Introduction to Machining and Machining Fluids

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Lecture – 14
Machining Fluids/Cutting Fluids and Its Additives

So, we are discussing about machining fluids and its properties, benefits, when you will use this cutting fluids in the machining operation what are the things that we are going get benefit out of it, as well as if you do not use it how the friction coefficient goes high then the power and other things goes high so that the requirement will be very high and the losses will be more. So, now, we will move on to the other part where we will study about the additives.

What are the additives that are used in the cutting fluids? What are its properties? How this will affect various properties of the cutting fluid? And how it will benefit the product and all those things we will see. So, the cutting fluid additives, there are many additives ranging from emulsifiers to the rust inhibitors and their mechanisms and all those things.

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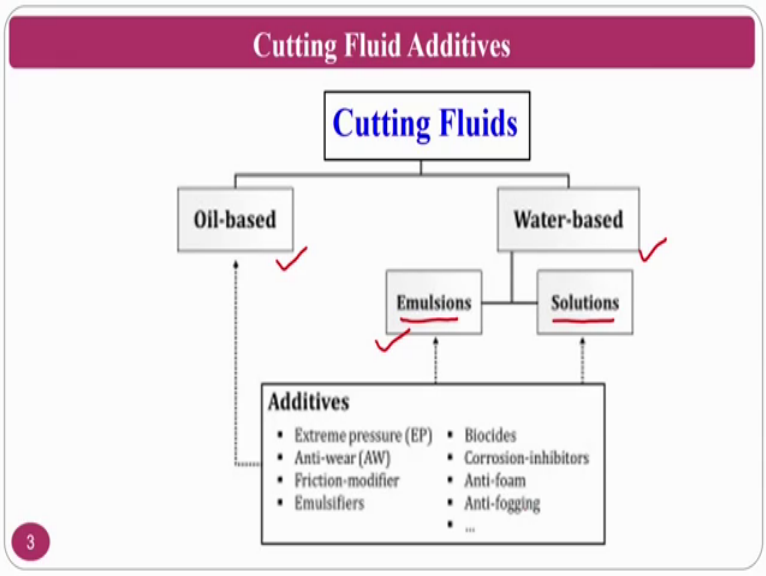

If you see the cutting fluids there are two types of cutting fluids normally metalworking fluids are the broadly says this word, but cutting fluids are specified words. So, cutting fluids are one part of metalworking fluids. Metalworking fluids even metal forming across some of the grease is they will use, some of the lubricants they will use those are

also come under the metalworking fluids. So, cutting fluid is subset of the metalworking fluid.

In the cutting fluids where there are the oil based cutting fluids and the water based cutting fluids. In the water based cutting fluids we all because since we are talking about the water based because water based you will give you the better cooling ability for that purpose we always go for water based. In the water base we have emulsions based and we have solutions, but normally we just go to the emulsions type mostly. But the additives normally whatever we use are the commonly used by the people operating people are extreme pressure reduce, anti wear resistivefriction, modifier, emulsifiers, biocides, corrosion, inhibitors are rust inhibitors antifoam and antifogging some of the things are commonly used names only ok, antifoam are the another one.

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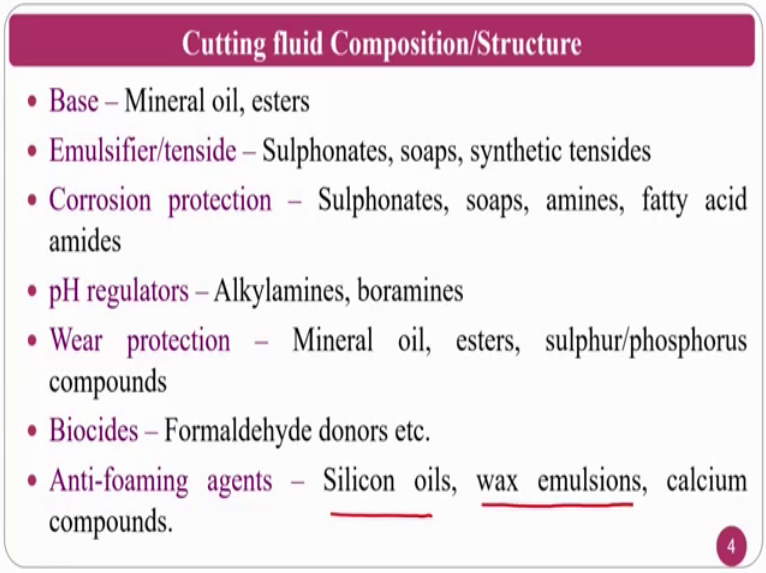

If you see the cutting fluid composition structure what are the things it will have? It will have a base, but that is called the mineral oils are we can say the esters and second followed by the emulsifiers, normally sulphonates soaps synthetic tensides these are all the some of the examples that will normally blend with the cutting fluid. The third one is corrosion prevention, for the corrosion prevention normally corrosion inhibitors are used which are again sulphonates soaps, amines, fatty acids and amides group pH regulators, pH regulators is required because if the pH goes up and down.

So, then there is a chances of metallurgical changes on the product because of the change in pH the it will causes the a metallurgical changes because of the high temperature that is there in during the machining operation and all those things. So, wear protection normally tool where one has to protect for that purpose mineral oil esters. Again we can see a this is a normally lubricant based particles you can use or dominating character; that means, that you can use less amount of water in the composition and all those things. Biocides normally biocides are used for the formation of microbial organisms in the cutting fluids.

So, antifoaming agents normally antifoaming agents are used such as silicon oils, wax, emulsions and all those things these are used to not generate the foam during the machining operation. If the foam takes place what will happen the visibility goes up and there is a disturbance in the machining operation also causes that is why normally antifoaming agents are used.

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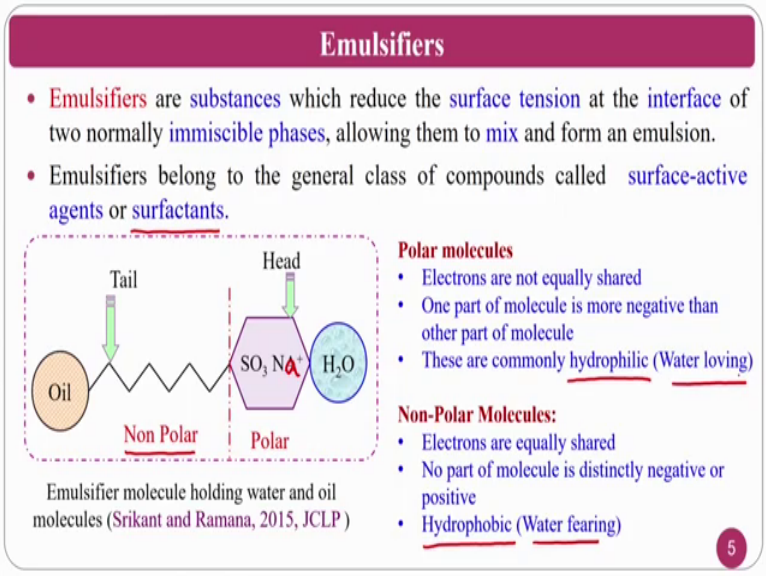

So, emulsifiers just we get into the emulsifiers what are the emulsifiers? How these are going to help on? These are the majors thing that the cutting fluid consist whenever you mix it is a emulsifiers. Emulsifiers are substances which reduce the surface tension at the interface of two normally immiscible phases are allowing to mix ok. When there are two phases assume that there is a oil you have a oil you have a water if you are going to mix these are not going to mix because they have their difference surface tensions. Whenever

you mix the emulsifier what will happen? This emulsifier will reduce the surface tension between these two that means, relative surface tension that probably like the highest surface tension material surface tension will be reduced and brought near to the lower surface tension. So, that both will become miscible that is what the intention of using the emulsifier.

Emulsifier belongs to general class of compounds which are called as the surfactants actually ok, emulsifier ok, whenever you are talking about the surface tension reduction. So, these are used by the surfactants ok. So, the other name is also calls surfactant. If you see here you have a water you have oil whenever you use the surfactant will have the polar group and nonpolar. So, polar group will try to attach to the polar group that is called H 2 O and nonpolar group will attached to the tail that is oil non polar. So, you have a head that is polar and tail nonpolar.

So, what is polar and what is nonpolar? Some people may be from b tech they may know what is polar what is nonpolar. So, let me explain about polar molecules and nonpolar molecules and all those things. In the polar molecules; that means, that since a emulsifier has both polar and nonpolar head. So, what the polar head is going to do is electrons are not equally shared that is why you can see here the not shared equally. So, one someplace minus are not constant there, one part of molecule is more negative than another part of molecules.

So that means, that some part will have more negativeness some part will have less negativeness and all those thing there will be a difference between these two things are commonly hydrophilic means what I will tell you in the upcoming slides, what is hydrophilic, what is hydrophobic and all those things. So, this will take care of the water content polar molecule the nonpolar molecules electrons are equally shared. So, electrons are equal shared in the nonpolar region and the no part of molecules is distinctly negative or positive.

So that means, there is no much differentiation between any part of this non polar region in a molecules. So, normally these are all a hydrophobic. So, water fearing and this hydrophilic means water loving. So, it will love. So, the hydrophilic means it will the spread assume that I have a surface of hydrophilic surface on which if I put water it will love; that means, it will spread easily. In hydrophobic means you just fear. So, it is not

like assume that a particular person for example, common example of the phobia if you see if there is a diagnosis of CT scan there will be a cylindrical hole big hole will be there. So, some people may fear inside going that is called phobia. So, you do not want to go; that means, that another waterfalls and hydrophobic surface it will not go it do not want to spread on that one just let me go away by so it will be having a spherical type of ball and it will go some. Example is lotus leave that is called hydrophobic surface basically.

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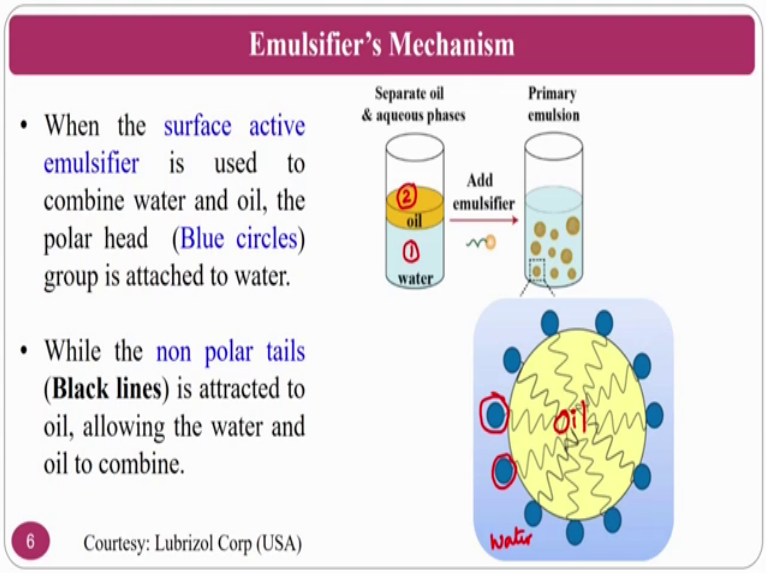

This is about the mechanism. However, we will go into the complete mechanism when a surface active emulsifier is used to combine with water and oil if you see in the picture. So, normally this blue circles. This blue circles are nothing, but you are polar molecules is attached to the water; that means, this blue one is water this is oil.

So, while the nonpolar tails that is black lines which are there inside the yellow region are attracted to oil and allowing the water to combine this means combine anyhow. You will see another picture you will have water and oil initially assume that I am mixing water and oil. So, this surface tension is different and viscosity is different and the density of this fluids are different, whenever you add both these things what will happen it will be separate entity, one is this one another one is this one these are separate entities when you add emulsifier. So, what will happen? This is a polar head and nonpolar tail

this will go and occupy their respective regions. It is polar go and occupy the polar regions that is water and it will dis integrate the oil molecules and it form a emulsion ok.

Emulsion does not mean that it is a uniform fluid it may be a uniform fluid. But the thing is that these interfaces are still existing; that means, that I mean to say water is a uniform thing I am not saying whenever you mix water with oil it is not that single entity it is a dual entity which where is the two things are there , but uniformly dispersing. In, if you do not add it is non uniform dispersing if you add the oil and water will have uniform dispersing that is the what I mean to say ok.

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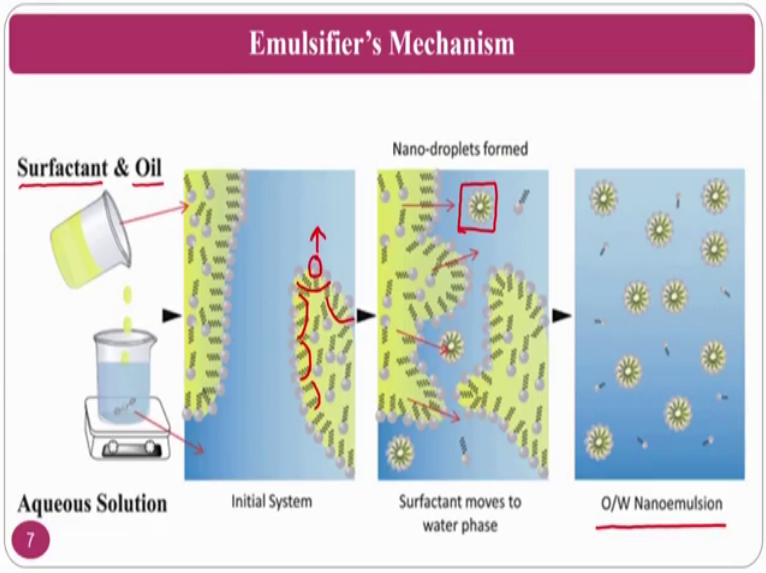

So, now you can see is a surfactant and oil, normally surfactant is nothing, but one of the emulsifier whenever you are mixing with this water aqua solution. So, initial system normally what will happen once you have a surfactant plus oil is there just you put into the water what will happen this oil molecules which are surrounded by the surfactants will try to pull into the water because it is water loving. Assume that this polar molecules of water loving molecules this will try to go into the water whenever you want to go.

Now, it will disintegrate this disintegrate and form a uniform dispersion that is what you can see here. The surfactant moves to the water phase surfactant that polar head tries to move into the water phase that is why it will gradually become these type of things ok, and uniform.

So, I am last what will happen it will pick up. Anyhow it is mechanism is shown here; however, the nanoemulsion is taken from the Google, but how the emulsification takes in the water and oil emulsion. So, that is mechanism that I want to show ok. You have a water where in you put the oil and you put the surfactant are emulsifiers then you just stir it. The polar head will track the nonpolar hill a group of polar hills will go by disintegrating from oil molecule and form at different-different uniform locations to make a uniform emulsion that is called liquid liquid emulsion. There is a slight difference between colloid and emulsion yes I will come.

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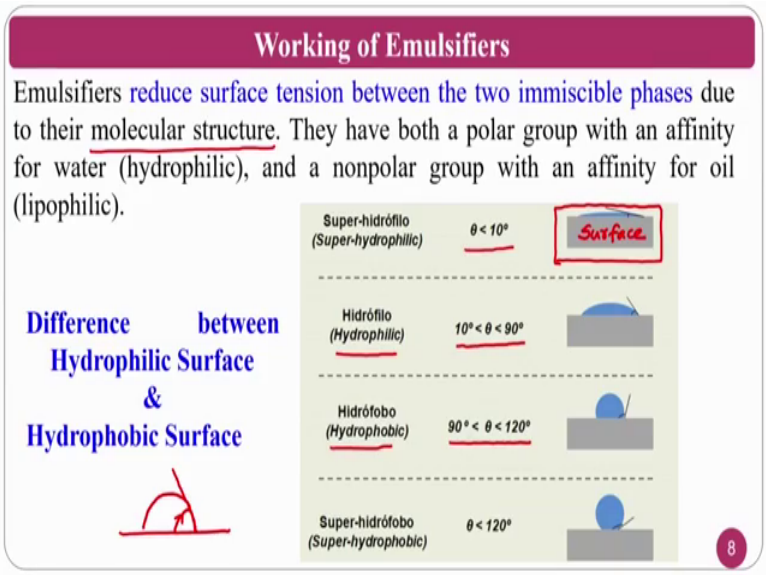

So, I was talking about hydrophobic and hydrophilic surfaces and all those things. Emulsifier reduce the surface tension between two immiscible faces due to their molecular structure ok. Because of their molecular structure that is called polar and nonpolar they have both group and affinity towards water that is called nonpolar group is affinity water and forms the molecule.

So, what is hydrophobic and hydrophilic? So, there is a concept called hydrophobic, hydrophilic, super hydrophobic, super hydrophilic, these all depend on surface to liquid interactions basically. If you see here if the angle is less than 10 degrees what will happen? It is called super hydrophilic surface you can see here how the water molecule is spreading on the surface, this is a surface, on surface it is there. Normally the contact angle will be measured from water to the free surface. So, assume that I have a surface

like this on top of it I have a droplet here. So, how do I measure? I measure like this, water to the free end this is my contact angle. That is how the contact angle is measured using goniometer there are normally contact angle measurements are there which is one type of this goniometers and all those things.

Then comes hydrophilic surfaces that is called the if the angle is between 10 to 90 degrees then it is called hydrophilic surface. Hydrophobic surface ranges from 90 to 120 degrees hydrophobic surface, if you see it may be and super hydrophobic surface will be like more than 120 degrees. If the contact angle is more than 120 degrees; that means, that if the water droplet falls on that surface what will happen? It will roll and it goes out example is your lotus leaf if the rain falls on a lotus leaf what will happen this droplets are droplets spherical as soon as it falls what will happen the it will disintegrate because of the kinetic energy which is a its process.

And it will this droplets will just if it is a inclined surface are the if the leaf is slightly inclined what will happen it will spherical ball bubbles will just goes out. Because it is hydrophobic surface in fear it will not have love towards the lotus leaf surface that is called hydrophobic surface.

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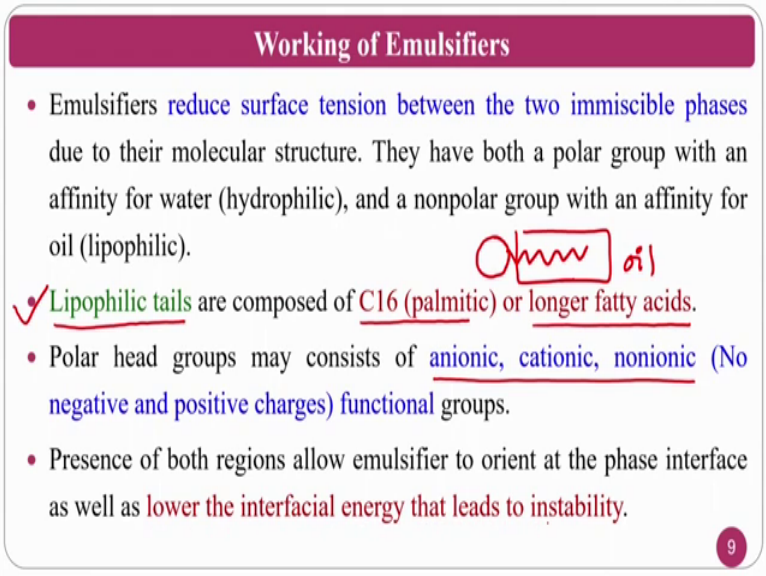

So, we now move to the emulsifier reduces surface tension between two immiscible phase due to their molecular structure. Lipophilic tails are composed of normally C16 that is longer fatty acids. What is lipophilic tails? Lipophilic tails means, lipophilic

means these fluids will mix with oils it do not mix with water it will mix with oils that is why lipophilic tails. If you see here what will happen? This is a polar and this is a non polar nonpolar will mix with oil this particular part will mix with oil that is why it is called lipophilic tail.

Normally it has longer fatty acids polar head groups may consist of anionic, cationic, nonanionic function groups ok. This polar head can be anionic, nonanionic or cationic. What are this non anionic? It is no negative and positive charges in the functional groups there is no negative charge that with no positive charge ok. So, the presence of both regions allow emulsifier to orient it the phase interface as well as lower interfacial energy that leads to instability. What it means is it has a flexibility. You have seen in the previous slide where if you are mixing a surfactant are emulsifier along with the water. What will happen? Whenever you mix it depend on its orientation, polar and nonpolar its will disintegrate and form its own fluid.

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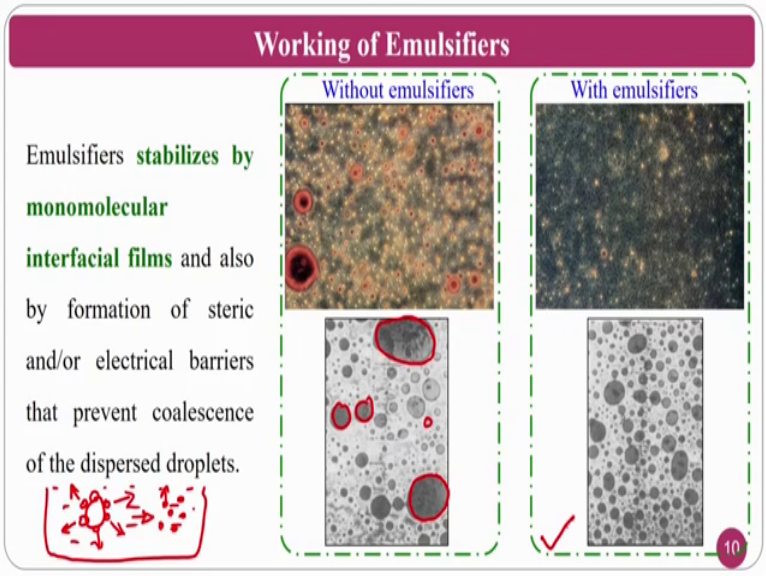

You can say emulsifier stabilizers by monomolecular interfacial films and also formation of electric barriers to prevent the coalescence of the dispersed droplets. If you do not use the emulsifiers what will happen? This particular oil molecules will join assume that I have 2 oil molecules, 3 oil molecules which are there in the water solution in a water solution. What will happen? This try to move each other and form a big droplet that is what you can see here

There is a non uniform droplets there is no uniform droplets there are so small ones there big ones are there all those things, but. What the statement says these dispersed droplets. So, from the electric barriers to prevent the coalition this it has to prevent. How it will prevent? Because it has a polar and which pulls towards the water.

What I mean to say is if I have a molecule bigger molecule is their if I having this surfactant on top of it what will happen, this move towards water assume that this is completely water filled it will move towards the water, this also move towards water, this also move towards water, this also move everybody move towards water, then this will disintegrate into different different molecules oil molecules. So, so that the uniform emulsion takes place, the coalescence group it will prevent the coalescence; that means, oil particle to oil particle joining it stops. Like if you use emulsifiers you can still may not get 100 percent uniform. If you will get better than if you do not use the emulsifier, but you can clearly see from this picture, picture 2. You understood, coalition it will prevent by pulling towards the water that is it.

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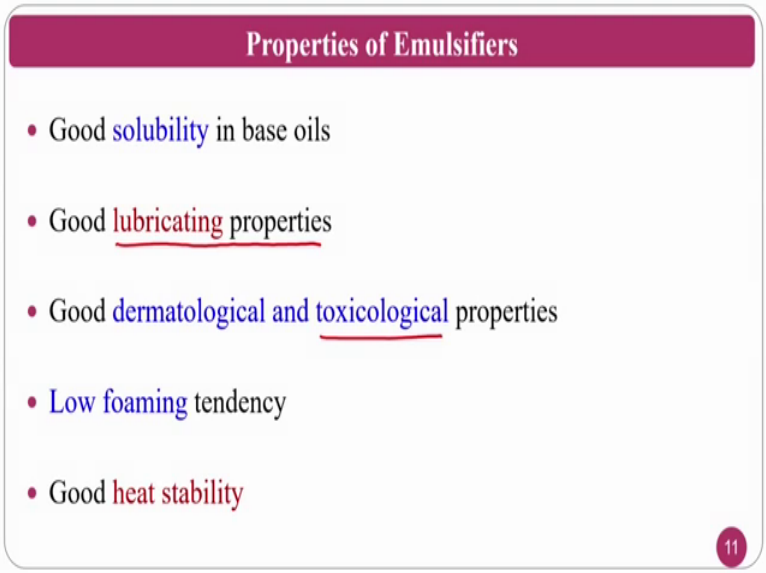

Properties of emulsifiers, normally it should have good solubility in base oil. Base oil means if you can mix with base oil then you can mix with water or you can normally the cutting fluids a lubricant whenever you purchase from the market it will be already blended inside the mineral oil. So that means, that it should be completely lipophilic lipophilic as I said that this completely emulsions are lipophilic it should uniformly mix

within oil whenever you mix into the water then only it will (Refer Time: 19:57). So, these are good stability in the base oils good lubricating properties. If already mineral oil will have lubricating property, if you have still more better lubricating property then that will enhance the performance.

Good dermatological and toxicological properties; that means, that whenever the operator operates this one and the cutting fluid is falling because of the rotation of the work piece what will happen it will splashes on the operator. It should be friendly to the dermatological surface of the operator; that means, if it falls on the surface of the hand or face or something it should be friendly. It should not deteriorate or it should not cause any type of discomfort to the operator and toxicological. Any type of toxins it should not produce if it produce assume that the operator in hails or if falls on surface if it is toxic then it will create lot of problems. So, it should not be toxicological and it should not be dermatological.

It should have better properties I mean to say its low foaming tendency, it should not firm become the firm it. If it is firm what will happen? Then the visibility of the operator towards a machining maybe opaque, it is may not give good look what is happening there and all those things. So, this is the problem. And heat stability should be there, it should not fluctuate and it should have uniform heat stability.

If it is an heat stability; that means, that it cannot be disintegrating to think; that means, whenever this cutting fluids falls what will happen assuming the fluid cooling process where 400 to 600 ml per minute is falling in the circumstances every molecule of the cutting fluid may not going to the cutting region. There will be 10 to 15 percent will go and remaining just it fall and it will go down to the cutting fluid tank for the recirculation. That mean that this 10 percent to 15 percent will have only thermal cracking will takes place because your cutting fluid is a petroleum product or it is a carbon based compounds. So, there is cracking will takes place, chemical cracking will takes place because of the temperature.

So, this cutting fluid will go and affect the virgin cutting fluid that is falling in the earth, then it will it is in it is heat stability will go down. So, that is why whenever I am speaking about here it is I am speaking about the first time whenever I am this cutting fluid. If you recycle it what will happen it heat stability will goes off partial goes off. So,

the heat stability will go on reducing if you are recycling again and again and again. Many times if you are recycling then stability may go down, but first time whenever you use it should have a good heat stability ok.

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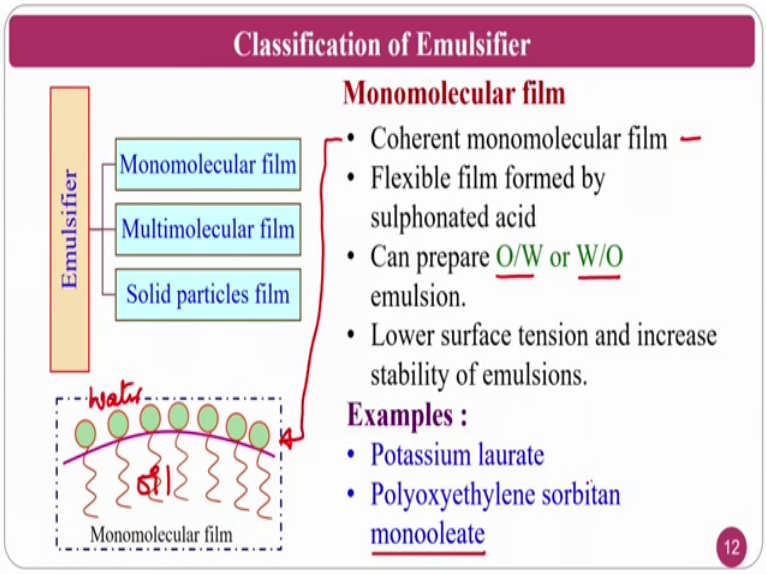

Classification of emulsifiers, if you see the classification of emulsifier normally monomolecular film is there, another one is multimolecular film is there, solid particle film also is there ok. If you see the monomolecular film as you have seen if it is in water this is the water region and this is the oil region and you can form a monomolecular film that is called coherent monomolecular film you can form here that is called whatever the point here is said is here.

And flexible film formed by the sulphonated acid. So that means, at the film is flexible enough and can prepare oil in water or water in oil emulsions. You can meet two types of a emulsions either in oil in water or water in oil. What is water in oil and oil in water will see in the upcoming slides.

Lower surface tension and increase the stability of emulsions. The surface tensions it lower the surface tension of the oil or another fluid which is about to mix two fluids whichever having the highest surface tension it will reduce to bring to the second one and try to mix it. Example potassium laurate is the one thing polyoxyethylene sorbitan is another monooleate is another one. So, these are the two examples of monomolecular film based emulsifiers ok.

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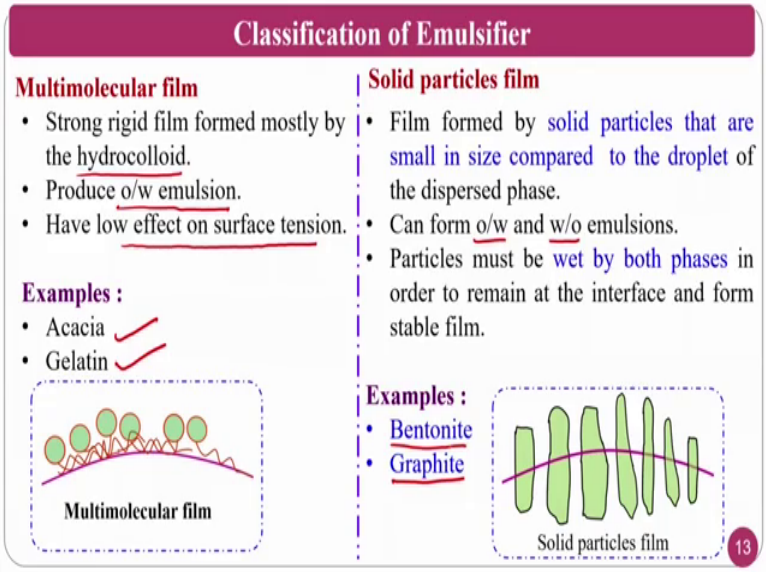

Multimolecular films emulsifier strong and rigid formed a mostly by the hydrocolloid as I said colloid. Emulsifier is liquid to liquid here if it is semi solid to liquid or solid to liquid normally it is called less colloid hydrocolloids. Normally if you might people might have heard about hydrogels, gelatin hydrogels, t e g hydrogels, p l e hydrogels , or p e g p l e p g hydrogels, there are hydrogels, hydro gel.

So, you have a sphere where in the water is bounded by the structure interlinking of this is nothing, but the hydrogel. It will have hydrothat means water will be there it will be in a network form if you cut you cannot see that one. It will be embedded in the polymer networks that is about the colloid. Produces oil in water emulsion this normally produces the only one type that is called oil in water emulsion may not be vice versa have no effect on the surface tension.

So, it will have the lower effect of the surface tension; that means, that it will may not form the emulsion proper because it may not reduce the surface tension as I expected or a person that is going to mix is expect. So acacia is one thing and gelatin is another thing if you can see multimolecular you can see all the things are on the surface it is not there in the inside the surface ok. This is how about the multimolecular will takes place.

And solid particle films film formed by the solid particles that are small in size compared to the droplet of the dispersed phase these are the solid particles that forms on the surface. Can form oil in water and water in oil emulsion both are emulsions it can form.

Particle must be wet in both phases in order to remain at the interface with that; that means, that it should be wet if a particle is there it should wet from the oil side it should wet from the leaf that is water side. So, it should be able to wet on the both sides.

For example, graphite is one of the example, bentonite is another example these are the examples of the emulsifier.

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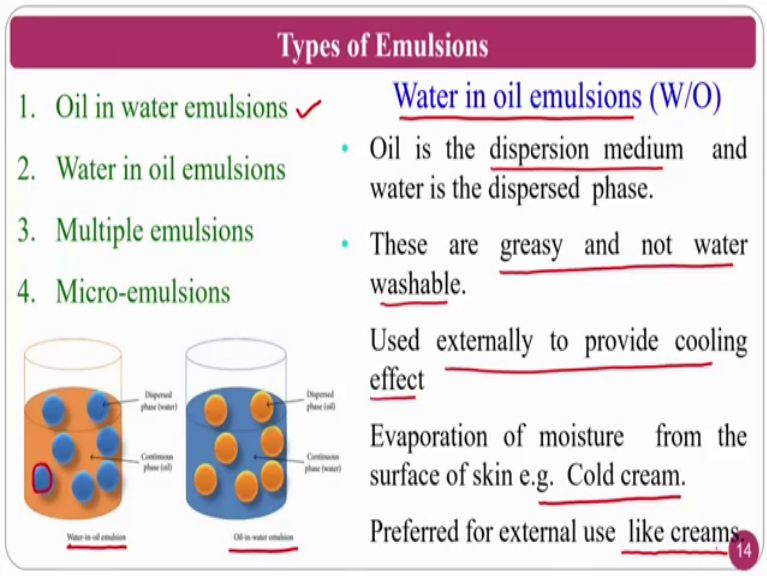

So, you can see oil in water emulsions. Oil in water emulsions is one type of thing and the second one is water in oil emulsions, multiple emulsions and micro emulsion these are the different varieties of emulsions are there. If you see water in oil emulsion it is look like this anyhow I will show you a bigger picture in not this one just you will come across in the next slide or something this is called water in oil emulsion.

These are the water molecules blue one are water molecules, here the orange one is oil which is a continuous phase and dispersed phase is water. Oil in the water here oil is spirit (Refer Time: 27:50) and water is there in the continuous phase. Water in oil emulsion oil is the dispersion medium and the water is the dispersive medium ok. See water in oil; that means, it is simply shows oil is my continuous phase and I am putting water in it ok. That is all simple.

So, in this one oil is a dispersion medium where is continuous medium water is just dropped in. These are greasy not water washable. What will happen when ever these are

emulsions are also used in washing industry, these are also used in many industries such as paste industries emulsions are used detergent liquids nowadays these are used in all these things. Used externally to provide the cooling effect, normally this also helps in the cooling effect. Why I am saying is you have oil which is a better lubricant whenever if you want a cooling ability what you do you cannot use directly you have to mix water. If you mix water cooling ability as from the curve of lubrication versus the cooling you see the water is a better coolant. So, you have to mix it if you mix it water your cooling ability will increase.

Evaporation of the moisture from the surface like skin if normally these also will use in the cold cream, so evaporation of the moisture will takes place; that means, water content is very less. So, equally goes up off if the temperature increases and prefer for external use like creams and all those things. Normally, water content will be very less and oil content is major content which is a continuous phase whenever you apply on this ice cold creams and all those things water will goes off that is what its. So, these are the one varieties that will normally use in the metal cutting also. For analogy purpose we have taken from creams and all those things.

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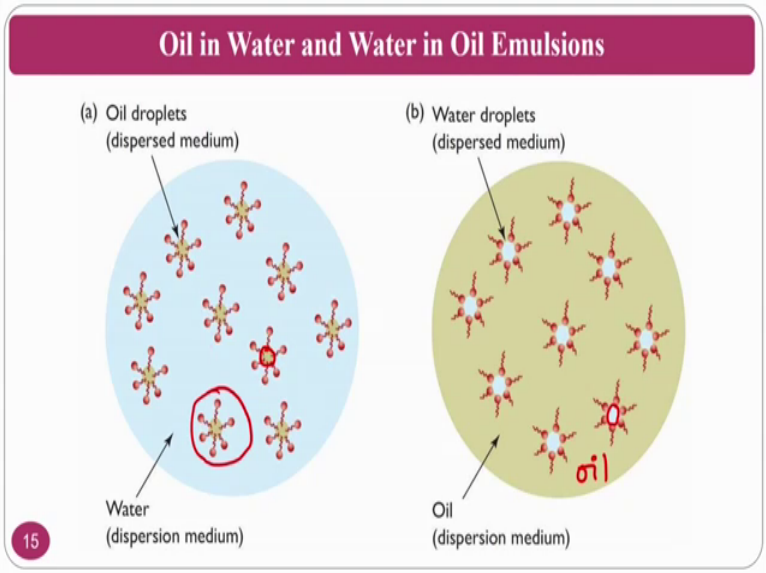

If you can see oil droplets that is called the oil in water this is a continuous phase water is a continuous phase that is dispersion medium and oils are dispersed inside ok.

And this oils along with the surfactants it will disintegrate and forms another one. So, oil heat is the oil and this is a water molecules, only thing you just it clearly observed where the polar side of emulsion is sticking. Water molecule if it is here your polar head is sticking to that one if you see in this first figure non polar is sticking ok. Polar always with water non polar always with leaf of that is called with oil that is about the water in oil, oil in water emulsions.

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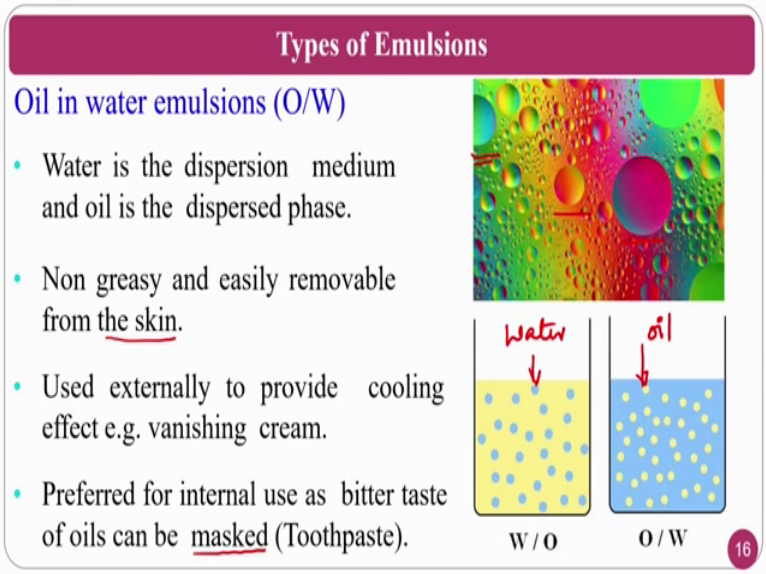

In oil in water emulsion water is the dispersion and oil is a dispersion that mean that you have water where in your putting oil; that means, that have a water in a glass just I am putting coconut oil to it some drops of coconut oil to it. Non greasy and easily removable the skin because main content is water, so you just like of it will goes off and use the externally provide the cooling effect that is called what is in the preset you have a major amount of water is there. So, it will be dominating cooling effects for the cutting fluids.

Preferred in internal use as a bitter taste oil can be masked; that means, that normally this also used in the toothpaste applications and all those things slightly it will be give the bitter taste. If you see how the oil in water water in oil looks like these are the droplets, if you are not going to use emulsifiers you will have different sizes you can see at the different sizes will be there and this is about water in oil where this blue ones are water and this particles are oil yellow ones are oil. So, this is about oil in water, water in oil emulsions.

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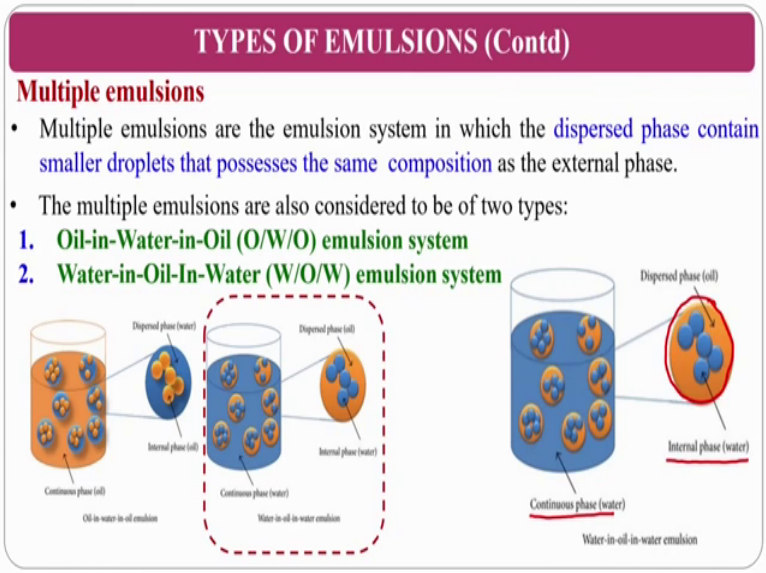

Now we will go to multiple emulsion. So, what do you mean by multiple emulsions? You have water and oil both two things are there, there are still more advanced things are there that is called oil in water in oil water in oil in water. So, will go through it the multiple dimensions are emulsion system in which dispersed phase contain the smaller droplets that possesses the same composition as external phase. That means, the internal structure and completely external structure will have a same; that means, water in oil in water. So, water is there inside, oil is there on top of it again water will be there that is called you can see the multiple emulsions called in two ways, oil in water in oil water in oil in water. So, this type two types of emulsions are there.

If you see the picture you can clearly understand how this will be for example, I will take the water oil in water emulsion if you see same like continuous phase is water and internal phase again will be water if it is a there is a water then and if you take a spheroid which is the oil inside again water will be there ok. That is called water inside the oil and on top of it you have a water again ok. That is what the this one.

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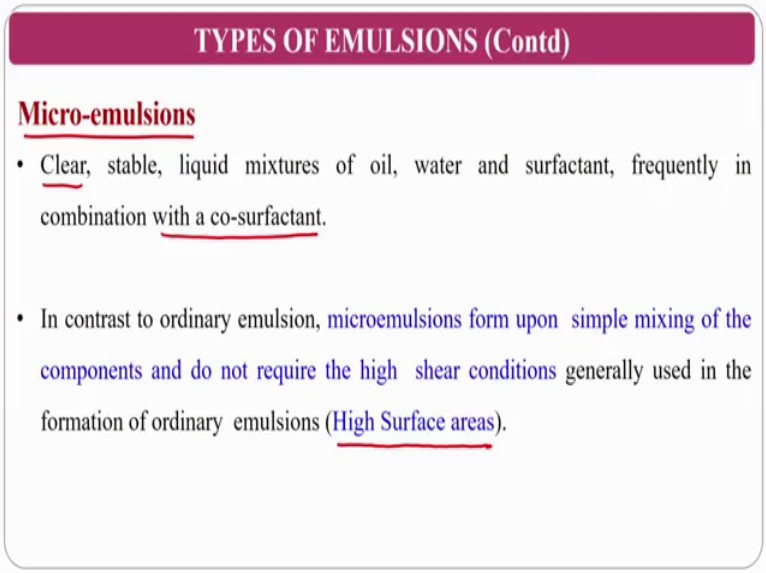

So, microemulsions is another one, normally micro nano if you go the basic advantage that you get is surface area will be large. So, if you have a more surface area what will happen suspending inside the liquid inside a leaf fluid will be easy that is what the advantage that is why people nowadays talk about microemulsion, nanoemulsions and all those things. So, many somebody may be interested in taking up the cutting fluid with microemulsions nanoemulsions and you can check the performance. You have a cutting fluid which you made of your own or you purchased it just you take emulsions different dimensions you can mix it if there is no emulsion preadded or blended with the existing one, otherwise you can take any type of oils normally I said the environmental friendly as a coconut oil, castor oil, neem oil or so, so many oils are there. Jst take the oil you just try to get the suitable emulsifiers and mix with the water in this mix with this oil then you mix with the water and you can make your own cutting fluids ok.

But make sure that it is chemically compatible and do not change its pH and all those things if it is there then it be obviously, a problem for machining operations. That is why what I mean to say is that then you can for the same composition of oil and water you mix microemulsions I mean to say you have a oil you have a water. So, you mix microemulsions and test the performance you mix the nono emulsions and check them ok.

So, you have a oil, you have water, you mix first in the oil normal emulsions mix with the water then you test your metal cutting properties. I means what is the performance of this one then instead of emulsion mix microemulsions and mix with water and you just check nanoemulsions again water and you check. So, there any difference you are finding that can be a good work. So, you can take up clear stable just let me introduce I am not going to introduce about the nanoemulsions, I just tell you about the microemulsions.

These are clear stable liquid mixtures of oil water and surfactant frequently in the combination of with a co-surfactant. These are one type surfactant which are clear stable and liquid pictures of oils, within the oil it will be there. In contrast to the ordinary emulsion microemulsions form of an simple mixing of the component and do not require high shearing conditions; that means, that you just put it and may not be required to stir it with very high loads and all those things you will be normal steering is also is sufficient to mix it because it is easily miscible in the cutting fluids because of its high surface areas and the suspending is very easy mixing is easy and proper and all those things.

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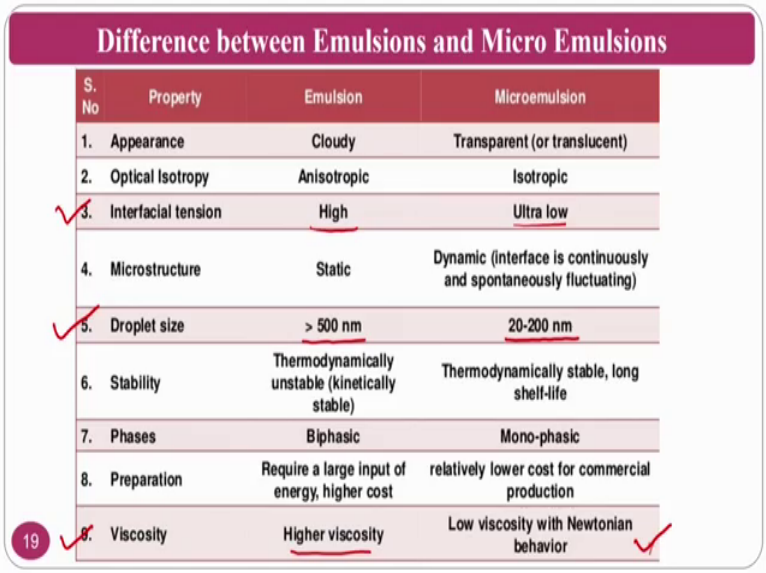

So, what are the differences between emulsions and microemulsions. Many differences are their appearance wise is optical isotropic interfacial tension and all those things. Normally if you see the first and foremost thing that normally you see droplet size. Droplet size normally in emulsion it will be greater than 500 nano mix, but if you see

some of the other papers normally this range they will tell is 1 to 10 micrometres and all those things some other people other this microemulsions are in the range of 20 to 200 nanometres, are slightly above plus or minus 10 minus 20 will be there.

Interfacial tension, second thing that you can see here interfacial tension is emulsion high here it is ultra low. So, interfacial tension is low (Refer Time: 37:45) So, easily miscible and those thing. Remaining are viscosity and if you see emulsions are high viscous and these are low viscous. If you see low viscous what will happen it is better easily miscible if you have high viscous having it is high viscous if you put a spoon and if you rotate you need lot of energy if you put water the same amount of water in a glass and if rotate rotating is called resistance to flow is very high. If the viscosity goes up that is what it says this is the difference between the emulsions and micro emulsion. I am not touching all the things anyhow you can study from this slide.

So, water soluble miscible fluids if you see the types general purpose soluble oils, emulsifier oils are different types that also used is dilutant and between normally the range between 1 is to 10 and 1 is to 40 to give milky emulsions normally used in for the general purpose machine operations these are all general soluble oils.

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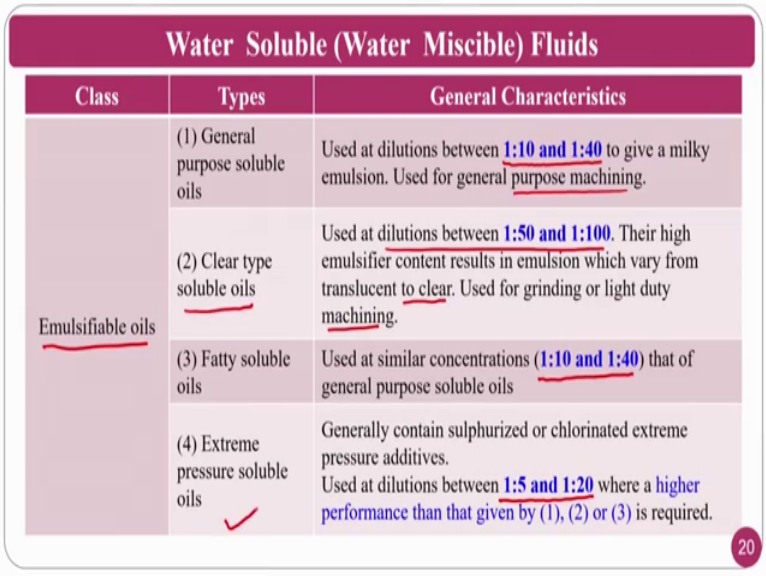

So, that ranges from 1 is to 10 to 1 is to 40 dilution; that means, that you have a 1litre of your fluid is there cutting fluid (Refer Time: 39:00) 10 litres of water if you want to mix this general purpose oils can be. You, if you clear type of soluble oil used the dilution

between 1 is to 50, 1 is to 100 their emulsifier content results in emulsion which vary transmission that is clear and used in grinding on the heavy duty machining operations. These are all used for heavy duty applications like where the u, u is nothing but the surface requirement energy required per unit volume where is very high there you can use.

Fatty soluble oils normally these are used where again for general purpose like 1 is to 10 to 1 is to 40 and the extreme process soluble oils these are all used for very low that is between 1 is to 5 to 1 is to 20, but where higher performance than the other 1 2 3 is required. That means, higher performance wherever you require like very big loads are there in all those things in that applications extreme pressures soluble oils are normally used. All these oils are used as a part of emulsifier or you can add emulsions to this oils ok.

So, next we will move on to extreme pressure additives. What is this extreme pressure additives and all those things we will see.

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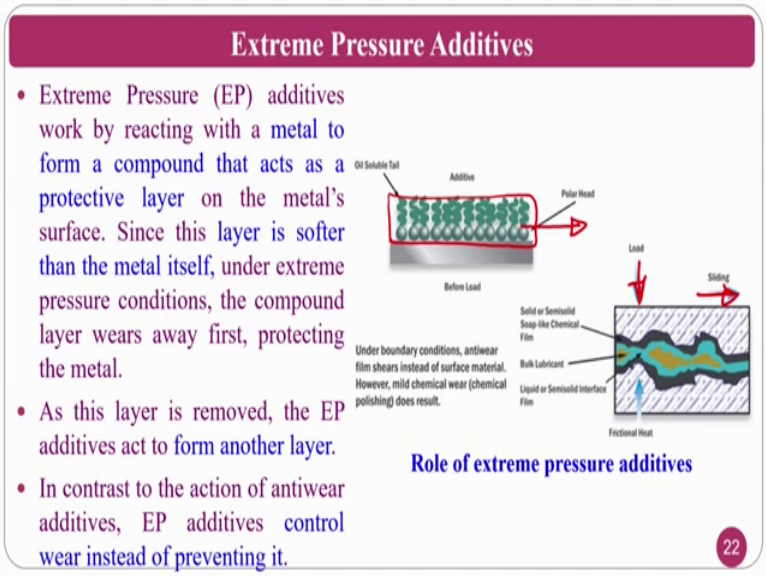

So, extreme pressure additives a work reacting with a metal form a compound that reacts a protective layer on the metal surface. Since this layer is softer than metal under extreme pressure conditions it bears of protecting in the metals. That means, whenever extreme pressure additive is added to the cutting fluid if it is falls during the machining

operation what will happen it forms a layer that is soft compared to my parent material of that material.

And whenever there is a pressure that falls are sharing takes place what will happen that soft layer will goes off by keeping the original metal layer intact that is what extreme pressure additives will do. This layer is removed and extreme pressure additive as a form another layer. What I mean to say is that since my cutting fluid is continuously falling if one extreme pressure additive layer which is soft gone automatically it is falling. So, it will form another layer that is what it mean to say.

In contrast to action to antiwear additives extreme pressure to control the wear instead of preventing it will control the wear that mean as I said it forms continuously the softer layer on the metal layer. So, that it will not damage my, the to assume that tool is there and cut work piece is moving on. So, if I have a cutting fluid continuously falling even though it takes off only it forms a soft layer extreme pressure additive fuse it will take off again, since the cutting fluid is there around continuously falling it will form another layer and it will control the wear up to the certain limit it will not prevent or something it cannot prevent, but it will control up to certain limit.

So, if you see here what will happen, this is a surface where some of the metal surface it will form on the soft layer will form on this one. If the soft layer goes off again soft layer will come. If you see in the tribiological where the soft layer will be formed on this one and soft layer will goes off whenever there is a sliding because of certain normal load also is there. So, what will happen this soft layer will goes off and soft layer will be uniformly it goes off it will form it goes off it will form. So, again I will goes off. So, that is the beauty about this one in the tribiological aspect.

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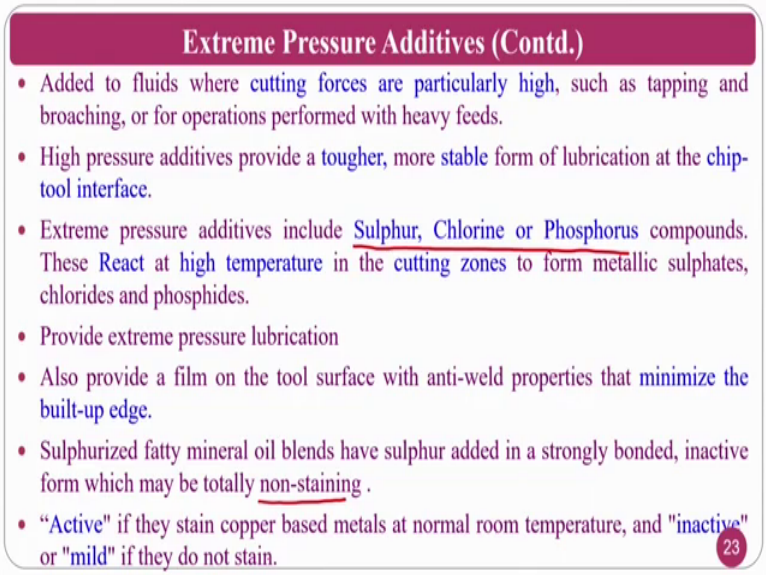

Added fluids where the cutting fluid forces are particularly high such as tapping and broaching operation (Refer Time: 43:12). These are applied for heavy load processes where the cutting forces are high like broaching operation you need to have lot of forces during the machining operation.

So, even though it forms soft layer the soft layer because of the heavy loads may take away and still have it forms into a layer. High pressure additives provide tougher more stable form of lubrication the chip tool interface. Means it will form a stable soft layer continuously till the cutting fluid fall in that area. Extreme pressure additive include sulphur chlorine and phosphorus compounds, these react at high temperature in cutting zones to form metallic sulphate, chlorides and phosphate what will happen. These are all made up of sulphur chlorine or phosphorus compounds. These compounds will react in the machining region where the temperature is very high and form metallic sulphates, metallic chlorides and metallic phosphides. This will form and it will give the soft layer, provide extreme pressure lubrication that is always the soft layer will be questioning it will give the lubrication like questioning and all those things.

Also provide a film that tool surface with anti weld properties to minimize build up edge, that mean what will happen it will form in and if it is soft layer is forming there is no formation of built up edge on top of it if instantaneously there is a molten metal that is sticking to the surface from the chip back side on to this one since there is a high

pressure additive which form a soft layer on this one what will happen it may not directly contact with my tool material. So, at certain point of time it may goes off. So, there is no formation of built up edge. Continuously if it falls is a soft layer do not have energy soft layer will goes off and because of the cutting fluid intake is regular. So, another soft layer will form. So, there is no possibility of forming the built up edge. The possibility I cannot say a 100 percent is not there I cannot say, but possibility will less possibility will be there.

So, sulphurized fatty mineral oil then have sulphur added in the strongly bonded inactive which may have totally non-staining. So, there is active if the stain copper based metals are normal room temperature that inactive mild if they do not stain that mean that staying in terms of colour change or something may not be dominating if you are using the this one that is about the non-staining and staining.

So, next we remove to anti foam additives. Anti foam additives that means, that how we can prevent the foam formation.

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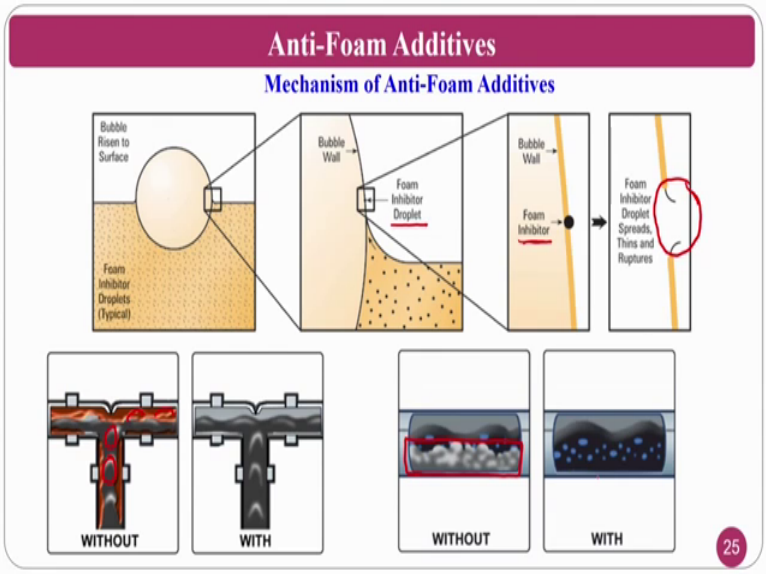

So, mechanism, you will have a bubble. This is a bubble risen foam surface foam inhibitor droplets are there. You can see in the yellow one you have a small small small droplets are there, black droplets are the black dots are there you can see these are the things. And when the bubble wall interact with the foam inhibited droplet what will happen this foam inhibitor which is a particle which will blast the bubble. Just you can

see here this is blasted the or it will penetrate into this one because of its nature and the bubble formation will not takes place what I mean to say the oil I have already antifoaming agents which are located like a black dots. Whenever the bubble formation is taking place this black dots goes and pinches it and the bubble will blast and there is it is a continuous process wherein the bubble formation will be there and this will go and punch it and became the liquid.

So, that is about the mechanism of anti foaming additives how it will act as anti foaming you can see without antifoam additives. You can see the bubble formations are there and all those things here. So, in the with antifoam additives there is no bubble formation here it is a very smooth in and they have you can also see without, normally there is a bubble formation you can see the white bubbles are there formed here if you get antifoam additives this will continuously punches the foam. So, there is no bubbles in this region that is if there is no bubbles in the vicinity of the metal cutting region what will happen it will have the operator will have can easily see and there is no much fluctuation.

If there is a gas bubble means it is having gas inside and the barrier is there oil barrier is or liquid barrier is there. What will happen? If these are more the cutting fluid which is coming back from the (Refer Time: 48:34) it may not allow also. So, there are some drawbacks are there for which normally antifoam additives used.

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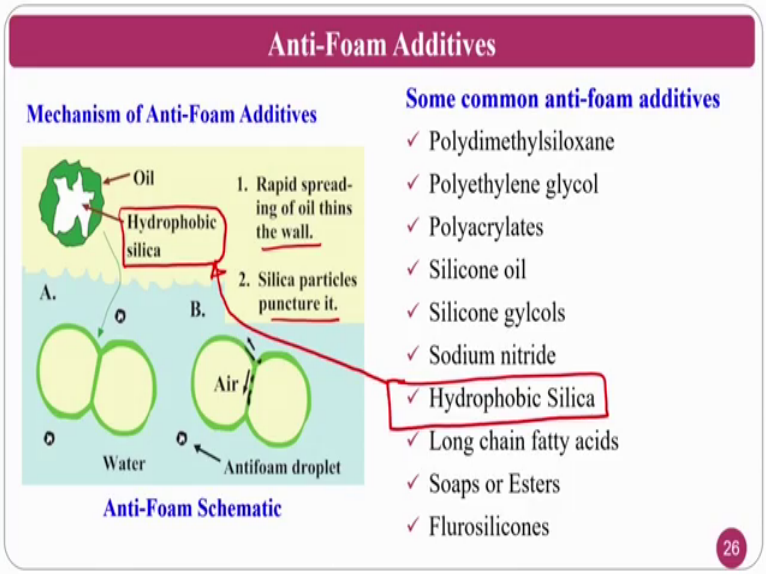

Mechanism of anti foam additives used is hydrophobic silica is one of the material that is used you are seen already; however, I am going to explain you again. So, you mix hydrophobic silica in the oil then you just mix with the water what will happen this will if there is a bubble in the water it will go and punch and it will remove that. So, some of the rapid spreading of the oil thin walls and silica particles punches it if it punctures, so the air bubbles will goes off.

Some of the common names are polydimethylsiloxane is one of the example, polyethylene glycol and polyacrylates another one silicone oil is another common example commonly using antifoam at agents. And silicone glycols, sodium nitride, hydrophobic silica you can see this hydrophobic silica is there and which is also there here ok. So, it will punches long chain fatty acids soaps are esters also will be used and flurosilicones will be used. These are the some of the names of the antifoam agents simple fundamental it will go and punch are the bubbles. So, that the bubbles amount will be reduced, 100 percent not you can reduce up to certain limit this about the anti foam agents.

Now, we were moving to another additive of the cutting fluid that is one of the most important additive that is called biocides. As I said whenever a workshop is there or a laboratory is there the cutting fluids are used continuously again and again what will happen they are you have 1 litre of cutting fluid or mineral oil where you are using 10 litre of water in it and do you use circulate for 2 months or 3 months assume that if water is there can you drink after 2 month no because microorganisms will form on it if you drink it will have a harm effect on your health.

So, for example, if you see your tetra packs or any juice packets and all those things they will have preservatives. Why the preservatives are normally used? Normally preservatives are used to enhance the life of that particular juice packet if you see real Tropicana and all those things. Some of the people nowadays are not using the preservative if you see the Amul milk or some of the like some places if you see there is nothing like there is things like for example, Tropicana 100 percent. So, maybe they are not using the preservatives.

And what is the use of preservatives? Preservatives preserve this for more life assume you are making a orange juice in your home can you drink after 5 days not possible

because it will affect to buy the microorganisms which are there in the atmosphere and it will destroy the orange juice. For that purpose same thing if you think in terms of cutting fluid in the workshop as I said you have a composition of 1 is to 10, where 10 stands for 10 litres of water your cutting fluid fall it will go up back your machining process completed it go back to the cutting fluid tank tomorrow we will come again you operate again it will go to the tank. Again you are using if you do not use biocides what will happen there will be a fungal formation there will be a bacterial formation or multiple. Commonly I can say that microbial formation will be dominating in the cutting fluid. In order to prevent that or in order to reduce that normally biocides are used that is the function of the biocides.

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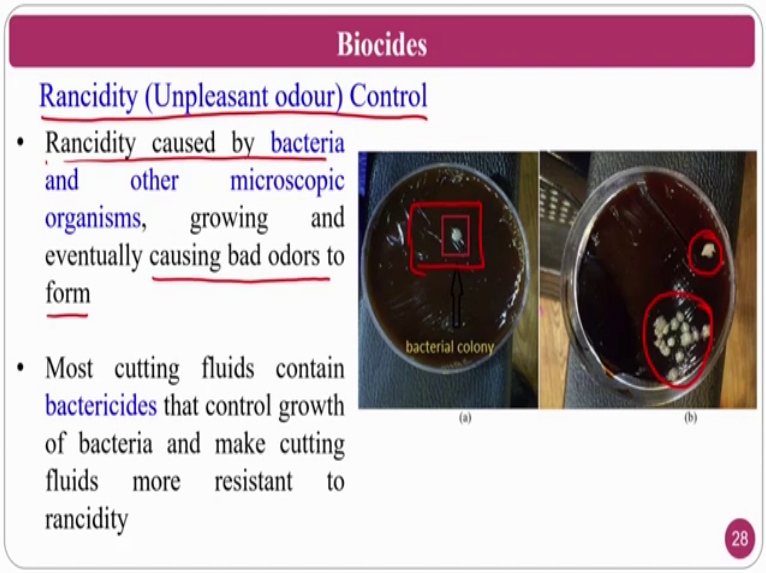

Going into the biocides whatever the picture that I am showing is a for the grease just I want to show you the how the bacterial formation takes place. For that purpose, so your grease is one type of lubricant if you to are taking as a grease it is a lubricant lubricants also you can get in form of mineral oils also. Rancidity is nothing, but your unpleasant order whenever if you are using again and again whenever it is destroyed what will happen automatically the smell will go up. So, you cannot bear the smell also.

Rancidity causes by the bacteria and other microscopic organisms growing eventually causing the bad odors to form. So, most of the cutting fluid contains bactericides that is called biocides that control the both of bacteria. And make the cutting fluid is more

resistant to rancidity replace your cutting fluids are subjected to are affected by the bacteria. If at all I want to protect from bacteria you have to use bactericides that is for regarding the bacteria is concerned. If at all fungus is there you have to use according to that you have some other organism is there you have to use that, if you mix all these for a bacteria, for fungus, for other some microorganisms you will use biocides. Biocides means if there is a living organism I want to prevent that one you will use the biocides.

You can see here how these are all forming and you can see the local colony of this bacterias, how the bacterial forming here on long term usage of this one.

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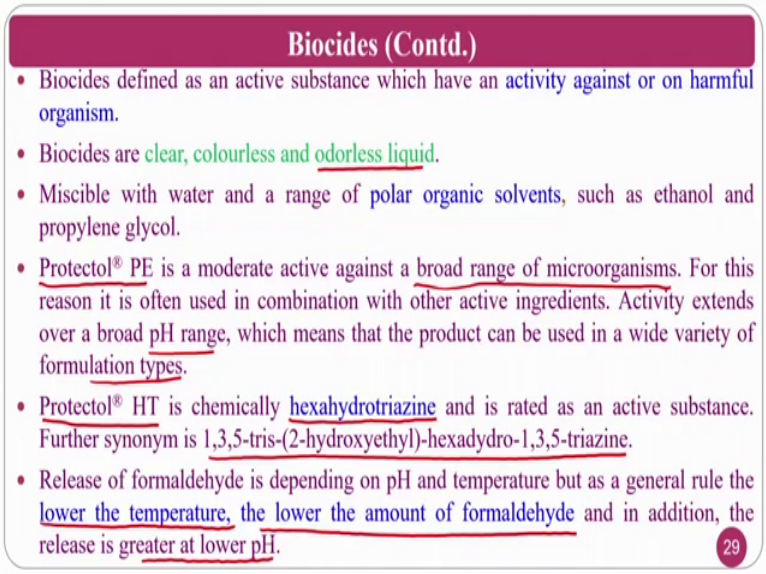

So, biocides defined as an active substances which have an active agent or on harmful organism against harmful organism say it will act against any living organism which is harmful to this cutting fluid it will act.

Biocides are clear colourless and odorless liquid, it are used to prevent the odor. So, the first thing is that you should not give any odor for that purpose it is always odorless liquid it do not have its own smell. The miscible with water and the range of polar organic solvent such as ethanol and it will be miscible with water, with oil and other things there is no problem of mixing of this biocides.

For example, there is a commercially available protectol PE is there which moderate active against the broad range of microorganisms. Normally there are many types of

biocides are there among which this is one type. This you can apply for many varieties of cutting fluids that is called broad range of microorganisms that are commonly growing on the cutting fluid. This reason often used in the combination with other active ingredient activity of broad pH range which means that the product can be used wide variety of formulation types. This can be used for variety of cutting fluids where different types of microorganisms are formed, and the pH if the microorganisms grows the flick pH will change. So, that if I m using the biocide of this protectol PE what will happen it will control the pH by clean the microorganisms.

Protectol HT is another one which is a trademark of the same company. Chemically it is called hexahydrotriazine and rated as active substance, normally this is another synonym for it which is a very big. So, you can shortly call it as hexahydrotriazine ok. This will be slightly active compared to previous one release of formaldehyde is depend on the pH and temperature, but general rule the lower temperature the lower the amount of formaldehyde. And the addition that release of greater at lower pH; that means, what will happen whenever you add there is a formaldehyde releasing will takes place.

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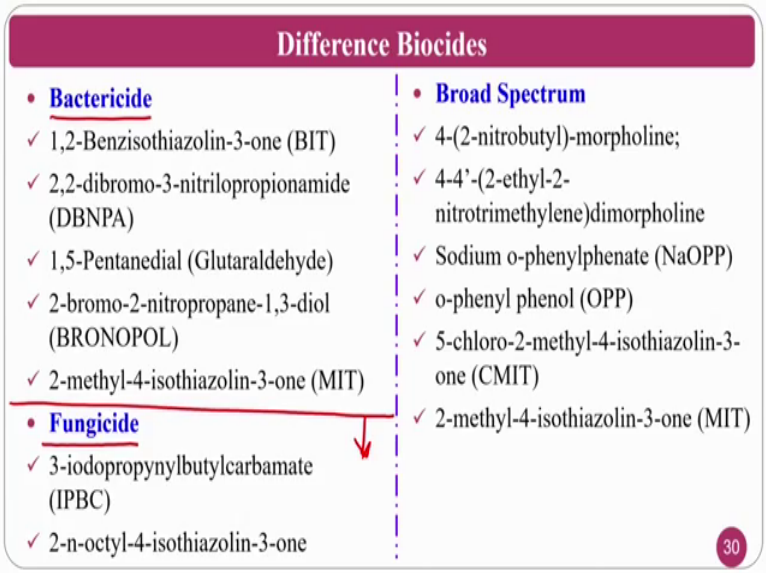

The mechanism I will show you in the next thing I think ok. So, whenever you add what will happen here is that release of depend on the pH of that certain fluid. This will also will change when whenever there is a temperature in the machining region goes up the formaldehyde releasing will also will takes place ok.

So, that is about the biocides. Different biocides are there this are the bactericide which prevent the bacterial formation. Then comes the fungicides, if at all I have fungus it had they eradicates the fungus you will go for this type of things. So, this will go for bacteria up to this one, and the bottom one will be fungicides. And then one broad spectrum you will have if at all I want to have to kill the microorganisms which have the bactericides, fungicides and all those things you will go for the broad spectrum of the materials ok. These are all the chemical names as a mechanical engineering you need not to by heart when the examination or something, you should know the basic what is a bactericide, what is a fungicide, and how the it will going to kill and all those things ok. So, that is about the biocides.

Another important addition to the cutting fluid is rust inhibitor. So, rust inhibitors means whenever the machining operation is going on is a cutting fluid contains 1 is to 10, assuming 10 litres of water the water will fall on a machining zone where the temperature is high. And assume that I have a work piece of iron based work piece, in that circumferences rust formation on my product that is coming out from the machine region is one of the problem. So, how to prevent for that purpose we should always try to have the rust inhibitors in the cutting fluid or rust inhibitors should be preblended in the cutting fluid so that this rusting effect will not takes place ok.

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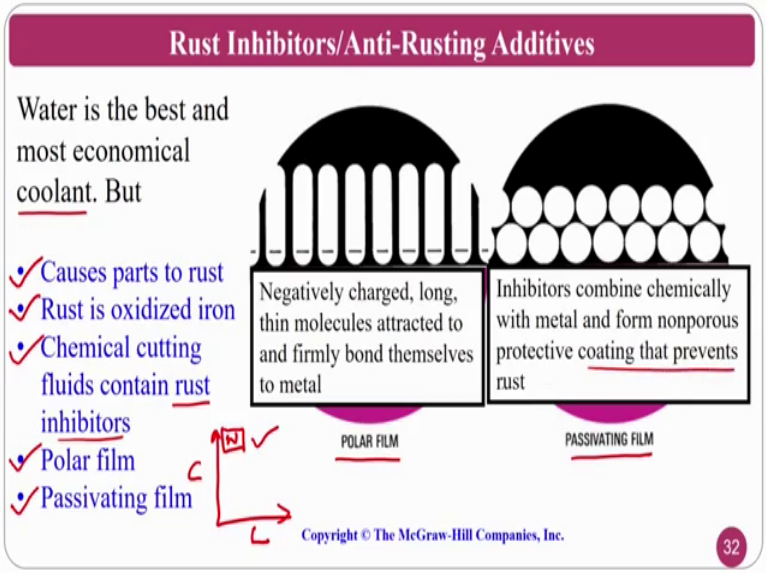

So, water is the best and most economical coolant ok, because it is freely available at the same time cost free and it has if you see the graph it has a better cooling ability. If you see the graph like lubrication versus cooling abilities water stays here ok. So, for that purpose this is a better coolant and it has no charge ok.

So, causes part rust normally if you are not going to use this part will cost causes the rust formation. Rust in oxidize iron normally if you see in a upcoming slides as you can see whenever I said in a previous lectures also if you have a mild steel plate you just put into the at open atmospheric conditions rainfalls and air blows and on top of it and all this thing rust will takes place. Rust is nothing, but oxide film takes place and it is easily around able with nail if you just scratch it will goes off ok.

Chemical cutting fluids contain the rust inhibitors normally synthetic and semi synthetic cutting fluids will basically contains this rust inhibitor. So, these are in the polar form as I said polar non polar (Refer Time: 61:14) and it is forms a passive passivating layer. If you see a polar film and a passivating film negatively charged long thin molecules attracted and firmly bond on themselves on the metal; that means, if you are falling a polar film; that means, that polar head will go and stick on the surface. So, that it will not allow the water content to come ok. So, that is one passivating film inhibitors combined the chemically with a metal and form nonporous protective coating that prevents the rust ok.

So, it will form a passive layer passivative layer means whenever you have rust inhibitors are there these rust inhibitors it just go and coat on top of it; that means, that it will go and sit on the top of it. So, that water content after that one if you are going to put this one in a open atmosphere also what will happen because of the moisture content in the water in the air are the chemicals that are present in the air like oxygen and all those things it will prevent from the rusting that is by making a passivating film.

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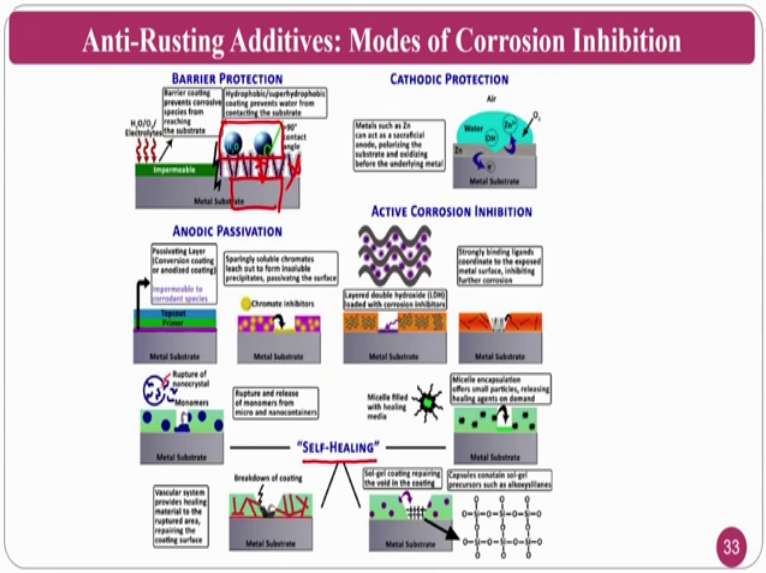

Modes of corrosion inhibition, such there are some modes that is barrier protection just you form a barrier like you just have a coating on top of it, the water molecules will be there. Cathodic protection normally this is a chemical reaction activate active corrosion inhibition, anodic passivation and self healing and all those things. These are the some of the chemical techniques where the anti rusting or rust inhibition will takes place.

Normally the some of the commonly used is barrier protection. So, barrier protection is just you have a passivate layer, the layer will be there on top of it if the waterfalls also it do not have much effect it will sit there is no direct contact between two surfaces ok. There is no direct contact this is about the anti rusting ok.

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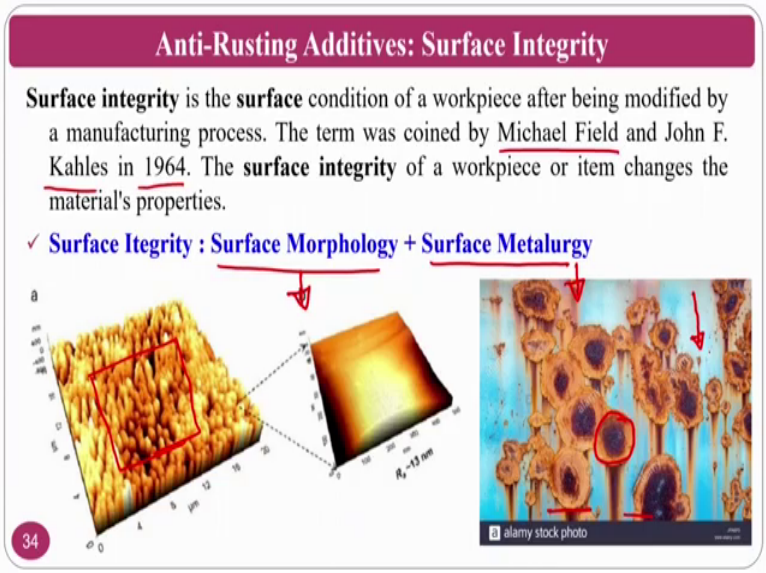

So, surface integrity, I was just talking about the surface integrity and surface roughness I have already taught you. But I forgot to give you some other glimpse that is called surface integrity is surface condition of the work piecebeing modified by the manufacturing process the term is coined by the Michael Field and John F Kahles in 1964. Surface integrity means surface morphology plus surface metalurgy ok. This is about the surface integrity.

When I was teaching in the previous classes I just forgot to give you the glimpse what is surface morphology. This is surface morphology; that means, that how the surface look like and all those things. This is about how the surface morphology topography means outside how it looks like from outside. Anatomy means it is a one of the subjects of medicos where they will read morphology and anatomy dissection and all those things are there ok. So, anatomy means inside we are not talking about inside we are talking about the external surface that is called the this surface, if you talking how the morphology look like whether the nanotubes are formed and all those things.

The second this is about surface morphology if you see the surface metalurgy as I was telling the oxide rusting and all those things will takes place. If you see here the rusting how the rusting is taking place and all those things this is called metallurgy. Even though thus assume that you are going to measure in this region surface roughness you are going to get a good surface softness, but you are surface metalurgy is very poor ok. For a

practical application the surface roughness is also important, on surface morphology not only roughness it appearance and all those things also important at the same time metallurgy is also important.

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The surface again just a glimpse this is surface morphology and this is surface metallurgy. You can see a chain on which how the rusting taken place. So, this is called surface metalurgy. So, you need both. If a machining operation is taking place if you are not going to control the rusting the surface metallurgical point even though you got a better surface roughness or morphology it is none of your application it will not match to any of your applications. Whenever you put this product into the practical condition may fail that is why both are important. For that purpose you need to add a rust inhibitors to the cutting fluid.

That is why whenever you are purchasing the cutting fluid you have to cross check the composition mineral oil is there, rust inhibitors are there, emulsifiers are there and many other biocides are there, they are minimum, but at the same time what is its quantity. Is it the quantity in a right amount or not, if it is not in a right amount then it will have ecological problems ok.

So, you should have always in the upcoming classes you will see if this additives. In this class you have clearly seen the advantage of this corrosion inhibitors, biocides and all those things, but you come across various disadvantage of this fluids in the upcoming

classes where the emission this will causes lot of dangerous emissions ok, that will hamper the operator environmental pollution water pollution and all those things, for that purpose as a mechanical engineering.

As a manufacturing engineer you should cross check whether the amount of this ingredients are within the limit or not as per your within the limit it will give you metal mechanical or manufacturing output that is good surface finish forces lesson all those things. And the same time it should not operate the operator also that is why you should take and take the right amount. So, this is about the surface metallurgy and surface morphological condition.

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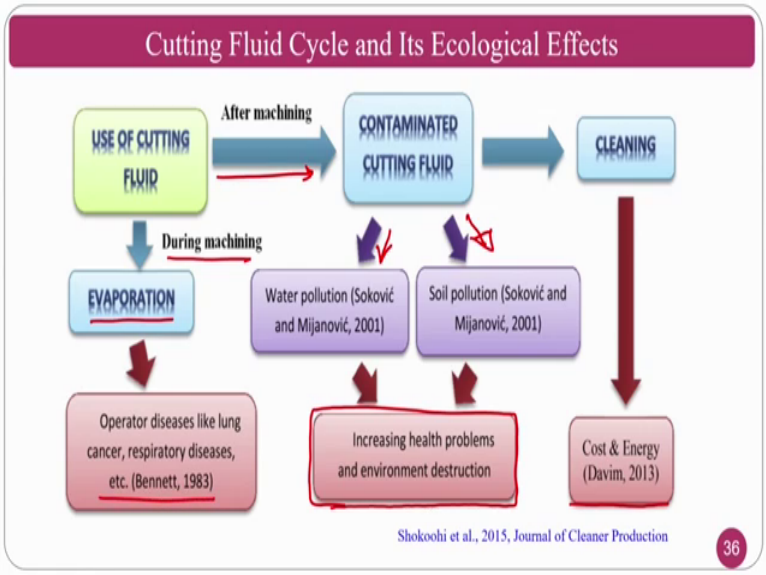

Now, you see this at cutting fluid cycle and ecological effects. Use of cutting fluid which will start after the machining what will happen though contaminated cutting fluid will come, if you see the cleaning by the filtering operation or something what will happen it will causes to the cost and energy if you are going to filter it, if you are not going to filter it then it will problem. So, contaminated cutting fluid if you see again it will causes the water pollution, again it will causes the soil pollution these two increases the health problems and environmental problems. That is why the cutting fluids you should use minimum you have studied about various techniques of cutting fluid application like flood cooling minimal quantity cutting fluid and all those things which choose right option.

If you are using like atomizing type of thing during the machining operation evaporation will takes place and operator diseases and all this things will cause. This is one of the cutting fluid cycle and its ecological effects. Why I am giving you this glimpse is in upcoming class is what we are going to see is the other side of a coin. The cutting fluid additives we have seen the advantages on one side, these cutting fluids will have adverse effect drastically adverse effect on other side that we will see in the upcoming classes.

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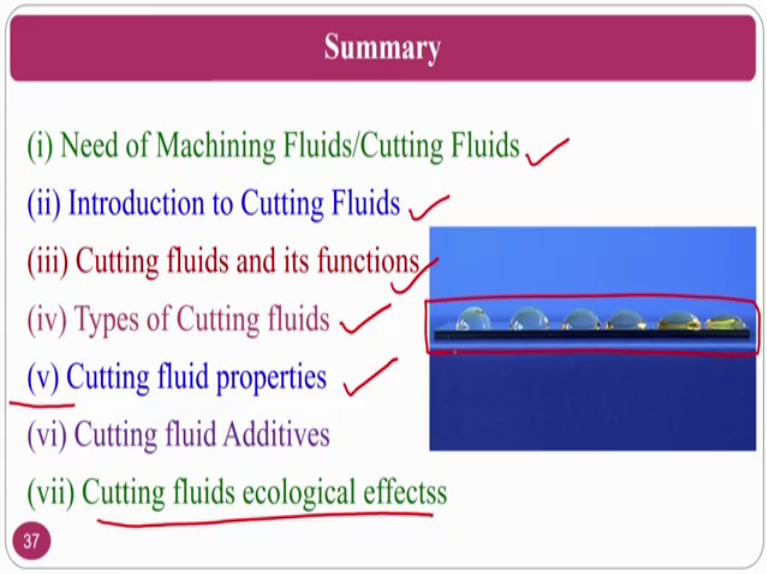

So, the summary what we have seen in the previous class and this class need of machining fluids in the cutting fluids, introduction to cutting fluids and cutting fluids and its functions types of cutting fluids cutting fluid properties. These are all we have studied in the previous class. Cutting fluid additives elaboratively we have seen and cutting fluid ecological effects and all those things we have seen. Most importantly we have studied about emulsifiers, biocides, rust inhibitor, microemulsions, multiple emulsions, many things of type of additives which we have used. And this is a glimpse which we have taken from the tribiological where you can see the surface change, if there is a particular surface is there how the contact angle changes that about the hydrophobic hydrophilic surface example that is why I was telling.

Thank you for this class. Hope you understood as much as possible because it is involved some chemistry also where the names are very big. Being a mechanical persons

sometimes you may not get, but however, I try to explain the best level how to correlate the these fluids to our manufacturing or metal cutting applications.

Thank you.