Introduction to Abrasive Machining and Finishing Processes

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Lecture- 03
Grinding Fluids/Cutting Fluids Additives and it's Emissions

In today's class, we are going to study about the grinding fluids which is indirectly the cutting fluids in terms of single point cutting tool, and the same thing can be used as a grinding fluids also ok. And what are the additives that one can add and it adverse effects. Normally, the cutting fluids or the fluids that normally uses for reducing the temperature and they improving the tribological conditions and other things. During this course of time the basical problem comes is emissions. So, how the emissions are coming and what are its problems and consequences. So, in broad spectrum, we will see the grinding fluids, what are the additives, why we have to add this additives, then we will see what are the consequences of this additives ok.

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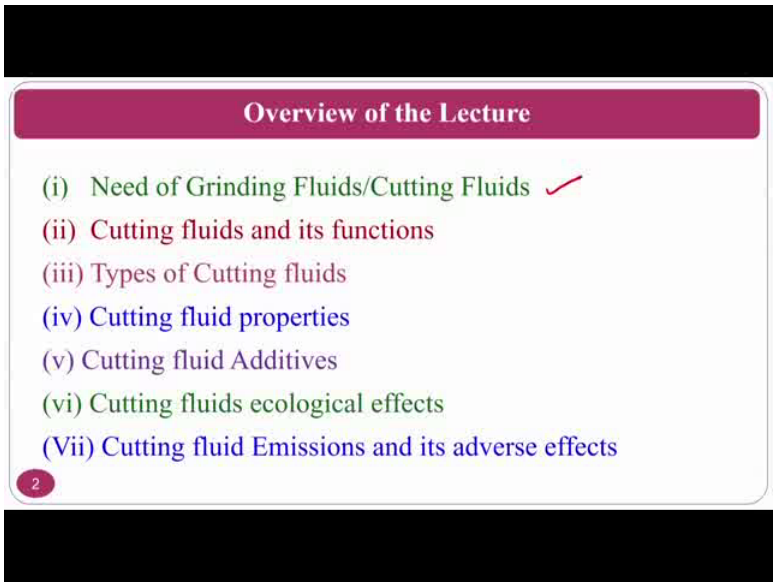

So, overview we will see the grinding fluid which is nothing but the cutting fluids, then the cutting fluids and its functions, types of cutting fluids, cutting fluid properties, additives, and ecological effects as well as its adverse effects or consequences of these grinding fluids in the grinding process.

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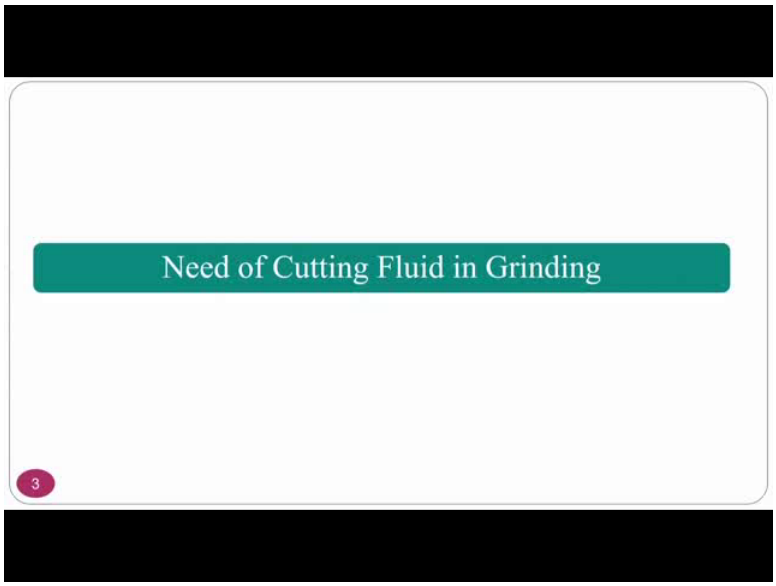

Need of cutting fluids in the grinding it has a great importance.

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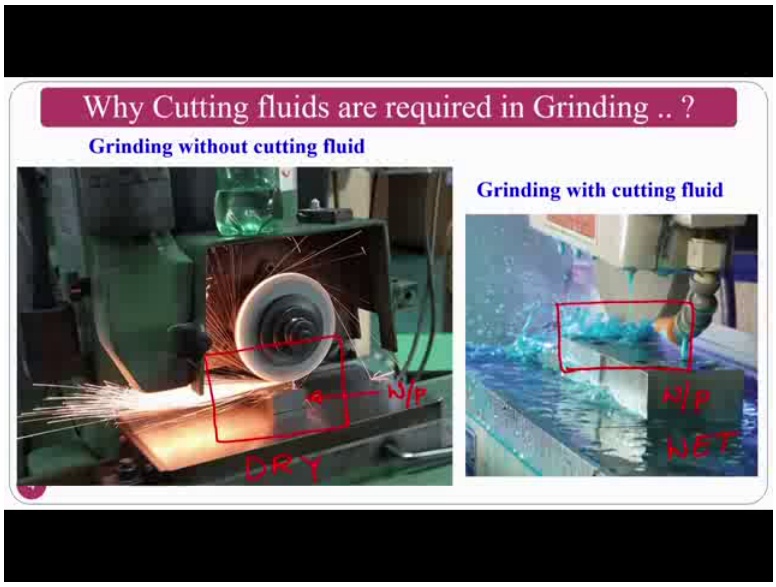

This is the work piece as you might have seen similar setup in the previous classes. So, if you are not going to use what is happening here, you see that machining region completely there is a fire type of spark is coming. So, because of this spark that temperature of the grinding wheel goes up, but since it is a non-conducting, so there is would not be problem for the grinding wheel, but the problem is the burning of the work piece.

So, the surface integrity which means surface morphology plus surface metallurgy, the surface metallurgy will drastically deteriorate. For that purpose in order to protect the work piece, we should use the cutting fluid, so that the cooling as well as lubrication action will takes place, and you can enormously reduce the sparking. So, if you see here the difference between this grinding zone and this particular zone ok. So, the work piece will be well protected in this condition. This is a another work piece where the wet grinding is going on, here the dry grinding is going on. This is the dry condition; this is a wet condition ok. So, because of these dry and wet conditions, you can improve your work piece in a great way in terms of metallurgical changes ok. For that purpose we need to go for the cutting fluids or the grinding fluids.

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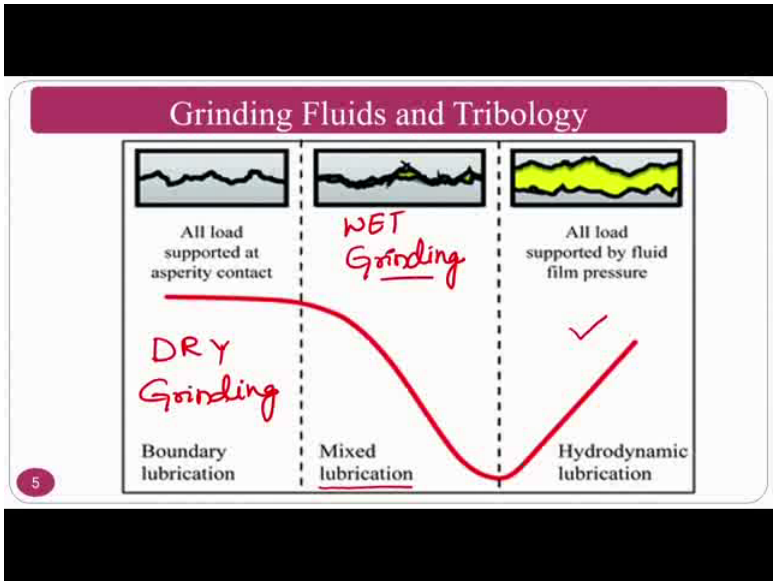

So, whenever you want to look at the Tribological aspects in the grinding process or metal cutting process, you come across with strive back curves. And normally this is there are three regions anyhow this particular thing I will explain whenever I am going to explain you the Tribological conditions or the Tribology of grinding and other things, if time permits. Otherwise, just a glimpse I am going to give you here is the, this is the boundary lubrication, where metal to metal or grinding wheel to the work piece will be contact.

Assume that this is my work piece and the grinding wheel both are in contact this is called surface to surface contact. In other conditions, if surface to surface contact is

there, in between there is a nano layer of cutting fluid even though you have metal to metal or ceramic to metal contact, you will have very minute layer of cutting fluid or the grinding fluid is there that is called mixed lubrication. Then the third one is hydrodynamic lubrication, normally hydrodynamic lubrication you do not want from the point grinding. Normally from the grinding this is the best suiting; grinding you want this one here what you will get is a wet grinding; and here you will just a get the dry grinding, which we do not want is a hydrodynamic boundary lubrication in terms of grinding process.

If this is the case, what will happen, there is no contact between the grinding wheel as well as the work piece, so which we may not like. But hydrodynamic lubrication is the most important and well signified lubrication in terms of a most of the tribological conditions like chip tool tribology or bearing other things, this is the mostly used one or mostly important one. But for our condition I strongly suggest you to go ahead with wet grinding. You have seen in the previous slide, in the dry grinding, it is just the spark is enormous; and in the wet grinding, so you can avoid by having a micro layer or a nano layer of cutting fluid ok.

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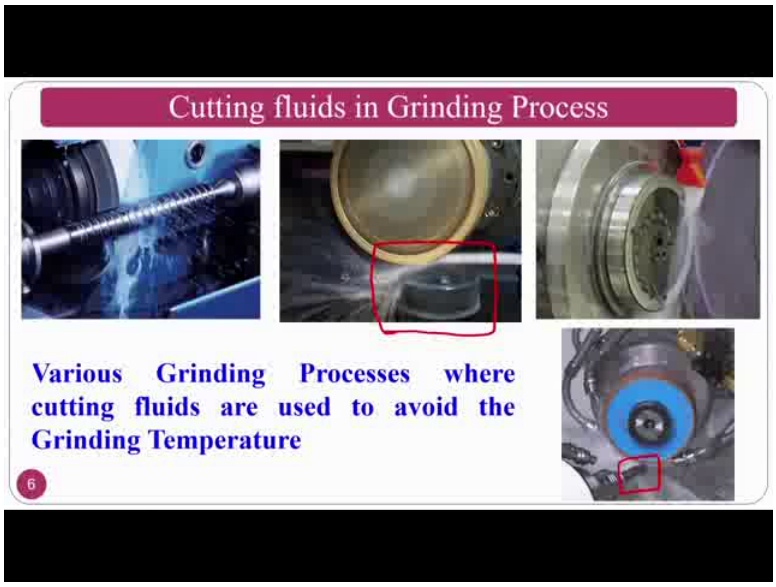

So, various grinding process where the cutting fluids are used to avoid the grinding temperatures is nothing but, you can see here the some of the grindings cylindrical grinding is there, then the lens polishing; you can see here, the lenses are grinding here.

So, if the temperature goes up, this is the, what lens that what we are varying basically this is the lens that they are fabricating here ok. If the temperature goes up what will happen it will damage the lens.

So, you can see the cylindrical grinding where the cylindrical components are fabricated at the same time tool and cutter grinder. Normally, if you see here the grinding of a cutting tool is doing here. So, if the temperature goes up, what will happen the tool material will metallurgically change in turn, the life of the cutting tool will drastically comes down. So, you need to use the cutting fluids in the grinding operation.

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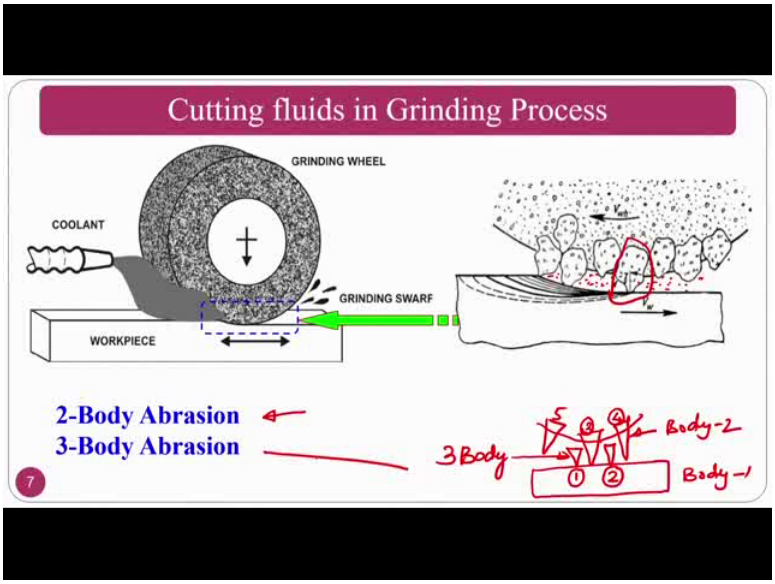

The cutting fluids this is what the, what is happening here is grinding. If you can use the cutting fluids, what will happen the cutting fluid will come here and occupy this locations and it will reduce the friction as well as it cools down the temperature of the work piece. So, there are two types of abrasions are there; one is a 2-body abrasion, another one is a 3-body abrasion. Normally, when you call it as a 2-body abrasion, assume that this particular abrasive particle is fixed. And it do not have its own axis of rotation, because it is a bonded abrasive particle, it is a bonded abrasive particle, which is binded by the binding material of the grinding wheel.

So, as per the instructions of the grinding wheel, it has to work. So, that means that whatever the machining or the grinding taking place, it is dictated by the bond, it cannot rotate about its own axis that is called 2-body abrasion. This is the body 1 and this is the

body 2 that is why it is called a 2-body abrasion. For example, if you go for lapping process or if you go for some other processes or assume that in a soft wheel that means, that the grade of a wheel is very soft in that circumstances, the bonding is very poked. And this particles will come out, and it also involve in the machining process that means, I have a work piece, I have the grinding wheel, where my particles are there. So, there are some particles which are de-laminated or de-bonded from this one and this also involves here.

So, that means, that these particular 1 and 2, these are the abrasive particles, these abrasive particles have their own axes of rotation to decide the surface roughness, and other things, apart from 3, and 4 ok, these are all bonded; 1, 2 is un-bonded and the 3, 4, 5 are bonded abrasives. Whenever you have a axes of rotation about its own axis, then it is called 3-body abrasion. You can see the work piece itself is 1 body, body 1, this is body 2 and this de-laminated or de-bonded are body-3 is called third body ok. So, this is called 3-D abrasion.

Hope you understand, if there is a 2-bodies are involved in abrasion process like grinding wheel and work piece material, it is a 2-body abrasion along with a this one assume that some of the 1 out particles are there this also involve in this 1, where this 1 out particles had its own axis of rotation; that means, that these are independent, then it is a 3-body abrasion. 3-bodies 1 is a grinding wheel another 1 is a work piece material, and de-bonded abrasive particles 3-bodies are involved that is why it is called a 3-body abrasion ok, this is about this one.

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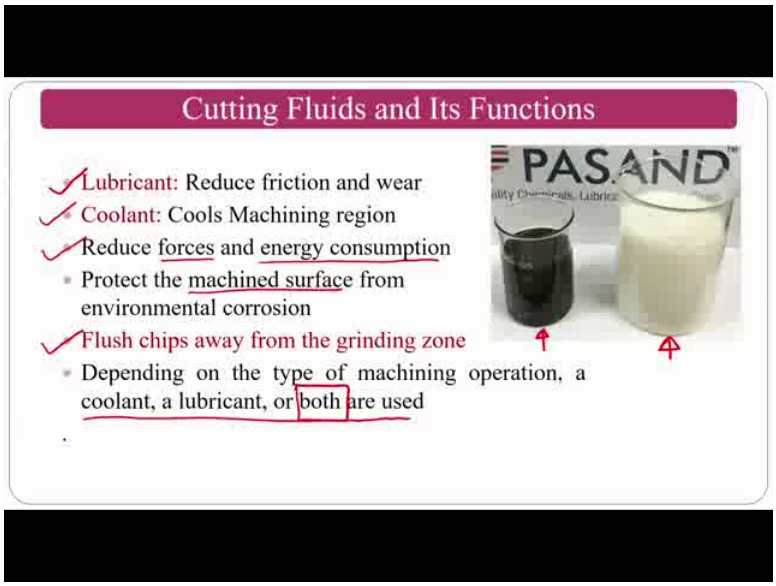

So, cutting fluids and its function basically the cutting fluids major function in this particular grinding process is lubrication, because the abrasion is the main mechanism of material removal. So, to counter it one must need a lubricating property. The second one is followed by cooling property temperature generates, so in order to remove that one you need a cooling property. Reduces the force, obviously, if it act as a lubricant and cooling then it will reduces the forces, and energy consumption that is required. Protects the machine surface from the environmental corrosion normally, there will be a some of the anti-rusting agents will be used in the cutting fluids, which can improve or by forming a passive layer on the surface, it will protect from the environment.

The flushing away the chips. So, if there is any chips or you have seen in the previous class that the loading is a biggest problem in a grinding process. Whenever you push the cutting fluid onto the grinding wheel, what will happen, there is a possibility that the wheel loading can be reduced and de-bonding of this loaded material will occur, and it can come out. In that way, chips can be flushed from the grinding wheel. So, depending on the type of machining operation a coolant, lubricant are both can be used. Normally in this condition, you have a abrasion effect, you have a temperature effect, that is why you need to go for both that is called lubricating as well as cooling properties that you have to go. You can see here this is a pure one that is purchased whenever you mix with water normally it will come as a milky white colour of the cutting fluid.

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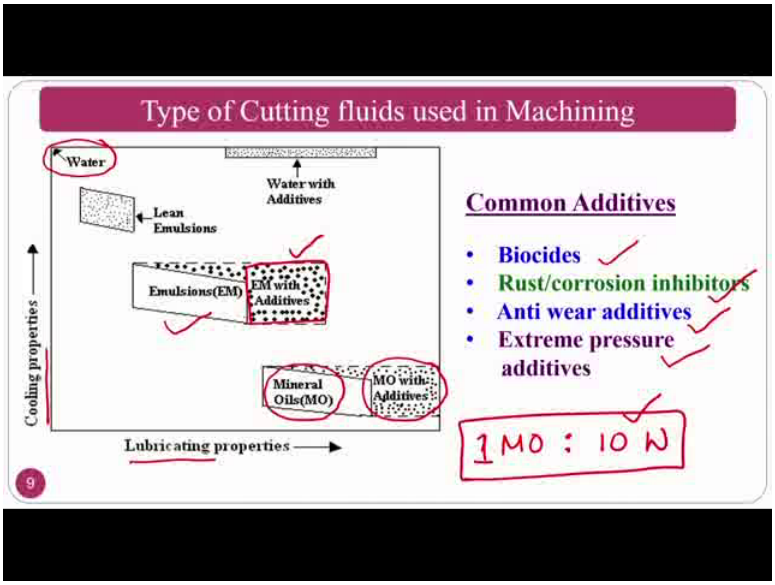

The cutting fluid normally, if we want to classify, there are two varieties of cutting fluid, one you can classify based on lubricating properties, another one is cooling property. Based on these two properties, you can decide which type of cutting fluid you want. If I want dominating cooling properties, I can go for water based cutting fluids. And if I want only the lubricating properties, then I can go for the mineral oils ok. So, these are the two extremes or I can go for mineral oil with additives. What are these additives I will explain you in this particular slide only after some time.

So, if at all I want both as I explained in the previous slide we require cooling property as well as a lubricating property for that purpose, what you have to do is you have to make the emulsions. Emulsions means just you have to mix the mineral oils with the water, so that you can make emulsion, but emulsion as such cannot work mostly for that purpose always people will go for some of the additives basically that is called emulsions with additives. This is the region where, you can go ahead and you can use it.

What are the additives the first and foremost additive is biocides, because it can prevent the formation of fungal, bacterial in the cutting fluid, because the people uses the cutting fluid some few months ok; in that circumstances, water is there enormously. Normally cutting fluids are made up of 1 litre of mineral oil is to 10 litres of water. So, in that circumstances water is a dominating fluid. This water, if you are keeping for months what will happen fungus and you are keeping under static level for that purpose these

may generate or these may attack by the bacterias, fungus and other things. For that purpose, you need to have biocides.

Rust, and inhibitors, if you are going to use water what will happen the final product that is coming out may be having rust, because the water will react especially iron based work pieces. So, you need to have the rust or corrosion inhibitors anti-wear additives. You need to have low shears strength materials whenever it comes to in contact with a two meeting surfaces it should shear easily. Extreme pressure additives, extreme pressure additives or the additives that you will use, so that even though at extreme pressure should form a layer so that proper tribological conditions can be maintained ok.

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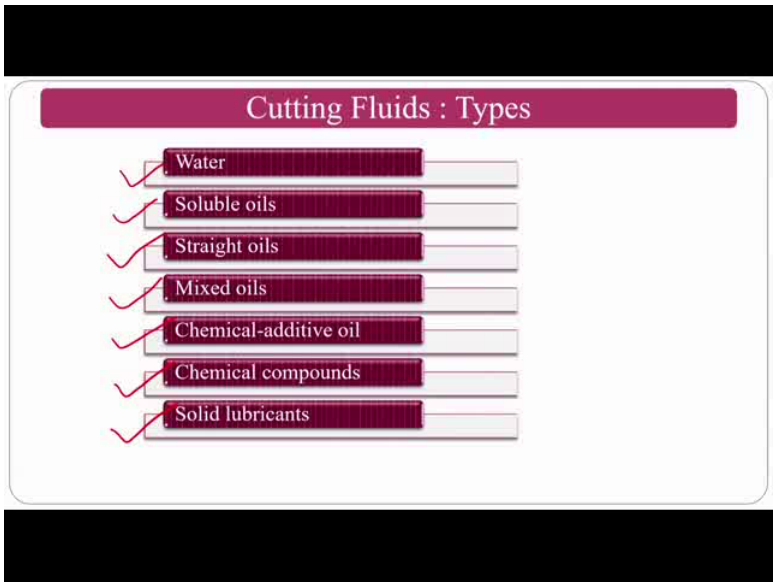

Cutting fluid types normally water based soluble oils, straight oils, mixed oils, chemical additives, chemical compounds and solid lubricants many more varieties are there. Some are, nowadays people are talking about echo friendly cutting fluids and other cutting fluids ok.

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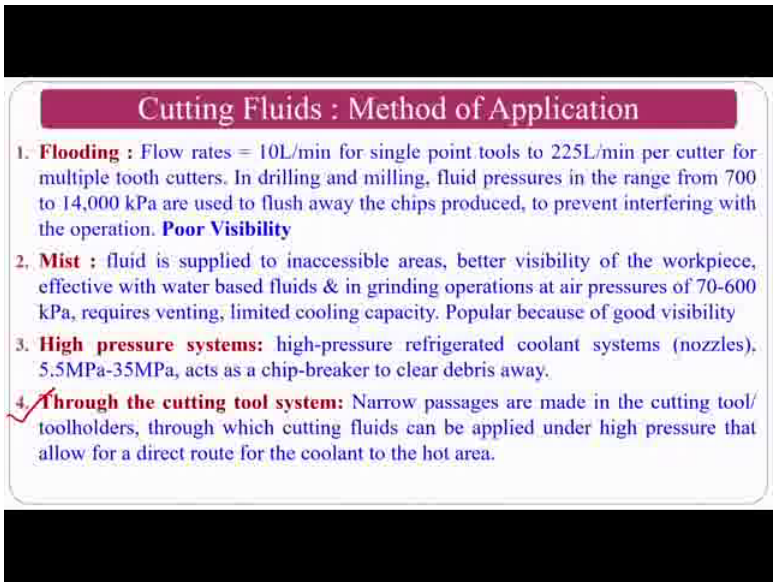

So, normally the mechanism or the methods of application of this cutting fluids, there are standard methods one is a flood cooling, flood cooling you might have seen in the workshops, where you will use a small nozzle and just you by virtue of gravity it will come or you use a small pump, so that you can pump it ok. So, the biggest problem here is the cutting fluid consumption is around 500 ml per minute ok. So, huge amount of cutting fluid that is why the cutting fluid cost are approximately 17 percent of the product cost.

So, another one is mist application, where you can mix the cutting fluid along with the compressed air. And you can mix in a two ways one is internally you can mix or externally you can mix, then you just push towards the machining region or the grinding region. So, high pressure additive systems you can use here there is no requirement of air, but you just you send high pressure cutting fluid into the grinding region. So, this is some other in a single point cutting tool or a multi point cutting tool like milling cutter and other things. The fourth one also refers that is you can make a internal holes in a cutting tool, but it may not be possible in grinding ok.

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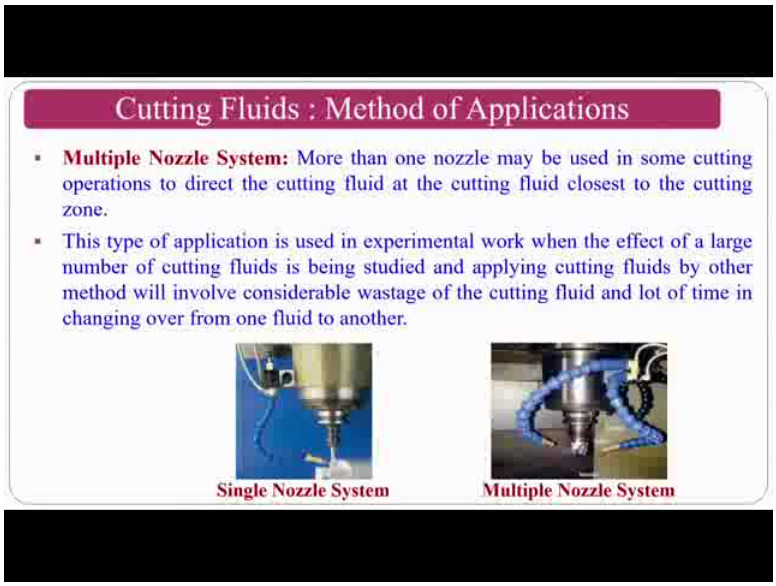

Another one which you can use is a multiple nozzle system in a milling process are this is the another since the milling and these are also comes under the multi point cutting tool processes this is also explained ok. So, if you want more details about this particular course or cutting fluids, you can refer to one of my course is introduction to machining and machining fluids, which I have previously taught on MOOCs course.

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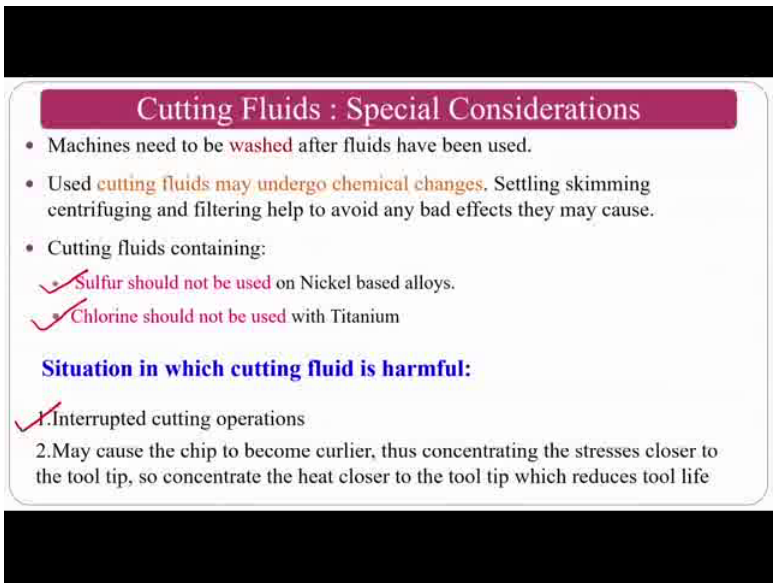

Special considerations, machines need to be washed after the fluids have been used, because if you do not wash then it will be a problem ok. Cutting fluids may undergo

chemical changes, because whenever you are using the first time, the chemical composition may be ok; whenever it comes to the high temperature region what will happen, there will be a chemical cracking will takes place. If you are reusing again and again the chemical cracking; the chemical cracking takes again and again, so the cutting fluid will go undergo air drastic changes. Cutting fluids containing sulphur should not be used for the nickel based alloys; and chlorine should not be used with a titanium, because this is chemically reactive.

Cutting fluids are harmful normally interrupted cutting operations it is, because the pressures are the forces of the cutting or the machining will come suddenly. So, sudden jerk will come. For that purpose, you should be very careful whenever you are using the interrupted and curly chips and other things. So, you should be very cautious about these type of things.

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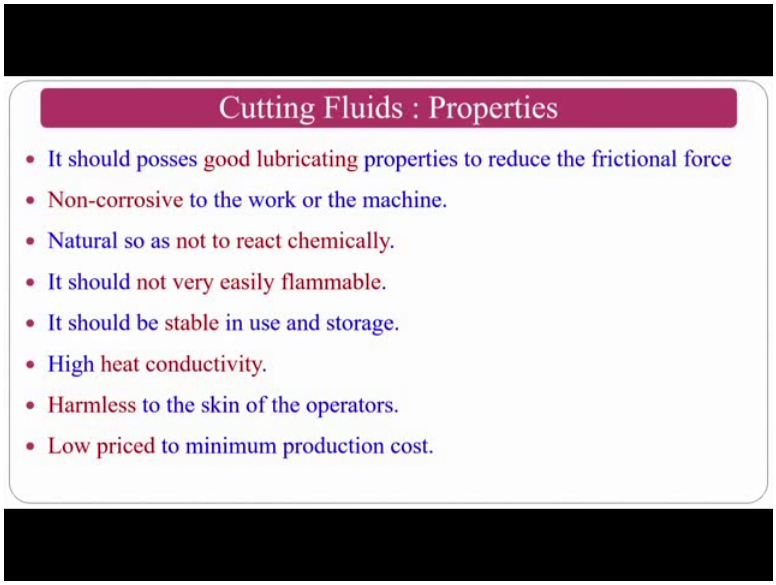

Properties it should posses good lubricating properties; obviously, lubricating. It should be non-corrosive, because if it is corrosive, then what will happen your lathe bed other things will be rusted. Natural, so that not react chemically. It should not very easily flammable; it should be non-flammable. And it should be a stable as well as high heat conductivity. If it has high heat conductivity what will happen, the temperature generating on the work piece, because of the grinding action can be taken out.

So, harmless to the skin, because whenever the chemically cracked cutting fluids or the grinding fluids because of the high velocity of grinding wheel may sometimes flash onto the operator. So, this operator normally operates with a hand in that circumstances, if it is fall on the hands or other parts of the body, it should not corrosive or it should not create any harmful to the operator ok. Most important thing is whenever particular person want to sell the product, he has to sell the product at minimal prize. When he can send minimal prize, if the production cost is less, so he can sell at the competitive prize in the market that is why the cutting fluids all should be economic.

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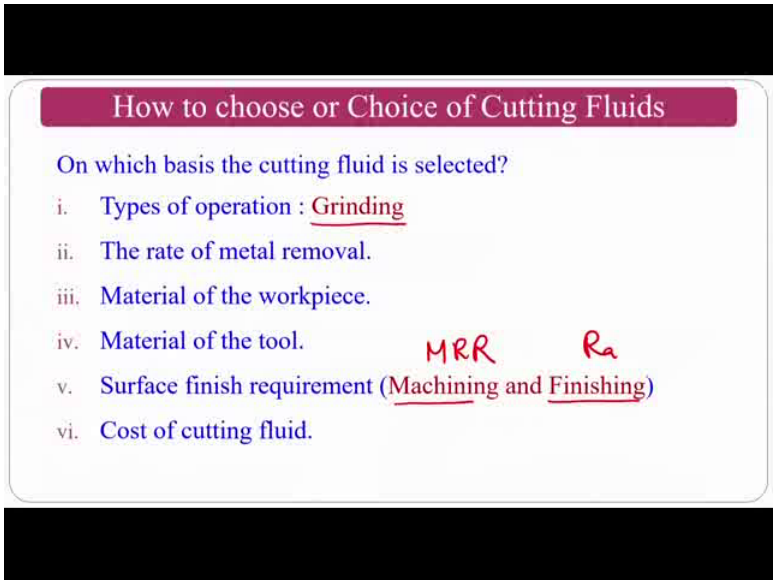

So, how to choose the choice of cutting fluid, on which basis the cutting fluid will be selected? So, the type of operating which is a normally in our condition current condition, it is a grinding operation. So, rate of material removal. Normally the material removal criteria in a grinding can be two ways, one can be material removal as well as another one is the finishing. So, if your condition is a material removal, the temperature will be very high, so you should always go for the cooling type of. If we are going for the finishing type wear the material removal is very less for example, I am just telling, if here the material removal is very less, and I am talking about the good surface finish that in that circumstances, you should go for the lubricating oils ok.

Material of the work piece if it is too hard you should the temperature will be very high. So, you should be optimumly choose the cutting fluids or the grinding fluids. Material of

the tool; that means, whether it is a vitrified bond along with the silicon carbide, vitrified bond along with the alumina or which type of things ok. Surface finish requirements, normally in a grinding, you can go for machining that is a material removal rate is a criteria and another one is the finishing, final surface roughness is the criteria this is what you have to check. The cost of the cutting fluid always the final thing at the most important thing is it should be economic.

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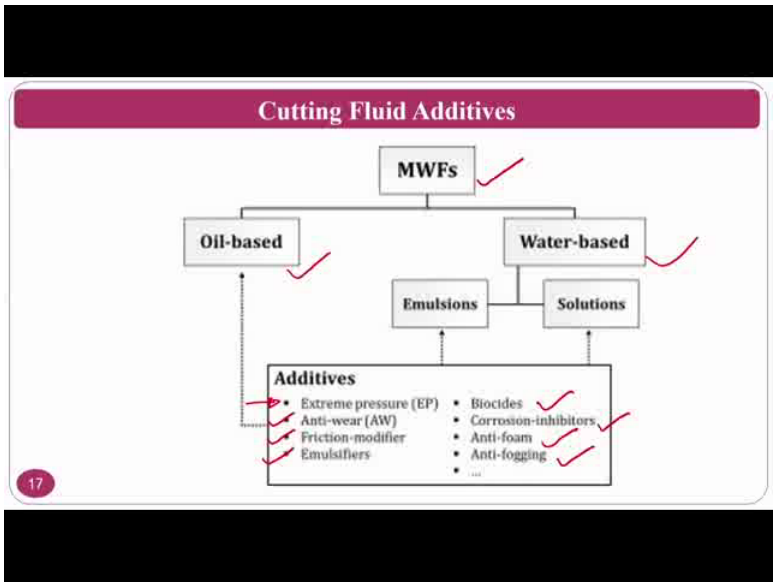

So, cutting fluid additives, the cutting fluid additives will be like metal working fluids normally it is common name, there are oil based and water based. So, if you see oil based or emulsions or the solutions, where you will have a extreme pressure additives, anti-wear additives, friction modifiers, emulsifiers, biocides, corrosion inhibiters, anti-foaming agents, anti-fogging agents, many many are there among which some are important which we will see in the upcoming slides.

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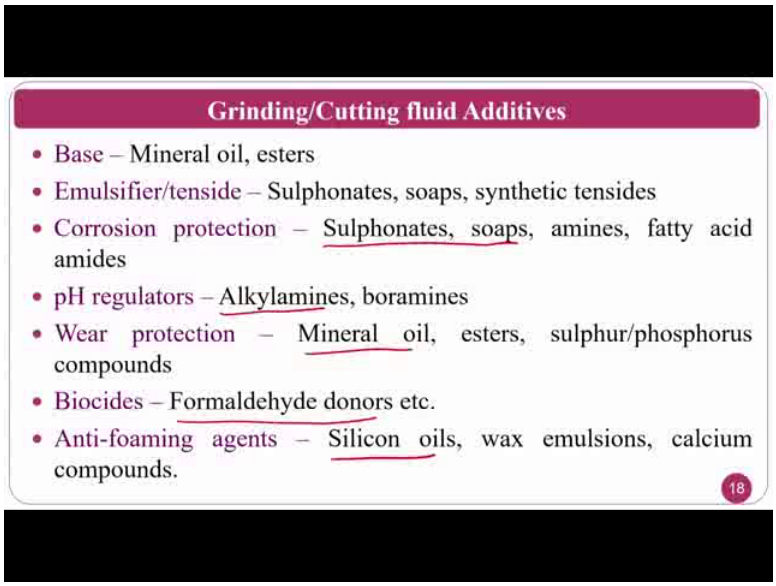

The grinding fluid additives the base is a mineral oils basically, Emulsifiers normally sulphonates soaps synthetic tensides and all those things corrosion protection sulphonates or soaps you can use. P H regulators alkylamines are will be used. And wear protection mineral oil esters, sulphur and other compounds you can use. The biocides for formaldehyde donors normally used. And anti-foaming agents to prevent the foam in the machining region, so that the visibility will be very good, it would not interrupt by forming the foam. So, silicon oils or the waxes or calcium compounds will be used in this particular anti-foaming agents.

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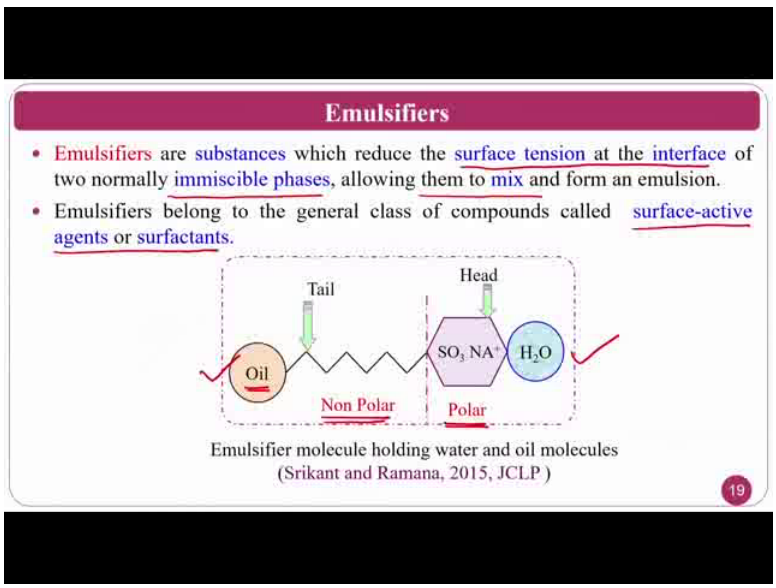

So, we will come into the one of the most important thing that is called emulsifiers. I said emulsions with additives ok, this is a mostly used. If at all I want to make an emulsion, I need emulsifiers. Emulsifiers are the substances which reduce the surface tension at the interface the main function is I, if I have a oil, if I have a water how to mix both ok. If I cannot mix how to disperse properly, for that purpose, if I can reduce the interfacial tension, then I can disperse properly. The emulsifiers basically reduces the surface tension at the interface of the two normally immiscible phases, allowing them to mix ok.

So, I can mix by adding a third one that is called emulsifier, I have oil mineral oil, I have water, I have mixed, it is not proper in that circumstances emulsifiers are used. Whenever you are getting a cutting fluid from the market for example, the Servo companies supply Servo Cut S. Whenever you mix into the water automatically it mixes, you do not require any emulsifiers or something, why, because it is already in built in it, whenever you use it you it will mix properly that is why, you will always see white colour milk type of thing. Emulsifiers belongs to general class of compounds that I called surface-active agents or surfactants ok.

Emulsifier molecules holding the water molecule and oil molecule, this is a oil molecule which is there. And it has a polar tail; this has a polar head and non-polar tail. Whenever see in a cutting fluid what will happen you are going to mix the oil with water. So, how do you want to mix you will add a emulsifier. Emulsifier will have a polar head and non-polar tail ok. The polar head will go on hold or it will go and attach to the H 2 O molecule that is a water molecule and non-polar tail will go and attach to the oil molecule. In that circumstances I have two things one is a water, another one is oil. So, polar head will come and hold the water and non-polar will (Refer Time: 25:58) So, that it will mix properly, so that is how the mechanism of emulsifier works between the two immiscible fluids of the cutting fluid.

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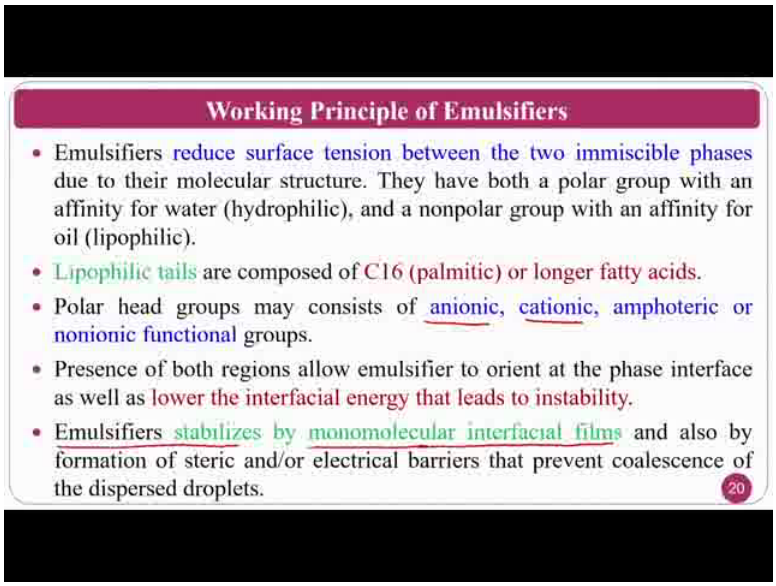

The working principle of a emulsifier. Emulsifier reduces surface tension between two immiscible phases, so that you can mix it properly. And Lipophilic tails are composed for the longer fatty acids. The polar head groups may consist of anionic or cationic groups. And the presence of both regions allow emulsifier to orient it phase interface, if it has a both polar and non-polar what will happen it can interact with the both immiscible fluids m emulsifier stabilizes by the monomolecular interfacial films ok. So, there are many types of emulsifiers are there monomolecular, some other molecular many things are there. So, mostly what it will do is, it will combine or it will adhere to the two molecules of the cutting fluid that is one is a water another one is a mineral oil, so that it can mix properly.

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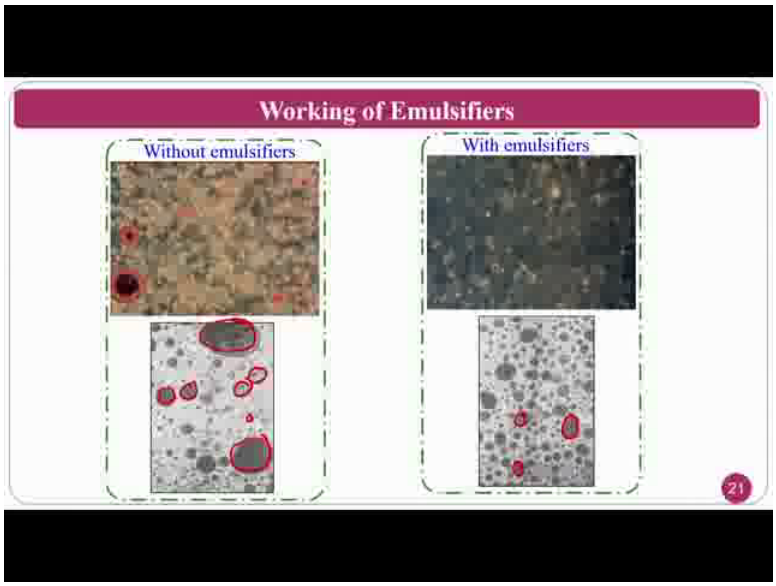

The working of emulsifiers you can see here without emulser, if I am not going to use the emulsifiers what will happen the oil molecules or random sizes ok. There is no uniformity and it can be a small one, it can be a big one ok. So, if you use the emulsifiers, what will happen the proper mixing or proper dispersion will takes place properly. So, you, you do not find much difference between the molecules, but there is slight variation will be there, but you can reduce this size variation in the cutting fluids.

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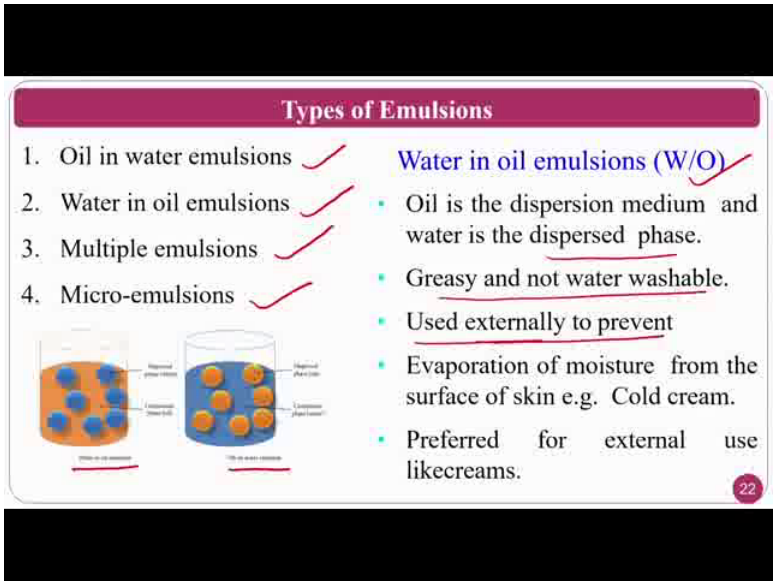

So, there are many types of emulsions one is oil in water emulsion, water in oil emulsion, multiple emulsions that is oil in water in oil, water oil in water, varieties are there micro emulsions and all those things. If you can see here, water in oil emulsions normally this blue ones are water, where oil is orange one, so water molecules are there. In the oil in water, so this is a water blue one is a water always the sea look like a blue. So, you just remember like that and this oil is suspended immiscible fluids are suspended ok. Water in oil emulsions are the first ones. Oil is dispersion medium and a water is a dispersed medium, greasy and not water washable, and used for externally preventive, and other things. What I mean to say is you have oil where you just dump the water ok, so you have the emulsions. If you want to mix properly, just use the emulsifiers in these conditions.

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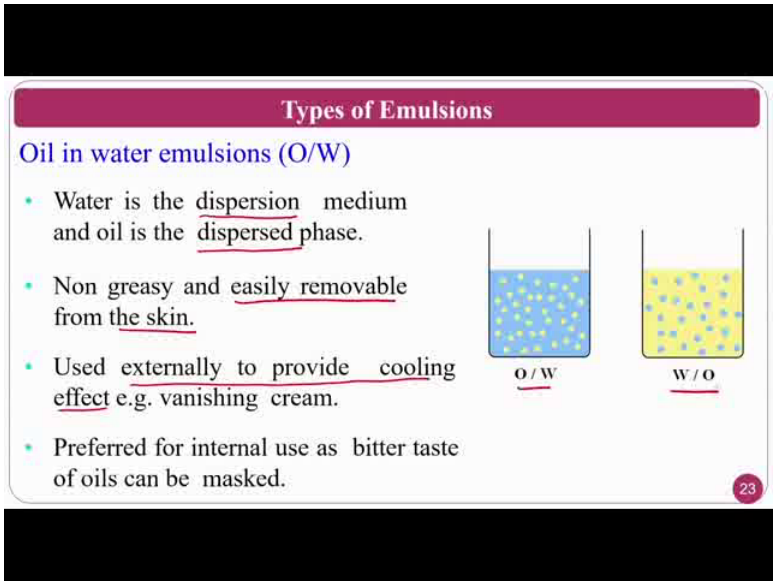

The second one is oil in water emulsions basically you have the water where you just pour the oil ok. In this condition, water is dispersion medium as well as oil is a dispersed medium. Non-greasy and easily removable from, from skin even though during grinding operation or machining operation, if the splashing occur you can remove easily. Used externally provide cooling effect, normally these are used externally for the cooling effect, because your water content is more, so you will have the cooling effect. Water is more, so you will have always better cooling properties in this one ok. Preferred for internal use as bitter taste of oil can be masked ok, oil in water, water in oil these are the emulsions.

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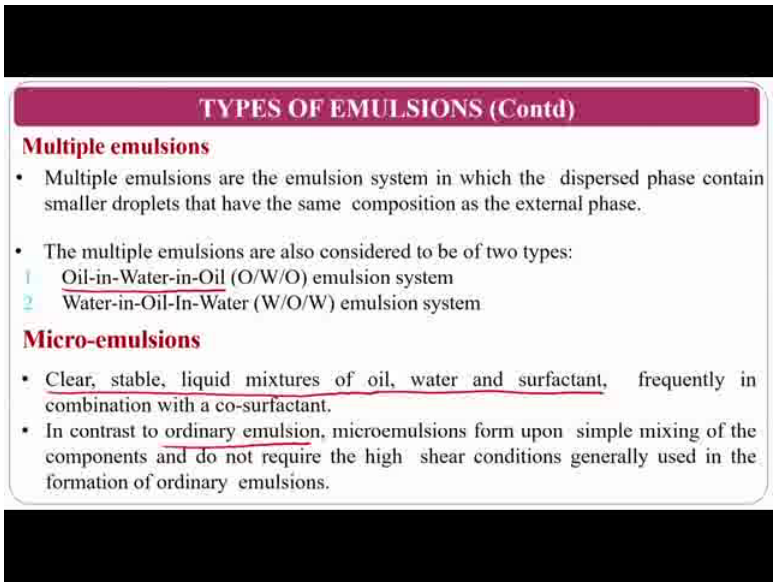

Multiple emulsions, multiple emulsions are there are two varieties basically oil in water in oil basically, you have a oil then water and oil, and water in oil in water. So, you have a water molecule inside the you have oil and inside you have a, and this is there inside the water ok. These are the two varieties and the micro emulsions, whenever the size of this emulsions are goes into micron region normally these are called as micro emulsions. But, whenever these micro emulsions basically will be very, very small in that is why it will be very good, it looks to the human eye, it is a very good clear emulsion or clear stable and liquid mixtures of oil water, and surfactant, and frequently in the combination of this co-surfactants also used.

In contrast to the ordinary emulsion, the micro emulsions form upon the simple mixing of the component and do not require high shear conditions. What I mean to say is, if my micro emulsions are used for a mixing or for blending the two fluids in that circumstances, it can be easily form. You need not stir with very high energy or something ok. For that purpose, you can for the micro emulsions where it can make a good emulsions with the oil as well as water by mixing a micro emulsions with very less mixing efforts.

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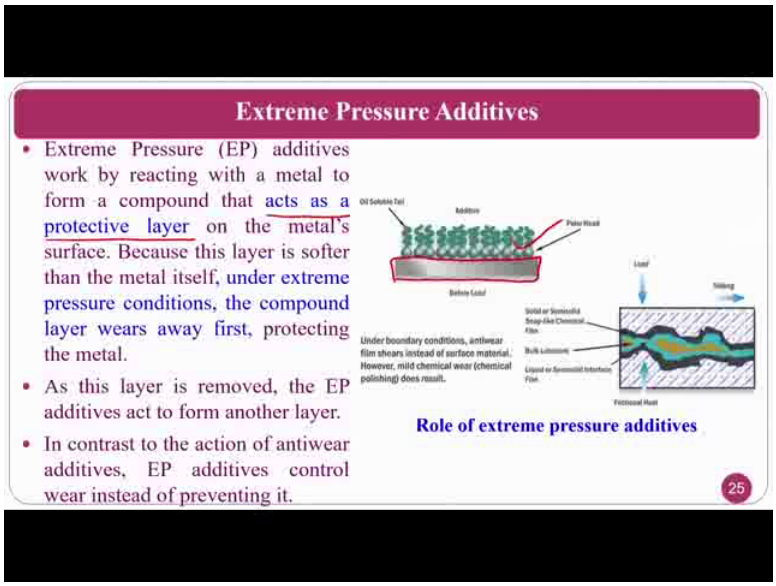

The second one is extreme pressure additives. The extreme pressure additives work by reacting with a metal to form a compound that act as a protective layer on the surface ok. So, under this extreme pressure conditions, this compound layer wears away the first that means, that these are some type of chemicals, which reacts with a work piece assume that the grinding process is going on whenever you are sending a extreme pressure additives, this will go and form a layer on the work piece ok.

So, even though the machining is taking place what will happen here is the first this layer goes off, and it will protect the work piece. This layer is removed and what is happening here is just, you can see one layer is forming and during the machining process it is going off, it is a narrow layer by per protecting the work piece. Since the cutting fluid is continuously falling the passive layer or the what of the layer that is a extreme pressure additives layer which is reacting to the work piece will form continuously, and this layer will be protecting for during the machining process. You can see here polar head and the non-polar tails are there, this is the work piece material, where the layer is formed here. So, even though the tribological conditions are severe it will form continuously, because the cutting fluid is falling continuously. So, it will protect at extreme pressures also or extreme conditions of the grinding also.

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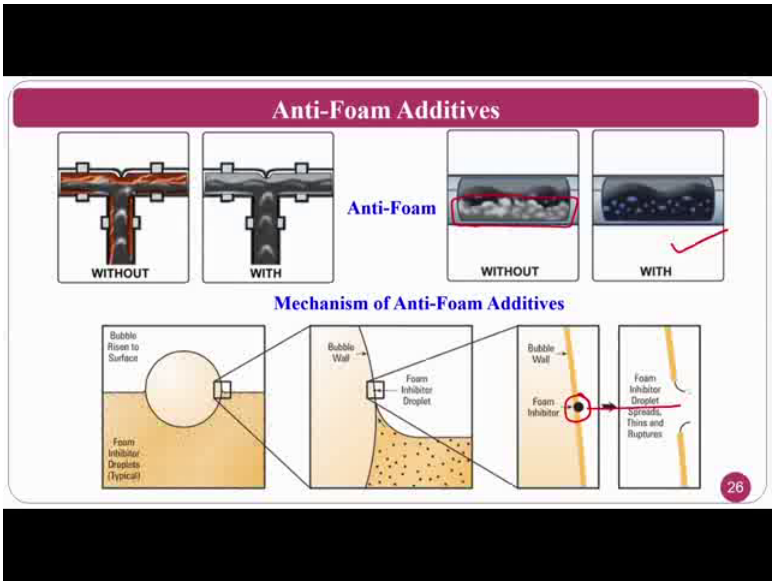

So, anti-foam additives the foaming is not good basically for the clear visibility will be loose, because the foam as you see know assume that I have a water and just putting a surf or something what will happen I can see, whenever you just mix it properly with the hand, whenever you are washing the clothes, what will happen foam will form. This foam will you lose the visibility first at the same time this foam some of the bubbles may break, so which may cause some intermittent chemical actions and other things that is why you did not, you do not want this foam to be in the machining conditions or as a part of the cutting fluids.

If you see here without anti-foam, there is a foam is forming which will interrupt the machining may not be interrupting directly, but it will hamper the performance. In that circumstances if you go for anti-foaming agents, so beautifully you can cover and you can do in a much better way. How this anti-foaming agents work ok. So, what will happen you have a firm in hit it to droplet and bubble risen from the surface, this is the bubble, this bubble anti-foam inhibiter droplet will come this is the foam inhibiter, which will come and hit the bubble form whenever it will hit the and it breaks the bubble, so that it would not form the bubble.

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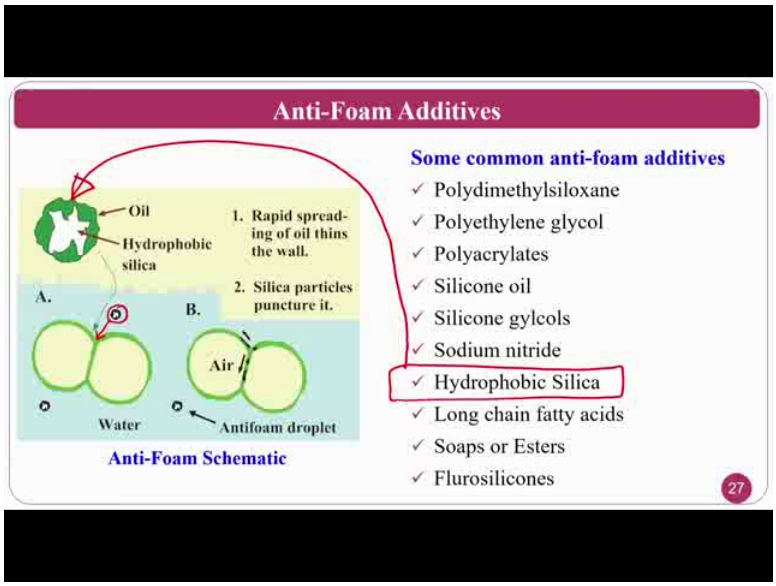

In this slide, you can clearly see the hydrophobic silica is the anti-foaming agent. What will happen it will come and it will hit the bubbles whenever it will hit, the bubbles, the bubbles will break. And there is similarly, you have millions and millions of a hydrophobic silica will be there, it will hit the whatever the bubbles that are generating. So, the bubble generation or the foam generation will be drastically reduced. Some of the common anti-foam additives, you can see these are the polydimethylsiloxane, silicone oil and hydrophobic silica, these are the things. Whatever we have seen in this present example hydrophobic silica that is used in this condition ok. So, this is the one of the examples soaps and esters, and flurosilicones these are the other things.

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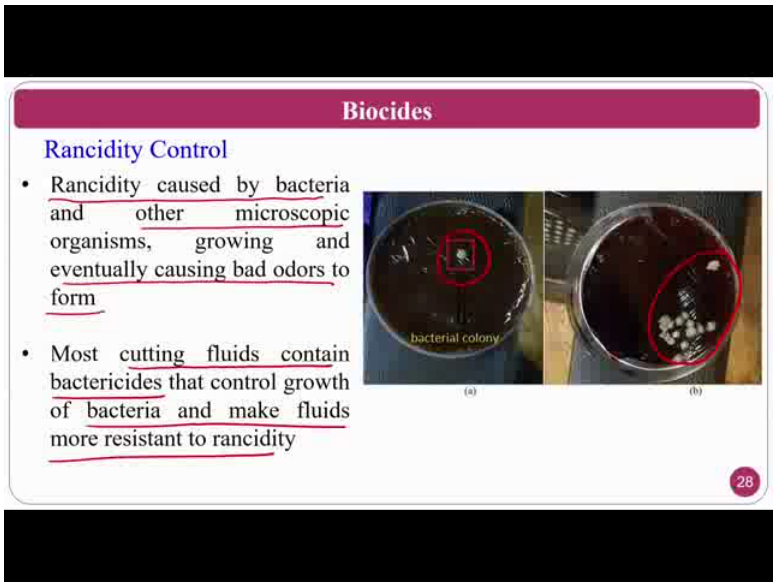

Biocides, biocides are rancidity controllers. What will happen rancidity is, rancidity is caused by the bacteria and other microscopic organisms growing eventually causing the bad odour to form; that means, that this is the grease normally cutting fluids greases these are all or the common cooling as well as lubricating agents. Since we are talking about grinding process, lubricating should be a primary concern for thus lubricating, the grease is one of the better lubricating medium.

If you see here, there is a bacterial colonies formed, if it would have been mixed with the biocides, what will happen your lifespan of this particular grease or the lubricating medium would have enormously increased ok. The most of the cutting fluid contains the bio-bactericides, the control the growth of bacteria make the fluid more resistant to rancidity. Rancidity means it is causing the bad odour. Normally whenever you see if you smell it, you will get a very bad smell ok.

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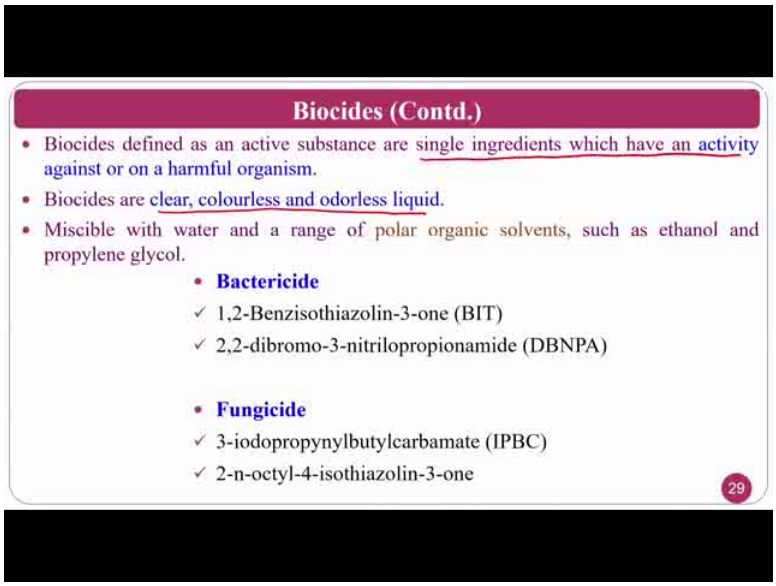

The biocides defined as a active substances or the single ingredients which have an activity against the harmful organisms; that means, that the bacteria, fungi, other organisms which will grow on this one, will not grow be whenever you add the bactericides, because it will kill the bactericides. Biocides are clear, colourless and odourless liquid, because rancidity it means that it is a bad smell. If this also gives the bad smell then there is no meaning, that is why it should be whenever I want to measure a certain surface roughness or something, my master should be much, much smoother. That means, that I do not want older means the primary material, that I am using should not give any odour, that is what the most important thing of this particular point is concerned.

Miscible with water and large and a range of polar solvents. Bactericides normal examples are these things and the fungicides these are the two examples. You can see bactericide and fungicides, and biocides is nothing but is a combination of both, you can kill the bacteria, you can kill the fungus and other micro organisms also.

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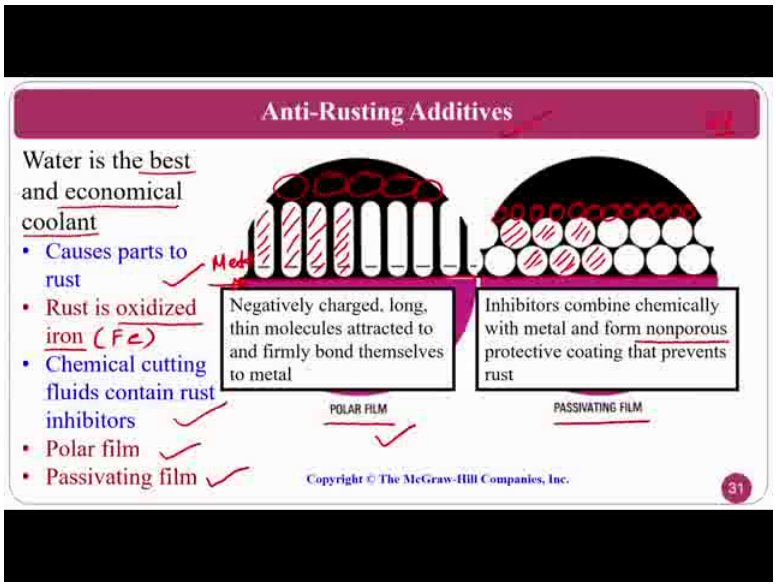

The next cutting fluid additive that we are going to study is anti rusting additives. So, in the anti-rusting additives normally this anti-rusting additives are mostly used in water based coolants, because as we have seen the lubrication as well as the cooling effects. Whenever we want the good cooling effects, we have to go for the water. Assume that I am going to use the dominating water very less cutting fluid in that circumstances; the problem with ferrous based work pieces is the rusting. So, to prevent that one we have to anti-rust additives. So, water is the best cooling as well as economic coolant ok.

So, it is a one of the best, because the convective heat transfer coefficient or conductive heat transfer coefficient is high compare to that normal mineral oil based cutting fluids that is why at the same time abundant water is there in the world. So, it is economic as well as a best cooling component in the cutting fluid, so but it causes the parts to rust that is the components will be rusted. At the same time rusted in the form of oxidized iron normally, what will happen the iron based work pieces will be rusted ok. So, if I am going to use for machining of mild steel ok, if I use the cutting fluid as a water, so it will rust, because that high temperature when the water falls on to the surface, so there is a possibility after sometime on that component rusting ok. There is a possibility to rust on that particular component after sometime.

So, the chemical cutting fluids contain rust inhibitors. Normally, whenever you are purchasing the chemical based cutting fluids, you will have the inbuilt rust inhibitors.

Rust inhibitors act in two forms one is the polar film formation and another one is passivating film formation. So, what is this polar film as well as passivating film that we will see here ok.

The first is polar film. What do you mean by polar film, if you see the negatively charged long thin molecules attracted, and firmly bond themselves to a metal what will happen these are the negatively charged long thin molecules, which are adhered to the surface like this these are there. So, these are the negatively charged and molecules, long molecules, which are adhered to the surface this is the peak one is the surface, so on top of it is adhered. This is called the polar film.

So, if the polar film is formed, what will happen if there is a water contact, then what will happen the water, if at all the droplets are falling, what will happen this will protect. The negatively charged long thin molecules will protect from the direct contact of the metal, because this pink one is the metal, this is the metal ok. So, it is protected by these thin structures.

So, in the other way what is passivating film protection? So, this are inhibitors combined chemically with a metal and form the nano porous form the non-porous protective coating that prevents the rusting ok. The other one is the passivating film; how it is going to form just we will check. The inhibitors combine chemically with the metal and form a non-porous protective coating that prevents the rust ok. So, here the most important thing that one has to observe is non-porous that means, that it is a purely a solid type of layer is forming. You can see this these are the reacted ones which reacted and form on the surface the pink one again is the surface, this is a surface on top of it, it is formed ok. Whenever it form what will happen or the water is waters try to come in contact with the work piece it cannot come, because this passivating film will abstract. So, the rusting cannot takes place.

If at all rusting has to take place, there is no other option apart from removing the polar film that is formed on it or the passivating film that is formed on it, otherwise it will be very difficult for the water molecule to contact directly the iron based work pieces, that is how the anti-rusting additives will help by forming two ways that is passivating film as well as polar film to protect the main surface of the work piece.

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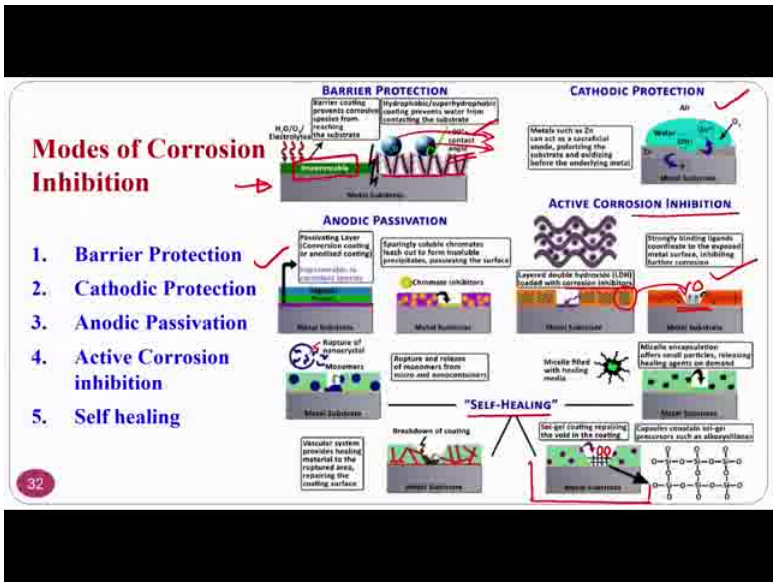

There are other modes of corrosion inhibition, then is barrier protection. These are also similar to the whatever we have seen till in the previous slide and the cathodic protection, anodic passivation, active corrosion inhibition and self healing. These are the other varieties or some are the broad names for whatever we have seen in the previous slide ok. If you see the barrier protection, the barrier protection normally what will happen here is this is the metal sub state, I am talking about this particular thing. So, what, what do we mean by barrier protection? So, the barrier protection is on a metal sub state you just put a coating, which is a barrier coating you can have this a impermeable coating on top of it, so that whenever the water molecule come in to picture or whenever the water molecule come in contact with a metal sub state it cannot.

The other way round is hydrophobic or super hydrophobic coating prevents water from contact in the surface. So, in the second barrier coating is hydrophobic or super hydrophobic coatings prevent water from the contacting surface. What will happen Lotus leaf; if you see a Lotus leaf, whenever the water droplet falls on it what will happen it simply crawls and fall off from the leaf that is called hydrophobic or super hydrophobic surfaces. Hydrophobic some people may have a the confusion about what is hydrophobic, hydrophilic, super hydrophobic, super hydrophilic and all those things just it is as simple as that one.

What you mean by just, I will explain you the difference between hydrophobic and hydrophilic, hydrophobic means, you have phobia, phobia means fearing assume that I the Lotus leaf is a hydrophobic surface, whenever the droplet falls, it fears to contact the surface and it falls down. Or you will have phobia some of the people will have the phobia, whenever you have to diagnose or something, whenever you will be sending to the city scan the cylindrical hallow cylinder will be there just a patient will be sent. So, some people will fear that is called phobia. So, immediately they will come out the. Similarly, the water droplet also whenever it falls, it has its own phobia to the surface nature of the surface that is called hydrophobic surface.

Hydrophilic surface means it is happy to contact. Normally whenever the water falls on hydrophilic surface it will freely spread on the surface that is ok, philic means it will fill the surface; phobic means it will remain as a droplet or approximately a droplet shape and falls off from the surface, whenever it becomes inclination ok, that is a difference between hydrophobic and a hydrophilic.

So, now, coming to the our hydrophobic and super hydrophobic coatings, what will happen here this is the coatings, what will happen in this coating, if it is hydrophobic, the contact angle is more than 90 degrees. So, it is a phobic surface. So, if the water falls also, it cannot directly cannot the work piece surface, so it will directly go away from this particular surface itself. So, it will go out that is called barrier protection. You can have the bare coating or you can go for hydrophobic or super hydrophobic coatings.

These second one is cathodic protection. So, in the cathodic protection basically you will have the metal such as zinc can act as a sacrificial anode, you will have a sacrificial anode. Before, whenever the water comes in contact with respect to zinc or the sacrifice shell material. So, it will sacrifice itself before it will allow water to contact the work piece surface ok. So, this sacrifice shell layer until unless the sacrifice shell layer is there, there is no water coming contact with the work piece surface, there is no problem of rusting in this second case also.

The third one is anodic passivation. Normally you might all know what is anodic passivation and all those things. A passivating layer that we have seen in the previous slide will form on a surface. So, if there is there is a passivating layer is which is non-porous; that means, that it is a solid layer that we have seen in the previous slide. It

would not allow the water to come in contact with the work piece directly. In that way, anodic passivation helps.

Active corrosion inhibition, the active corrosion inhibition is a layered or double layered hydroxide, lay loaded with the corrosion inhibitors. These are strongly binding leasants coordinate to the exposed metal surface inhibiting the further corrosion. What will happen these are the things which will align to the metal surface, whenever the water falls on this surface, it would not allow the water to contact the original surface that is how the active corrosion inhibition works.

The self healing, the self healing in many ways, you can see in a composites also self healing composites are there, self healing smart materials are there many, many materials whenever there is a crack, the self healing materials will grow into the crack, so that it will wind up or it will cure the crack. So, similarly what will happen here is the breakdown of coating, whenever normally what they will send is the sole jell coating here, if you see in this particular picture, there is a sole jell coating repairing wide in the coating what will happen whenever there is a breakdown of this sole jell coating, there is a capsules containing the sole jell precursors, this capsules will come and fall in this region ok.

In that circumstances the basic advantage is whenever the water droplet come in picture also it would not have a direct contact that is how you can protect the surface or the metal surface are basically what I am talking about is a iron based surfaces from the corrosion. So, on all the cases, if you have seen, there will be a coating which helps or there will be a sacrifice shell layer or there will be a self healing layers, these are all will protect water droplet to come in direct contact with respect to the work piece ok. This is how the corrosion inhibition will takes place or these are the modes how the corrosion inhibition takes place.

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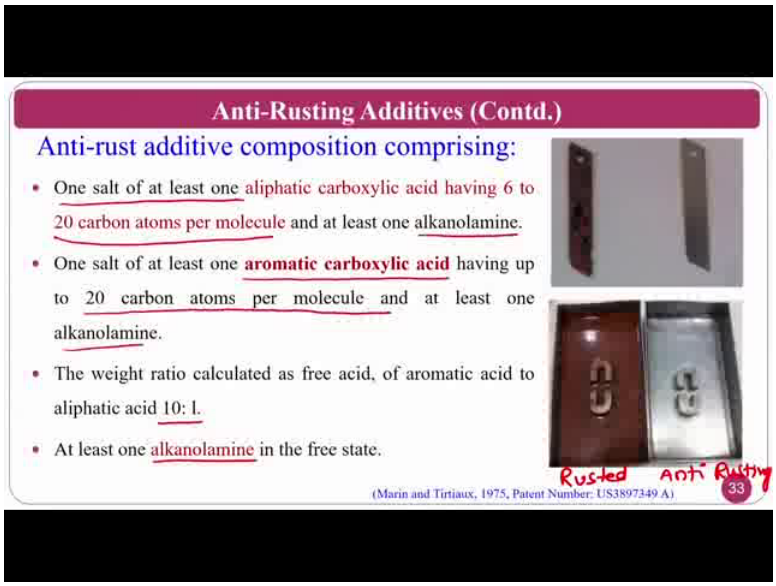

So, anti-rusting additives if you see the anti-rusting additives the composition. Normally, the anti-rust additive composition will have one salt at least one of the aliphatic carboxylic acid having 6 to 20 carbon atoms per molecule and at least one alkanolamine ok. This slightly goes into the chemistry ok, you have to slightly understand. And one salt of the at least one aromatic hydro carboxylic acid having up to 20 carbon atoms per molecule and at least one is alkanolamine, this is another one. So, the weight ratio normally is 10 is to 1 at the same time at least one alkanolamine in the free state should be available. You can see in the rusted state this is a rusted one, where the machining has done without anti-rusting additives and with anti, (Refer Time: 51:59).

Whenever you are going to use anti-rusting additive, so you can clearly see the difference between the 1 and 2. So, it is the beauty about the anti-rusting additives that is why one has to mix the anti-rusting additives in the cutting fluid. If you are not going to mix, then your components especially iron based components will rust and you cannot sell your products into the market ok. So, if you become engineers in a certain in manufacturing industry, the main motive of this particular slide is you have to use the required amount, you should not use high or low your required amount based on your application.

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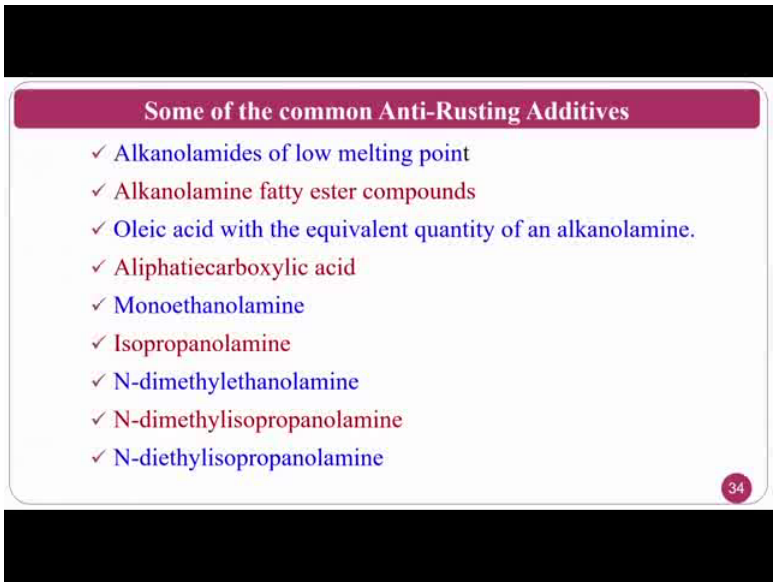

So, some of the common anti rusting additives we have seen in the previous slide alkanolamides of low melting point, alkanolamine fatty ester compounds, monoethanolamine, isopropanolamine, these are the names of the anti rusting additives that are used commonly in the cutting fluids or in other applications ok.

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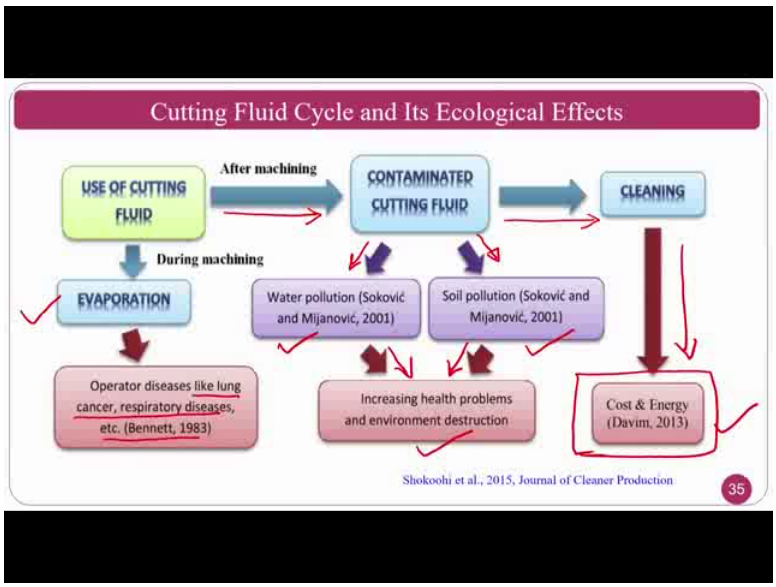

Cutting fluid cycle if you see, we have seen emulsifiers which are nothing but the surface surfactant, which are nothing but the surfactants. We have seen anti foaming agent, anti-rusting agent, many more additives biocides and many more additives, which we have

seen. But this is a positive side of the cutting fluid we have seen, because from the performance of the quality of the component, we have seen, but it has a negative effect a rupee coin. Assume that if you take a rupee coin it has two sides one may be a positive side, I am not saying about the rupee coin I am just saying that, you have one side positives and another side negatives. So, you also should accept whenever you take this additives along with a mineral oil the negatives also will come along with the positives.

So, this negatives we will see some of the glimpse in this slide we will explain, I will explain you in this slide. Use of cutting fluid after machining what will happen, the contaminated cutting fluid will come. So, contaminated cutting fluid means it is thermally cracked and it lost its original potential I mean to say that the original potential is slightly decreased. Then there are multiple options one is a cleaning, the cleaning is one thing that, you can do before recycling, but it incur lot of cost and energy ok.

The other alternative you have to dump into the soil where it will lead to soil pollution; otherwise, if you want to throughout into the water body like a river or a sea or a ocean, what will happen it will leads to the soil pollution. These two soil pollution as well as the water pollution will cause in terms of health problems to the environmental destructions. So, you are destroying the soil surrounding your company, or the same time you are destroying the water bodies surrounding, your company ok. This is a negative effect from the soil point of view, from the water point of view better would have been to cleaning even though some of the amount.

But that will incur or that will increases the cost of your product, because this cost whatever you are spending a company spends the cost and energy in cleaning you have to indirectly impose on the product that you are selling. So, people goes for this soil or water bodies dumping ok, which is environmentally not a feasible solution. Otherwise, you can go for evaporations like missed cooling or minimum quantity lubrication type of things that people can go. So, this also causes some of the problems like lungs cancer, respiratory diseases and other things ok.

We have seen the cutting fluids has its own positives anti-rusting additives will protect from rusting, biocides will protect from the biological organisms growth like fungus, bacteria other things at the same time this also have negative effects on the operator that is a system where the operator is working on surroundings, which is nothing but the

outside water bodies or soil bodies or if you are evaporating something then nearby the localities of the common people. These are all the negative effects ok. The more details about this cutting fluid emissions and other things we will see in the next class.

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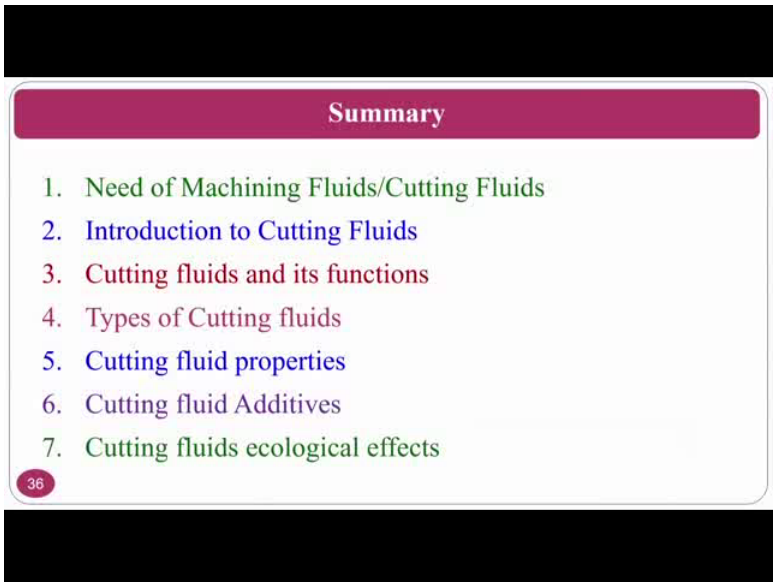

So, the summary of this particular class is need of machining or the grinding fluids introduction to cutting fluid, cutting fluid and its functions we have seen types of cutting fluids, cutting fluid properties cutting fluid additives, at the same time we have seen ecological aspects. It just, just a glimpse of ecological aspects we have seen ok. So, the cutting fluid additives what are the additives that are used and what are the positives of the additives, and we have seen what are the negatives of the cutting fluid additives in a glimpse. In the next class, what we will see is what are cutting fluids or grinding fluids and how this will affect the environment, operator, soil, water and other things that we will see in the next class.

I am very thankful for your kind attention and hopefully we will meet in a next class.