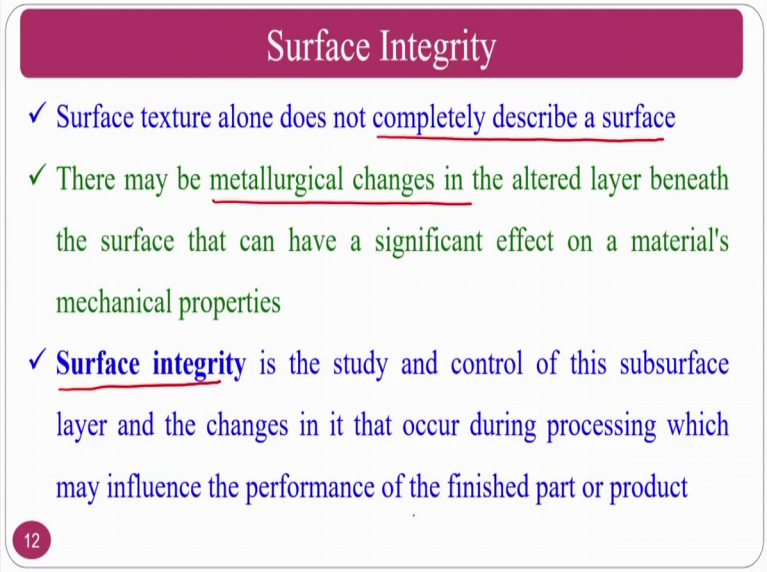

So, the surface integrating, surface structure alone does not completely describe the surface ok. So, there may be a metallurgical changes in altered layers beneath the surface that have significant effect on material mechanical properties. So, the metallurgical changes, beneath the surface, as you have seen the EDM surface, there is a craters are there, if you put that into a some mechanical application what will happen? Its mechanical properties will be much much poor and this recast layer will be much brittle, even though the parent material is ductile, then it will be a big problem.

The surface integrity now, we move on to surface integrity is the study of control of the substrate layer and the changes that occur during the processing, which may influence

the performance of the finished product.

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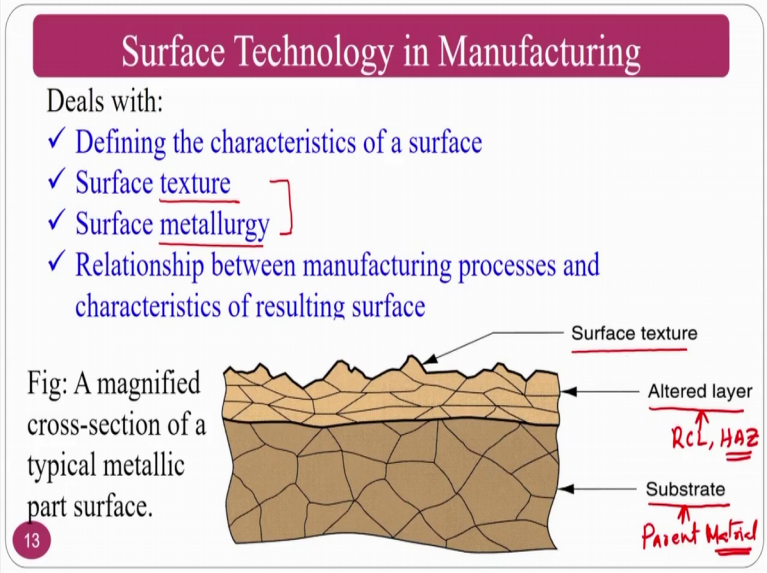

So, indirectly what I mean to say is that surface integrity will also deal with surface metallurgy, along with surface morphology ok.

What it deal with. So, deal with the characteristics of the surface, surface texture, surface metallurgy in small terms, these 2 will be combined as a surface integrity. The relationship between manufacturing process and characteristics, resulting in surface is nothing but, the surface integrity, if you see a magnified cross section of any thermally destroyed layer or any other surface structure, altered layer and substrate ok. Substrate is nothing, but your parent material ok.

What mean by parent material assume that, you have a mild steel and you are doing a EDM of a mild steel, in that you are going to get a surface, that is this particular altered layer is nothing, but your recast layer heat affected zone and other things.

Why I am telling always recast layer and heat affected zone, it is very easy for the B. Tech students for the M. Tech student and PhD student and understand because, B. Tech students would have undergone the course of the advanced machining process or at least basic machining processes, such as grinding process, advanced machining process among that the basic process is electric discharge machining process.

So, electric discharge machining process you will understand recast layer, heat affected

zone, conversion layer, substrate or parent material. These are all the things are common, that is why for to make it simple I am explaining most of the time in terms of recast layer heat affected zone comparing to the parent material.

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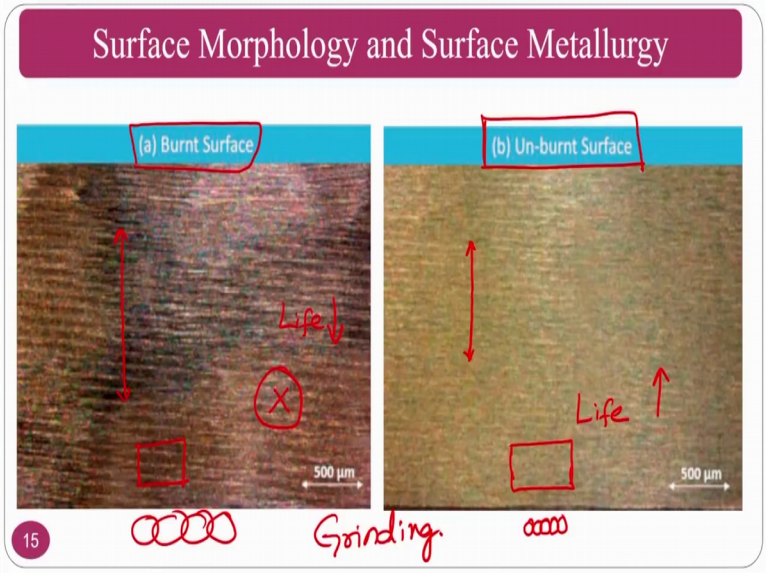

Importance of surface integrity, surface morphology and surface metallurgy, if you see the burnt surface and the un burnt surface, in a grinding process. Which one you prefer basically, this one you may not prefer because, the surface roughness, if you are going to measure across the surface perpendicular to the grinding surface, you may approximately get the same surface roughness value ok.

If your surface roughness value is different, than is the, it is a different story. Even though the surface roughness is same metallurgically burnt surface, which have different microstructure un burnt surface, which will have approximately the parental surface. Indirectly what I mean to say, if you are going to put both the work pieces in a practical application, what is you are going to get is the life of this component will be high compared to this component because, metallurgical changes are different. If you are going to take these 2 surfaces and measure the surface roughness value, it may be same. But, metallurgy is different, that is the cause, if the metallurgy is different, then its mechanical properties are going to affect.

Why the mechanical properties are going to affect? If you see the micro structurals of this surface, the grains may be this much big. If you see the surface metallurgical or

micro structurals analysis of this one, you may get a microstructure different, if the microstructure is different; obviously, the mechanical properties also will vary, that is what you have seen in 2 slides before or 3 slides before, that whenever you have a metallurgically destroyed surface or metallurgically changed surface, if you put in a mechanical practical application. So, its mechanical properties may be less compared to your parent material or substrate material, that is why, you may get less life for the burnt surface or metallurgically destroyed surface.

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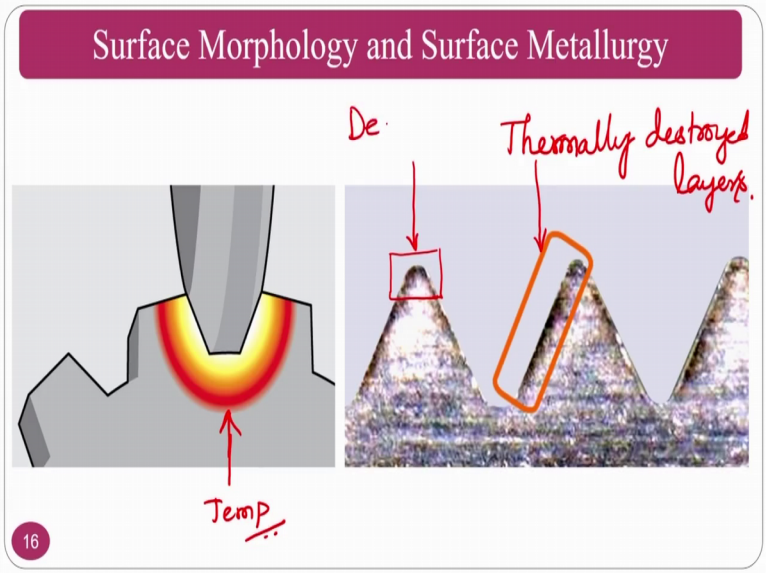

You can see here, whenever you make a some of the manufacturing processes, how the temperature destroys the manufacturing products? If at all I want to make a particular thread, in that circumstances because, of the form grinding or any other process are form electric discharge grinding process or this cannot be electric discharge grinding process because, there is a contact between work piece and tool.

But, any type of severe processes are mechanically severe process you can see the temperature in this region will be very high because, of its temperature heat generation will be very high because, of the heat generation what will happen? Thermally destroyed layers will form. This thermally destroyed layers, if you are going to put into practical application, this thread may fail because, this is completely deteriorated microstructure, these deteriorated microstructure will play a crucial role in the tool life and other things.

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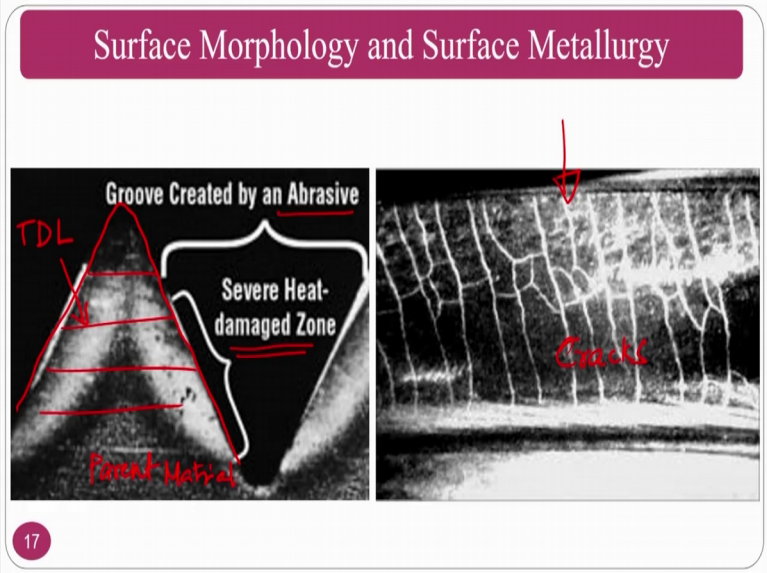

You can see here, how the morphology and metallurgy will be different? The same thing if you see here, grooves created by the abrasive processes that is a form grinding process, the parent material is here. But, this is thermally destroyed layer, deteriorated layer, this is thermally destroyed or deteriorated layers, this layer if you take the image of this heat damage zone, what you are going to see is these are thermally cracks are formed and compared to the parent material, this is completely deteriorated and if you are going to put the surface in the practical application, what will happen? This cracks will grow and it will become a powder assume that, this material is a cast iron material.

In that circumstances whenever you do the machining of cast iron, you will get powder form and you just put into a practical application by making a threads like this, what will happen? This complete thread may become cracks and pieces pieces. So, because it is already thermally destroyed layer, that is the importance of metallurgy and you have to find some solution and if you are tall, if it is not your job of interest or something, you should collaborate, how to go about it? If at all it is a abrasive processes, that are creating here. So, you could use some of the cutting fluids so, that the machining temperature can be reduced, proper cutting fluids and other things.

So, for example, to understand about these you can go through one of the courses that I already taught, you is introduction to machining and machining fluids, this is there on the YouTube and MOOCS and NPTEL websites and you can go through it and you can see,

how the temperature generation will be taken place in a single point cutting tool machining processes and other multipoint cutting tool abrasive processes and how you can take the heat from the machining region, if the taking of the machining region heat is done, there will be changes in the cutting fluids, how these changes are occurring?

And how you can make effectively you are own bio cutting fluids or sustainable cutting fluids. These are all explained in the introduction to machining and machining fluids, this is the course title and you can select the some of the suitable lectures, that way the relevant material is explained ok.

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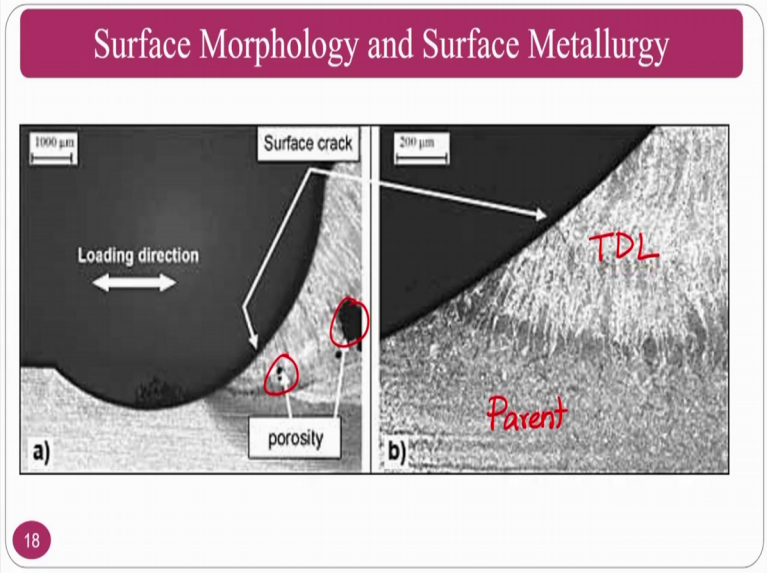

You can see here the metallurgical changes again, the porosity and other things are metallurgical changes porosity and other are whenever it is casted there may be a some changes, if you see the surface here, this is a parent material and this is the thermally destroyed layers or thermally deteriorated layers, these are the layers which are not to be manufactured.

But, this is the manufacturing constraints, you have to manufacture because, of it will be it came as a by product. But, you can neglect it by using some of the advanced polymer assisted abrasive finishing processes, where there are polymer grinding wheels, there are polymer based some other cutting tools are there. So, you can use because that these tools are not that much hard that are the ceramic cutting tools and other things.

So, what will happen? The interacting forces between work piece material and these tools are very less. So, what you are going to gain is this disturbances are thermal energy generation during the machining processes will be very less. So, there will be minimal thermally disturbed layers or once you do this process, if you want to remove this thermally disturbed layers, you can go for some of the advanced polymer assisted abrasive finishing processes, such as abrasive flow finishing process and so on.

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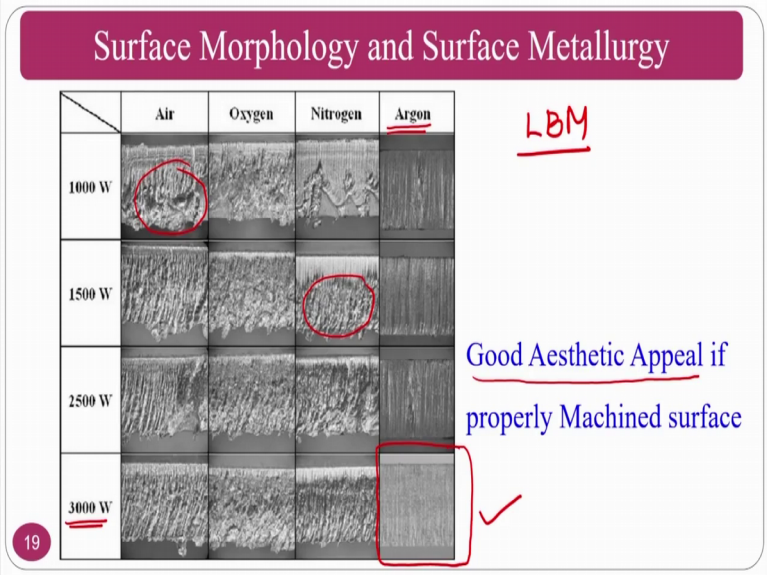

You can see here, some of the things you can do on your own, such as if you can control the atmospheric gases and other things, if you can control the various input parameters in laser beam machining. In the laser beam machining, if you can control the some of the input parameters like, laser power and the gas is that you are going to give. So, you can get very very good surfaces, in laser beam machining also ok.

How do you differentiate? If you can see the surface morphology of the surface, you can feel it a good aesthetic appeal, if it is properly machined by giving proper input conditions like, laser power and some of the good inert gases. So, that you will get a good aesthetic appeal and you can get a minimum thermally destroyed layers, that is what the importance of metallurgy ok.

So, surface morphology also play a major role because, you can see the surface morphology, it is completely disturbed at the same time surface metallurgy will also be disturbed ok. That is why, surface morphology also important surface metallurgy also

important. Hope you understood about, surface metallurgy importance.

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Now, being a manufacturing engineer, what is our main motto is to understand, surface morphology in particular surface roughness in manufacturing processes ok. As a manufacturing engineer, we should be more worried about surface roughness rather than the surface metallurgy. But, surface metallurgy is also important after seeing this much study. So, if you are not confident about surface metallurgical aspects and other things, you can collaborate or you can read and you can do the research in that area also.

Now, we move on to the surface morphology in particularly, surface roughness in manufacturing process. Surface roughness, why it is important?

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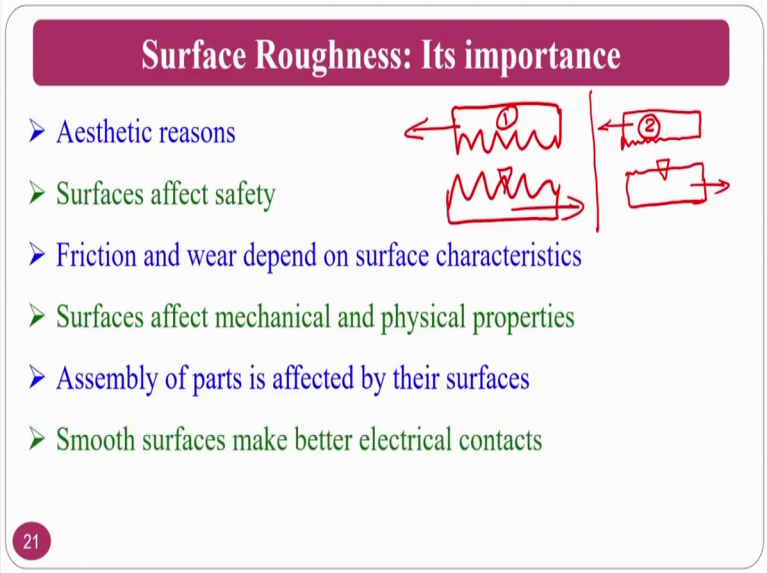

It is important because, the first and foremost thing is that aesthetic reasons, whenever you see certain product, if the surface roughness is too low; that means, that surface finish is very good; that means, that it looks very beautiful, it looks very shiny and it attracts you ok. So, that is why surface roughness is important.

Surface affects safety, if there is two work pieces, which is one drilled and burrs are there, another one drilled is there burrs are not there, burrs are finished by polymer assisted abrasive finishing processes. In that circumstances, you always preferred the second one because, safety. Burrs means, unwanted or un removed material sticking to the surface, that may be very sharp, if you hold it what will happen? It may cut your hand ok. Safety is also most important, that is why surface roughness plays a major role in this one.

Friction and wear, if the surface roughness is very high, what will happen? Assume that I have one surface like this; another surface is like this, what will happen? If both surfaces are moved in this one in this directions, then friction is very high. Whenever we mating condition, in other conditions, I have a surface like this and I have a surface like this. So, friction and wear, if it is moving in these 2 directions by mating to each other, what will happen, is the friction and wear will be very high in case of 1 compared to in case of 2 because, the surface roughness is low in case of 2 compared to 1.

Surfaces affect the mechanical and physical properties, as I said the surface roughness

also play a major role in mechanical as well as physical properties like, mechanical property, if you are going to measure the hardness value. If I am going to measure the hardness weaker hardness here, if the material is same, then here the interacting surfaces will also will vary and surface mechanical properties and physical properties also will vary.

Assembly of parts is affected, assume that I have a 1 and 2 again, what will happen, if the surface is too rough, it is very difficult to assemble, if the surface is smooth it is very easy to assemble. So, if whenever you are you want to make a machine tool, you have to make the parts properly finished. So, that setting up or assembly will be better.

Smooth surfaces makes better electrical contacts, if the electrical contacts surface is rough, what will happen sometimes it will be connecting sometimes it will be not connecting ok. If the surface is very rough, assume normally you could have understood or you could have gone through when you regarding the Lagrangian brothers story of EDM ok.

What Lagrangian brothers has studied, or they have understood, or they have seen. So, they have seen a electrical switches,which are becoming black ok. They have seen, what why it is becoming black and other things? Then later on they understood that it is because of the short circuit and other things shoot is forming because, the electrical connections are not proper.

If the electrical connections are proper, then connectivity electrical conductivity will be better and it will be easy because, of there is a gap between this and the spark will generate because, air will act as a dielectric fluid because, of this spark the surface that is generated there will be much rougher and slowly it eats away. So, the gap will be increasing. So, this they have understood in a clear way, then they have developed the electric discharge machining in later case, there is a big story is there ok.

Why I am telling is that? If the surface is smooth in this condition in connections what will happen conductivity will be better, if the smooth surface is not there conductivity will be may be sometimes will be connected sometimes will be not connected that is why you can see in the hostels, people will be putting the switch tuck tuck tuck tuck like ok. Why they are putting? They are putting because, the connection is not proper because, of one of the reasons maybe the surface roughness is very high on the both the connecting

sites.

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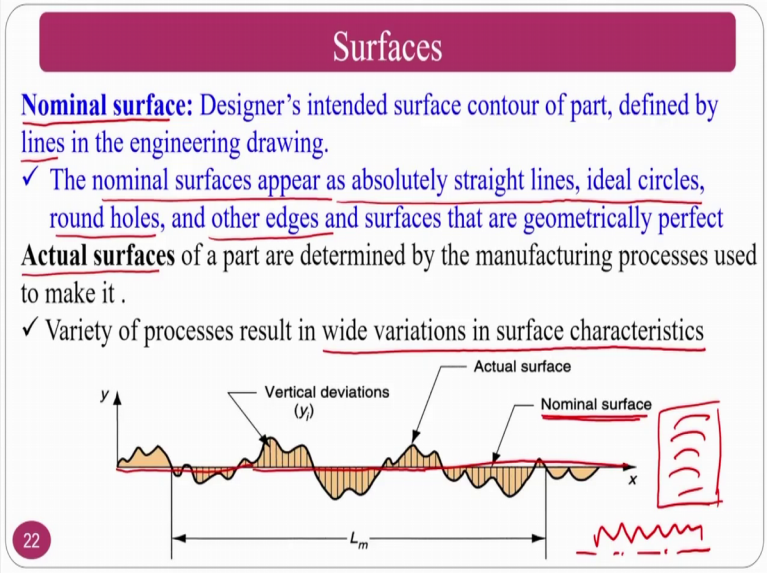

The surfaces. So, there are surfaces like nominal surface and actual surface, we will explain with respect to the figure. So, nominal surface, the nominal surface is nothing but, the designers intended surface, which is a line basically. Basically if I want a surface, I would like to have a perfectly flat surface like a this line, this is called nominal surface, which I want theoretically. But, can I get it, practically manufacturing people may not get it that is why the nominal surfaces appear as absolutely a straight line, ideal circles, round holes and edges and surfaces that are geometrically perfect ok. If I want to make a hole I cannot make a perfect circle, if I want to make perfect edges, I cannot make ok. Only these are the theoretically mentioned values.

Then actual surfaces of the part are determined by the manufacturing process used to it, variety of processes will result in wide variations in surface characteristics; that means, that if you are going to do the milling process, you will get the milling cutter marks on a surface like this. If you are going to use the boring process are turning process normally you will get the feed marks like this ok.

Nominal surface what is required or what you want theoretically but, actually what you are going to get is the surface, that is why pits and tolerances and other things came into existence and the metrology is the science of measurements came into picture because, what I want and what I am getting are completely different, that is why whenever you

see a supplier will be provided with tolerances. I cannot say I want a rod of 10 mm, nobody in this world can provide a rod of 10 mm, he can provide 10 plus or minus 0.01 mm also thing that variation will be there, this variation accords also surface roughnesses.

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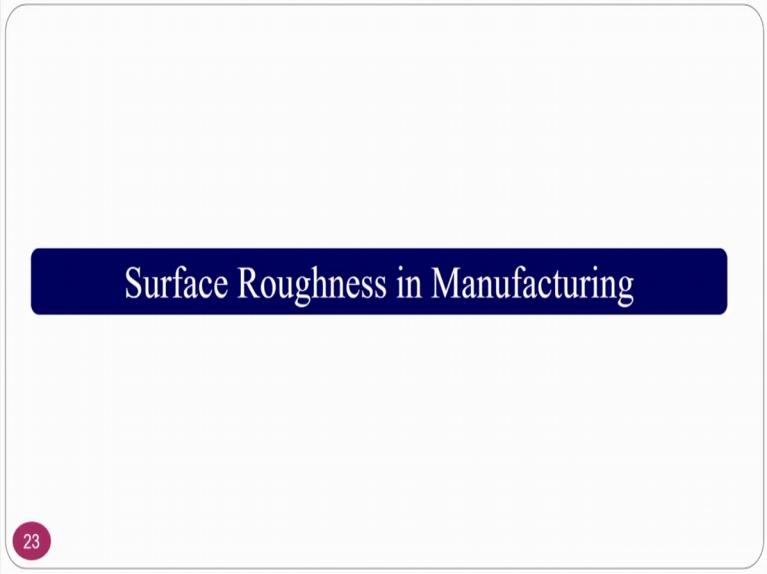

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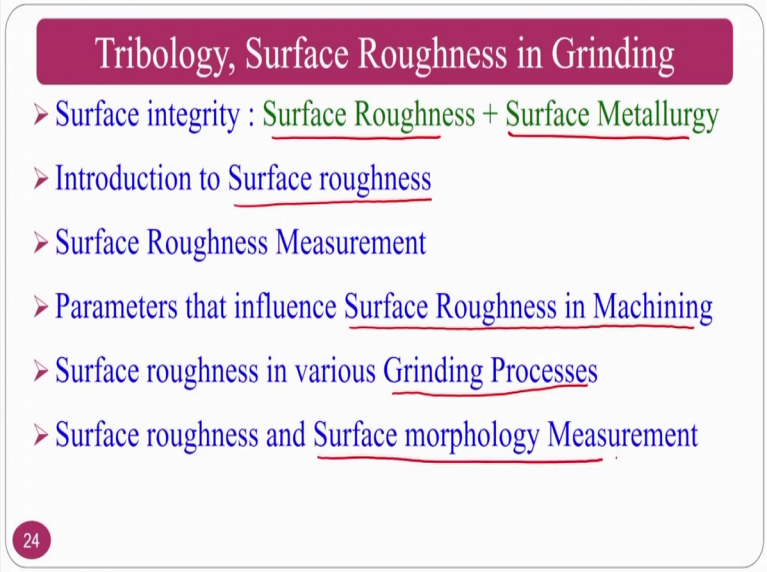

The surface roughness in manufacturing, the surface integrity which I mean to say is surface roughness and surface metallurgy introduction to the surface roughness. Now we will see the roughness measurement techniques, how the surface roughness will be

measured and the parameters that influents the surface roughness in machining various machining processes and surface roughness in various grinding processes and surface roughness in an surface roughness morphology measurement and other things we will see.

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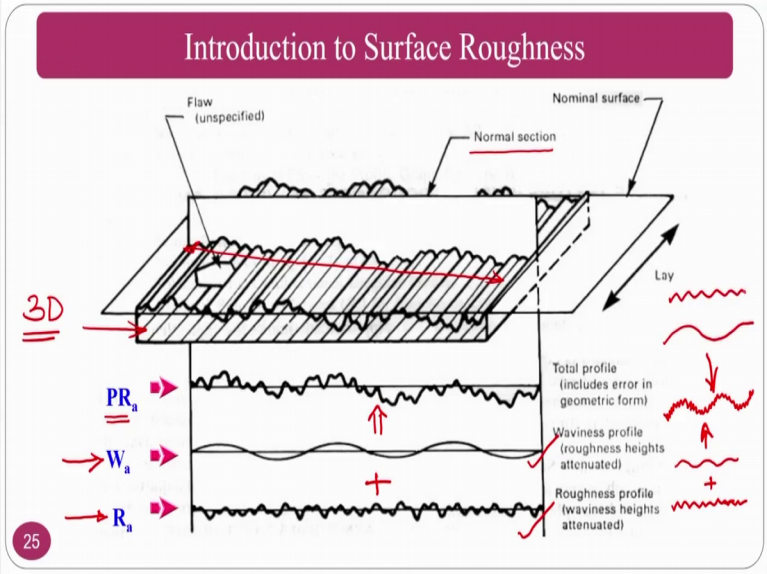

Surface roughness introduction so, introduction to the surface roughness, how the surface roughness will be mentioned or how the surface roughness will be explained ok. So, this is the 3 dimensional surface, where the 3D view is given this can be converted in to the 2D just you make a section ok. This is the normal section that you are going to do and you are going to measure the surface roughness along this whatever the provided ok.

The first one is PR a that is nothing but, profile surface roughness. Your profile surface roughness is a roughness is the combination of waviness plus roughness. what do you mean by the waviness and toughness? We are going to see here, this is W a is nothing but waviness, R a is nothing but roughness. So, high amplitude and low frequency signal normally corresponding to the waviness and vice versa is roughness, if you combined these two and if you plot this will come ok.

So, what I mean to say is, this is the roughness of any profile and this is the waviness, if you combine both these two, what you are going to get is a profile roughness. How the profile roughness look like? This look like a waviness one with roughness, how? This one, it may not be exactly looking the same. So, what I mean to say is, if you want to

divide into roughness and waviness, this you can divide into like this.

Similarly, and you can divide the same thing that is there on other side also ok, that is nothing but, the profile roughness ok. Many people may understand the roughness, normally people will understand roughness, people can understand easily waviness also the normally, what I am understood from the bachelor students, you may have to understand, what is the profile roughness? Profile roughness, if you are superimposing the roughness on waviness, then you are going to get the profile roughness.

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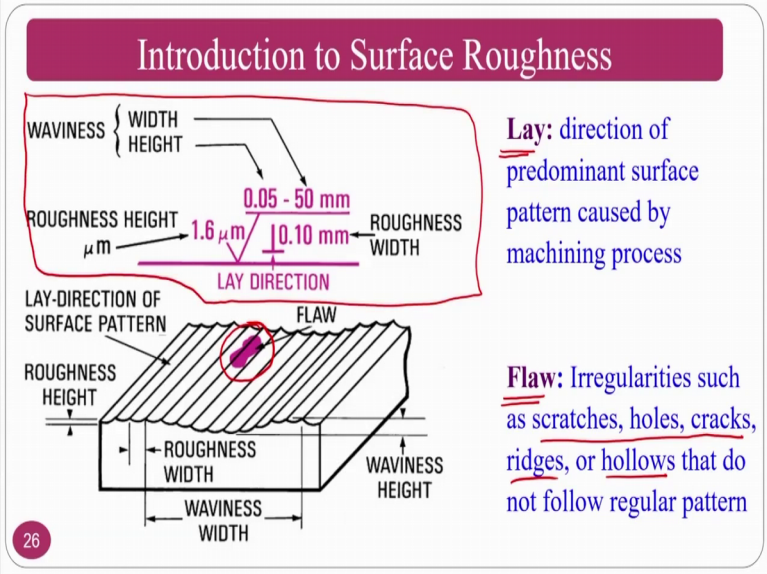

Similarly, you can see the lay is nothing but, predominant direction of the surface pattern at the same time flaw flaw is nothing but, irregularities such as scratches, holes, cracks, ridges, hollows many other things are nothing but, the flaw. So, we will see how the surface roughness representation will be done in upcoming slides, that is why I am not going to touch about, how the surface roughness is going to be represented, I will see and explain you in the upcoming slides.

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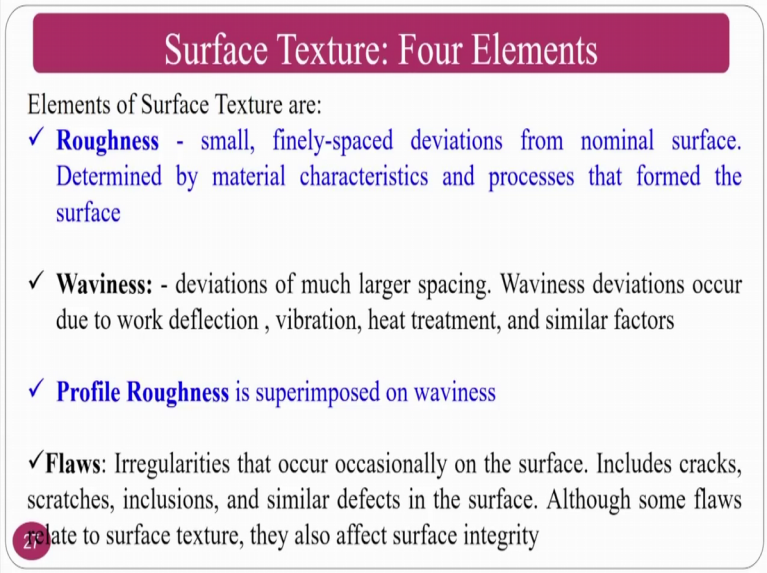

Surface texture you have 4 elements. One is a roughness, another one is waviness, profile roughness and flaws, that you have seen in the previous slides, you have surface roughness values, which is a high frequency low amplitude signals, waviness high amplitude and low frequency signals, if you are going to club both you are going to get a profile roughness, then flaws some of the metallurgical defects like, holes, ridges and other things.

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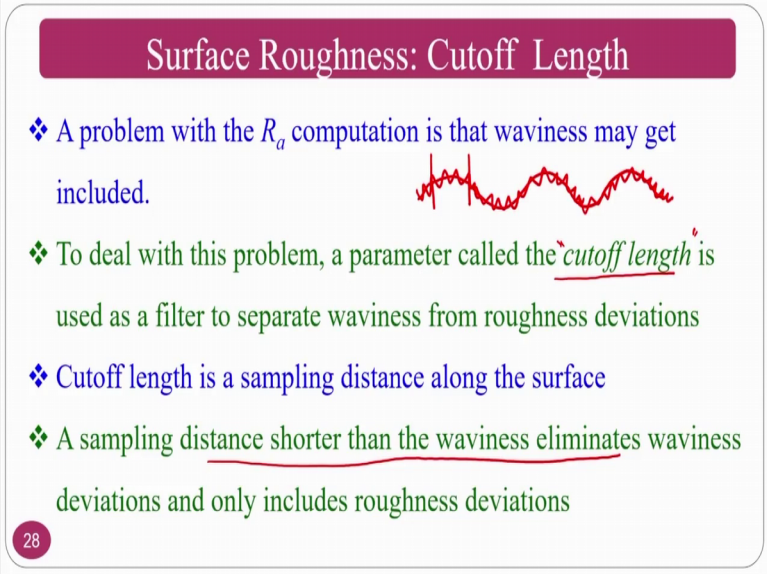

Whenever you measure the surface roughness you should understand, what is the cutoff

length. A problem with surface roughness computation is that waviness may get included, sometimes if you are waviness also get included in this one, then you are not going to get the actual roughness value, what you are going to get is the profile roughness value. To deal with this problem a parameter called cutoff length is used as a filter to separate waviness from the roughness deviations that is nothing but, the cutoff length what is the cutoff length and other things we will see.

The cutoff length is a sampling distance along the surface. A sampling distance is shorter than the waviness. So, that it can eliminate the waviness deviations and only include roughness deviation ok. The cutoff length normally, your waviness is this ok, if at all you want to embed or superimpose the roughness it will be like this ok. If you do not can give the cutoff length and other thing, what will happen? If you are the waviness is too small, then it can give the value that you are going to get is profile roughness ok.

What I want is surface roughness. For that purpose, you normally give a cutoff length that is less than your waviness. In that circumstances, what will it will do is it will eliminate the waviness and it will give you the original roughness value.

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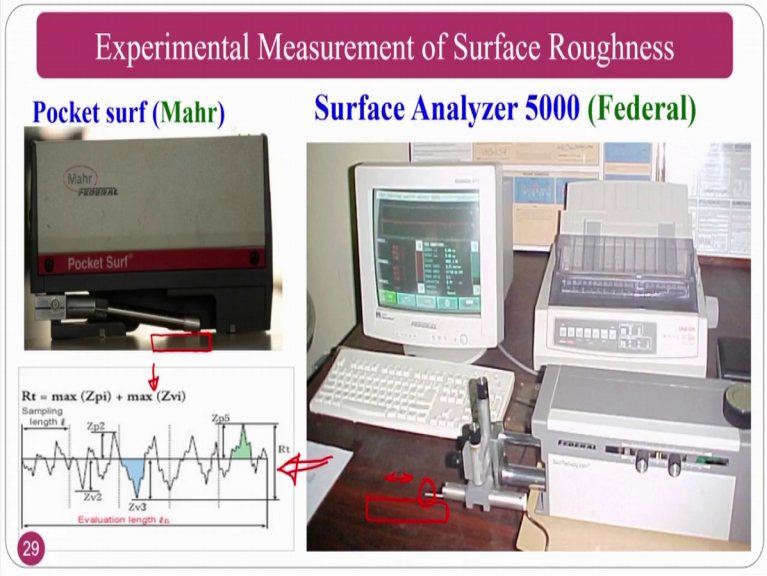

How do you measure the surface roughness? Normally, contact measurement is there, noncontact measurement is there and other things, whatever you are seeing here is a pocket surf, if you see this one a pocket surf, this is a portable surface roughness measurement technique, where you will have a probe just you put your surface here and

you press the button which is there on the pocket ok.

What it will give you is this surface roughness value, at the same time, if at all you want to go for more accuracy, then there is another type of contact surface roughness measurements are there. You can place the workpiece here and you can give a reciprocating motion, whenever you click on this one, you will get this contact probe, this contact probe will reciprocate and will give you the surface roughness value and this also will give you similar to this 2D profiles ok. The surface analyser 5000 which is a brand of a federal and pocket surf is normally it is can be developed by many other, whatever you are seeing here is the marked pocket surf ok.

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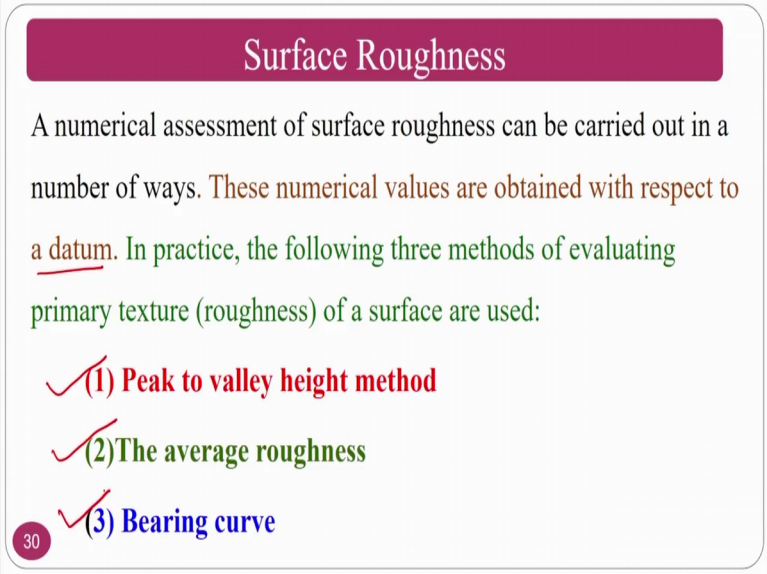

The surface roughness normally numerical assessment of the surface roughness can be carried out by number of ways; these numerical values are obtained with respect to the datum ok. In practice, normally the following methods are used. One is peak to valley height method, average roughness method and bearing curve, these are the 3 methods normally the surface can be measured or surface morphology can be expressed.

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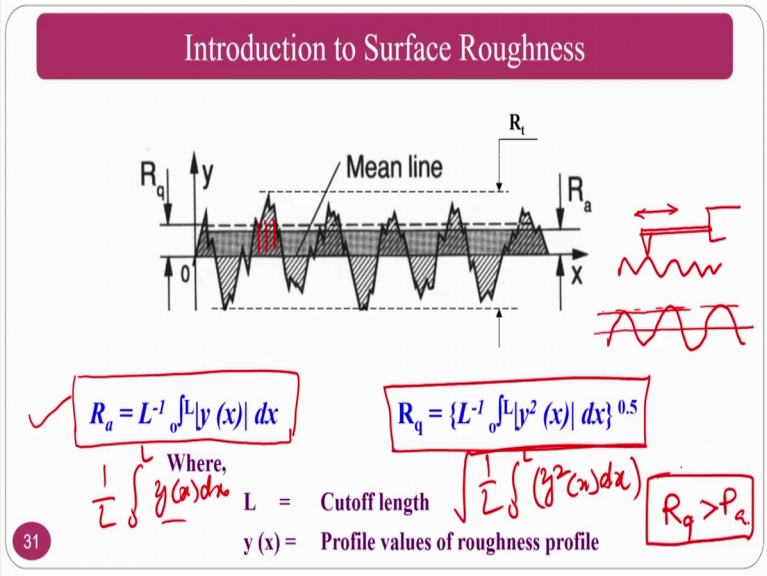

If you see this surface, where you can see the R a. R a normally is representing by the central line average value or a mean line and R q represent the RMS value, root mean square value ok. The equation is given and at the same time everything is given here. So, what is the physics or how the surface roughness can be measured? Whenever the probe moves on top of the surface, what will happen?

It do not know where is the datum, where is the mean line and other things ok. Whenever the surface is there, assume that my surface is these, on top of it my probe is moving ok. This is probe is connected to the machine, the probe is moving. Now, probe known only the path. So, the software that is there in the system will draw a particular line and cross check the area above the curve is equivalent to area below the curve or not ok.

So, let me exaggerate, this is the surface. The first what it will do it will draw a line here, whether the area above the curve is equivalent to R naught it will cross check, so, obviously, naught. So, gradually it will go down go down go down and will come to a certain surface, where area above the curve or area above the line is equivalent to area below the line, that it will take as a mean line or central line, from there simple these that you can calculate R a where 1 by l, integral 0 to l, y of x into dx you can calculate, y of x is nothing but, the small small fragments that you can do from the mean line.

At the same time RMS value normally, it is also 1 by l, 0 to l, y square of x into dx, these are all will come under root because, of which what is you are going to get is

approximately similar value. These are the 2 values that is centreline average value and the RMS value, these are the 2 values are internationally accepted but, whenever you see 2 is 2 values for a same surface approximately same but, RMS value will be slightly higher side compared to centreline average value.

But, if at all the roughness is too rough, then if at all you are calculating the R a value and R q value, R q value will be somewhat higher because, you are y square x values y values will be slightly higher whenever you do y square and combine and you do normally the R q value, sometimes R slightly higher compared to R a value. That you have to note.

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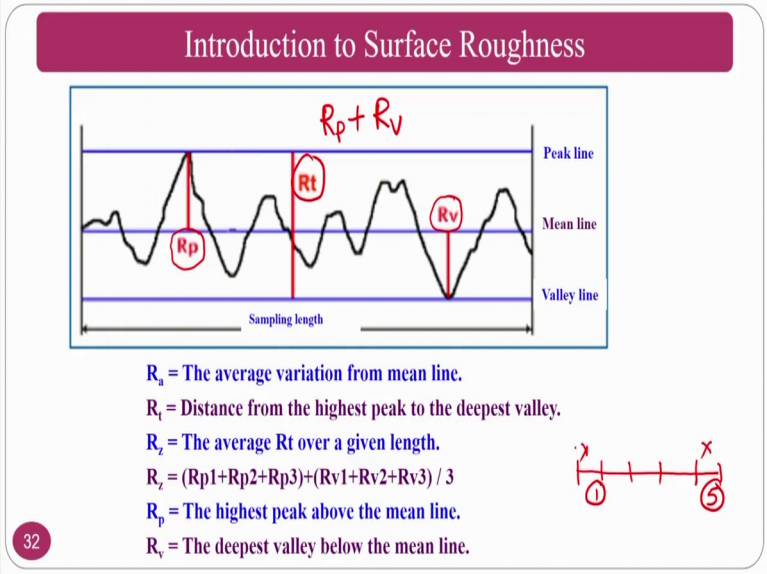

And you can see another values such as, R p, R t, R v and other things. R v stands for the lowest valley from the mean line, R p stands for the highest peak from the mean line, R t is nothing but, you are R p plus R v, that is highest peak to the lowest value, these are the things that are sometimes are important for some of the manufacturing processes.

So, in this particular class, what we have understood is that what is the surface integrity and how the surface morphology along with the surface metallurgy can club and what is the importance of surface metallurgy? What are the remedies being a manufacturing engineer sometimes it may not be our bread and butter. So, how to eradicate the or how to take care of the metallurgical aspects by coating techniques and we have seen the ship where the corrosion taking place enormously.

So, anti-foul coating should be done there and at the same time, how the surface integrity plays a major role and then we move on to, what is the importance of surface roughness? Whether aesthetic appeal point of view, from the safety point of view, from the mechanical properties point of view, this is very good and then we saw how the surface roughness is mentioned in surface roughness can be mentioned in terms of many ways, the normally you can give surface roughness value, waviness value, as well as your profile roughness value. Profile roughness value is the combination of your waviness and the surface roughness or you can say the superimposing of roughness value with respect to the waviness will give us the profile roughness.

How to calculate the surface roughness that we have seen, which you have seen the contact type of surface profilometers, where the cutoff length will be given under the things and the cutoff length normally, whenever you give, if you do not mention much things, what it will understand is it will take 5 cutoff lengths ok. So, if there is a surface, it will divide in to 5 cutoff lengths and the first cutoff length and last cutoff length will give for the acceleration and deceleration, remaining things, it will take for the measurement.

So, if I am giving 0.1 as cutting cutoff length. So, it will measure the distance of 0.5 and the probe or measuring probe will start from particular point and 1 and 5, this first one and fifth one will be for acceleration because, my probe is at stationery and at one but, at the probe will go to the stationery at 5. So, this things it would not consider but, it will consider a 3 in between and it will give the average value.

So, 2 things are important is inversely that is roughness value, as well as the R q that is root mean square value. At the same time maximum peak value, as well as maximum value and combination of both are also important in sometimes, that can be evident and we will go on to the next set session, where we will measure, how to measure the surface roughness and other things we will see.

We will go to the next session, in the next class. How to measure the surface roughness and other things and we will also see how to represent the surface roughness and many things about the surface morphology being a manufacturing engineer we should know about surface morphology representation, surface roughness measurement techniques and other things, we will see in the next class.

Thank you.