Fundamentals of Manufacturing Processes
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Lecture – 42
Material Removal Processes: Cutting Fluids

Hello, I welcome you all in this presentation relate with the subject fundamentals of manufacturing processes and we are talking about the metal removal processes. In the last few presentations I have talked about the 2 life tool materials and we know that the there are different tool materials which offer the different properties. So, considering the properties of the tool materials we need to make the tools in the different ways.

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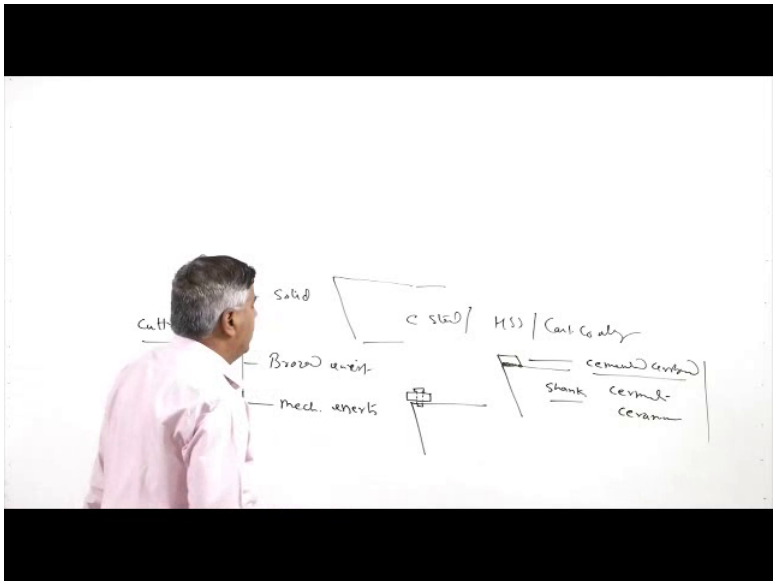

So, there are 3 types of the cutting tools, 3 ways by which cutting tools are made one is like the solid tool where in entire the tool is made of the given tool material which we have selected and normally this happens in case of like metals like carbon steel or high speedy steel or cast cobalt alloys, but in other cases like another one is the brazed insert, brazed insert tool where in the tools on the tool shank we braze the insert, insert is used. So, the insert is brazed like this on the shank. So, here the shank does not interact with the work piece, but that cutting tool insert interacts with the work piece and this normally used for making the cemented carbide tools are made of the inserts cermets and ceramics.

So, these are the tool materials which are used for making the brazed inserts as well as the mechanically held inserts. So, where in the shank and this is the insert there will be a through hole and there mechanical arrangement like nuts are used for holding the shank holding the insert with the shank. So, once since the inserts have the number of cutting edges. So, once if the one insert goes out of the, once one cutting edge fails then another cutting is brought into the action by indexing.

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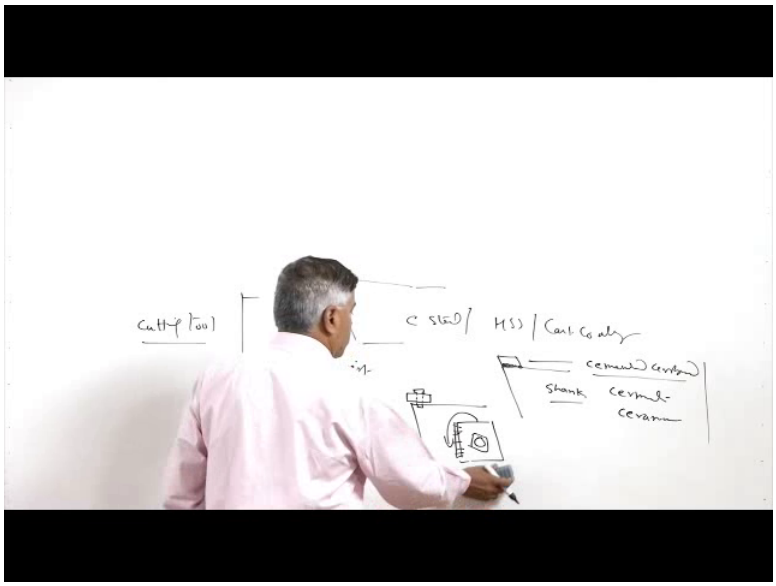

So, say this is the top view of one insert and here this will be used for holding the insert onto the shank and once say this a edge is working on and once if it goes out of order then another edge can be brought into the action. So, in this kind of indexing is possible and so without changing the setup just index, the insert is indexed. So, that it can be brought into the cutting action. So, these are the 3 different forms of the tool, solid tool normally used for like tough materials, low cost tough materials while inserts are made of the high cost high hardness motives like cemented carbide, ceramics serenades polycrystalline diamond etcetera.

Now, another thing when these inserts are when these tools are used will notice that during the machining very long curly chips are produced during the machining of the ductile materials, like say low carbon steels.

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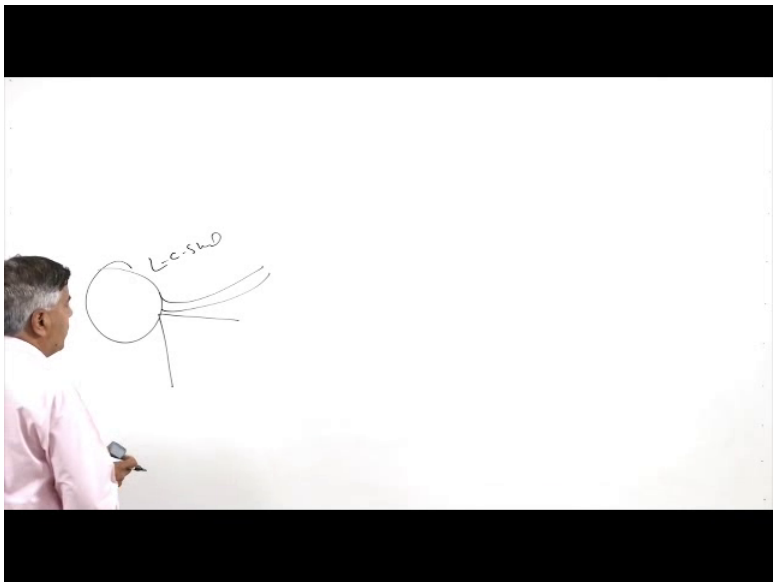

When these are machine it produces very long curly chips which will be wrapping around the tool will be wrapping around the machined work piece. So, it will be damaging to the surface finish of the machine work piece as well as it can harm to the operator who is working on it, it makes the cutting zone very messy. So, it is important that unnecessary formation of the long chips is avoided and for that purpose basically the chip breakers are used so that was the chip is formed, it is a tightly curl and broken away you with the help of the chip breakers.

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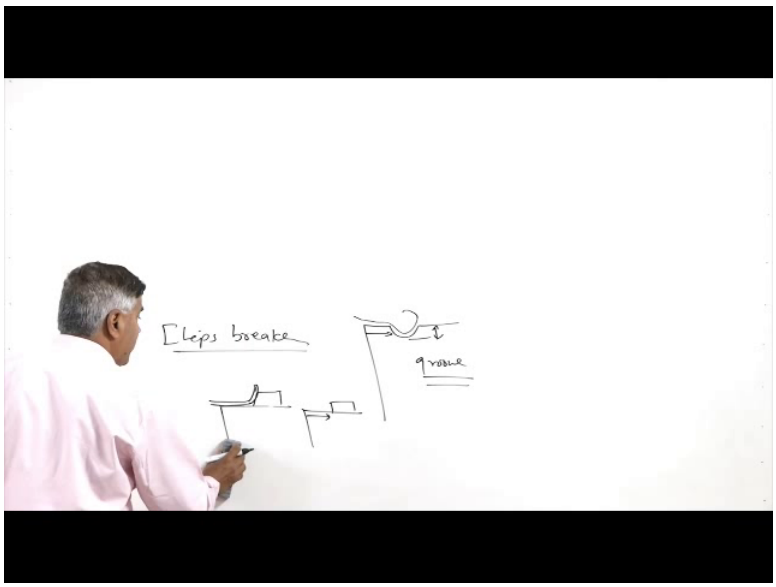

So, the chip breakers are basically of the 2 types one is where in one gap is made. So, you after getting removed from the work piece the chips will be flowing through the moving through this gap and then it will be broken or it will be curled back and unnecessary lengthy this will avoid to the formation of the unnecessary lengthy chips. So, the depth of this groove as well as the location away from the cutting edge these are the 2 factors that will be governing the effectiveness of the chip breaker of the groove type.

Another is the abstraction type chip breaker wherein on the wreck face of the tool one abstraction is placed in this way. So, that after we getting the chips after getting removed from the work piece flowing through, moving through the face of the tool, it hits to the breaker and then it gets curled or its direction is changed so that it is broken. So, this kind of the abstraction, this is the abstraction kind of the chip breaker where in the height of the chip breaker and the location of the chip breaker abstraction type chip breaker will be governing the effectiveness of this kind of the chip breaker.

So, chip breakers basically help in breaking the chips easily which in turn breaking the chips, avoiding the unnecessary formation of the lengthy chips, at the same time it will also be reducing the frictional heat and unnecessary rising temperature due to the friction between the chip and tool. Now you will see there are various types of the inserts which are made as for the cross section, the inserts are classified in the different ways and the typical insert is like circular shape.

Another one wherein the insert will have the cutting is at 90 degree, then another one where in the cutting edges or at like 80 degree.

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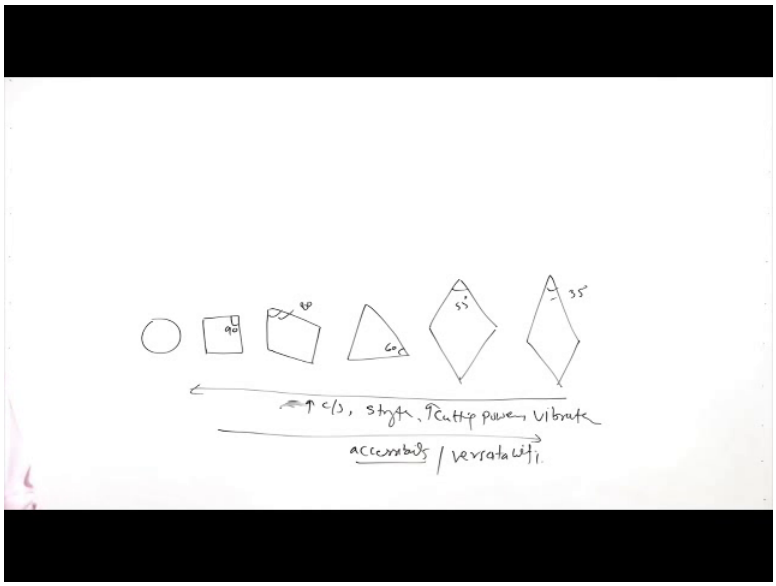

So, this included angle is 80 degree, this angle is 90 degree and then another insert is having the included angle 60 degree, then we may have at 55 degree, like this 55 degree or even 35 degree like this.

So, if we see the included angle is getting reduced from this side to this side. So, this will be reducing the cutting edge cross sectional area or increasing the cutting edge cross sectional area. So, this side moving from the right to the left there is increasing cross sectional area of the cutting edge which will be making the increasing the strength of the cutting edge, but at the same time it will require the more cutting power, increase the cutting power requirement as well as it will also increase the vibration tendency of the tool.

On the other hand on moving from the left to right there will be increase in accessibility, accessibility of the tool to the cutting zones as well as it also increases the versatility, versatility of the tool for the cutting. So, means under the complicated situations as well as difficult to access locations can also be machined using such kind of the insert. So, based on the cross section of the cutting tool inserts this classification has been made and another aspect is about the relationship of the tool geometry and the tool material.

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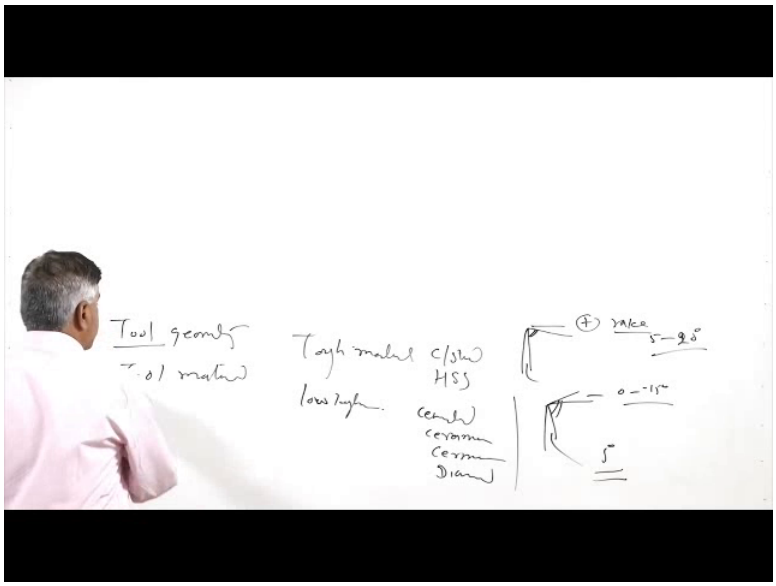

So, tool geometry and the tool material. So, like the tough tool materials, tough tool materials like carbon steel high speed steel these are normally made with the positive rack angle, positive rack angle because these are tough. So, they can sustain the cutting conditions even with the lesser cutting edge cross sectional area which is offered by the positive right angle, but in case of the low toughness materials like cemented carbide, ceramics and cermets, diamond etcetera.

What we will see that these are the low toughness material. So, we need to make the cutting edge is stronger by increasing the cross sectional area and for that purpose negative rack is used, negative rack can vary like say from like say 0 to minus 15 degrees while positive rack normally 5 to 20 degree. So, these and on the other hand the clearance in both the cases is of the 5 degree. So, that rubbing with the rubbing of the tool or insert with the work piece can be avoided.

Now, we know that during the machining lot of the heat is generated and the heat generation basically comes from the heat comes, means say the heat is generated due to the deformation occurring at the primary shear zone as well as in the secondary shear zone and the friction occurring between the chip and tool and the tool and work piece.

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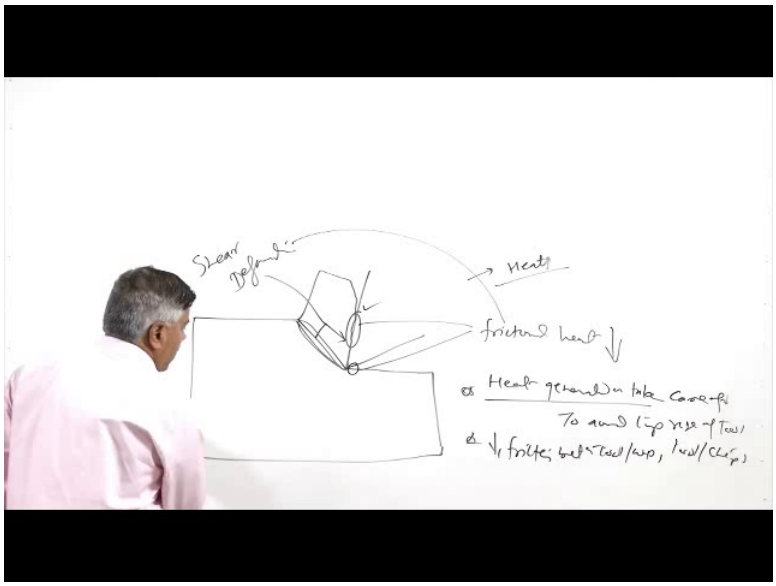

So, the tool and work piece and the chip and tool these are the 2 zones which will be causing the frictional heat, on the other hand the deformation of the chip at the chip tool interface as well as deformation in the shear plane these 2 will be causing the shear deformation. Primary and the secondary deformation and for both these activities like to overcome the friction as well as to cause the shear deformation we need to consume the energy and whatever energy is consumed that is converted into the heat.

So, what is our goal our goal is to look into the 2 aspects like whatever heat is generated, heat generated is taken care of properly. So, that there is no major rise in temperature. So, taking care of avoid the rise in temperature of the tool. So, to avoid temperature rise of tool, this is one aspect and the second is the frictional heat is reduced by reducing the friction between the chip and tool as well as tool and work piece. So, reducing friction between tool and work piece and the tool and the chip is the another target.

So, all the both these are the sources of heat, but since the, these 2 deformations cannot be cannot be taken care of or cannot be avoided. So, we need to work on the frictional aspect and the friction can be reduced by this suitable lubrication; in order to deal with these conditions, because with the both, these conditions will be leading to the loss of the material from the tool, because the heat generation leads to the softening of the flank and the face as well as the nose.

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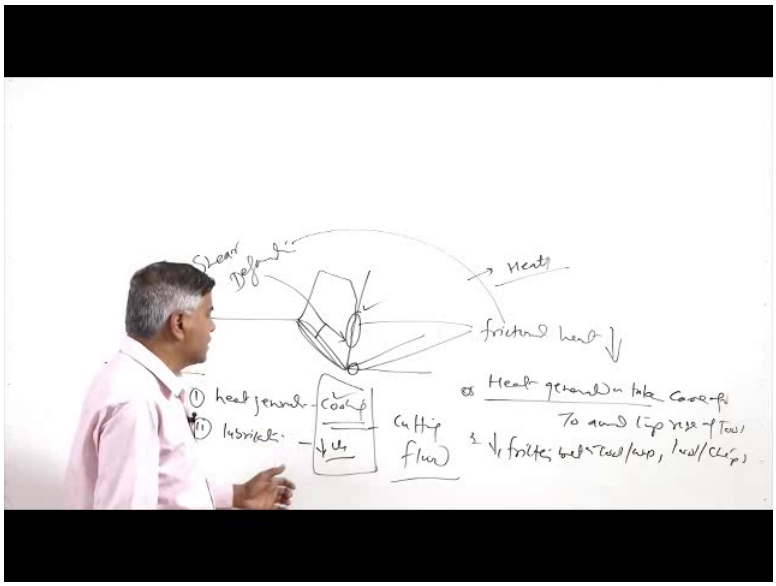

So, the it le leads to the loss of the material by the Edison abrasion diffusion, chemical reaction as well as deformation at the same time rubbing of the chip with the tool also causes due to the friction causes the weir.

So, we need to take care of the heat generation aspect and for this purpose we need to use the cutting fluid for the cooling purpose and another is the lubrication at the tool chip interface as well as tool and work piece interface. So, that the friction between the tool and work piece and chip and tool can be reduced. So, this to deal with these two purposes we need to use the cutting fluid. So, it is expected that cutting fluid will perform the cooling. So, that the heat generated can be taken care of as well as cutting fluid will provide the lubrication so that the friction between tool and chip and chip and tool and work piece can be reduced.

Apart from these 2 functions when the cutting fluid is used it helps to achieve the other functions as well which includes like reducing the work piece temperature it makes the handling of the job easy.

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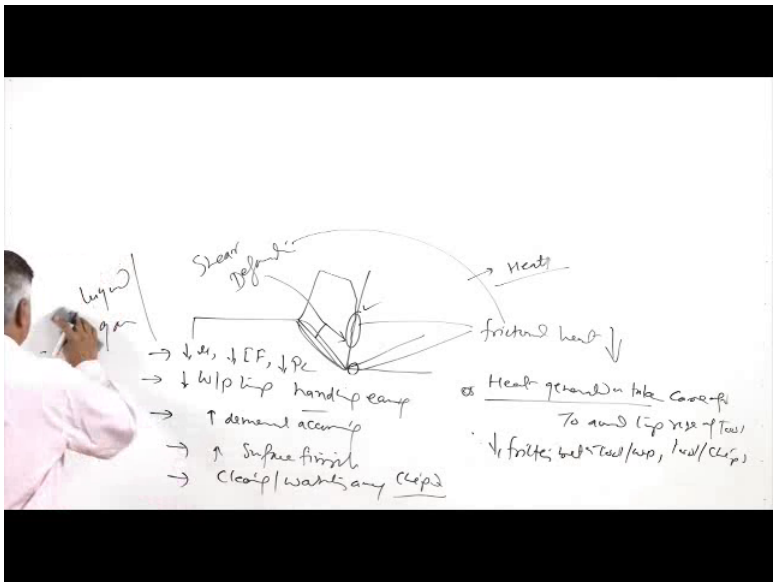

It makes the handling of the job easy, the second one it reduction in temperature of the work piece reduces the expansion and contraction during the machining. So, it helps to increase the dimensional accuracy of the component being machined, it increases the surface finish also because reduction in temperature avoids any kind of the oxidation or interactions with the other environmental conditions which are there. At the same time use of the cutting fluids helps in clearing or washing away, washing away the cutting chips which are being formed around the cutting zone. So, to the cutting zone will be easily cleared from the chips when the cutting fluid is used.

So, these are the added benefit apart from this reduction in the friction helps in reducing the cutting forces which will be generated during the machining, it will also help in reducing the power consumption for the machining. So, it is always good to use the cutting fluids so that the heat generated can be carried away by the cutting fluid as well as it can provide the desired lubrication between the chip and tool the tool and the work piece.

Apart from these 2 functions other second differences are automatically achieved, for the cutting fluid purpose normally the liquids or the gases are used. So, as for the case the suitable type of the cutting fluid is used. So, to perform these 2 functions of the cutting fluid inform of the cooling.

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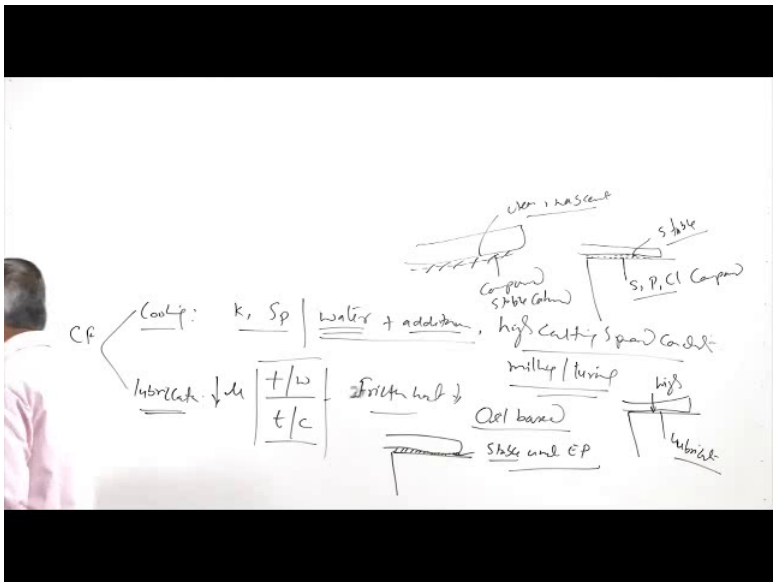

And the lubrication we need to use 2 different types of the cutting fluids, like for cooling purpose it is required that heat is carried away from the cutting zone effectively it is necessary that thermal conductivity of the cutting fluid is good and the specific heat of the cutting fluid is also good. So, that heat can be easily cleared away from the cutting zone tool and the work piece easily and both these properties are good with the water that is why water is very commonly used cutting fluids plus.

Sometimes some kind of additives are also used so that it can be made more corrosion resistance as well as it can provide the some good for some good the lubrication qualities, apart from this water as a coolant helps in effectively in clearing the heat away from the cutting zone especially under the high cutting speed conditions and therefore, the for the cooling purpose cutting fluid mainly the water based cutting fluids are used.

Then another one is the lubrication another important function is the lubrication, for the cooling purpose like an like a milling, turning are the common operations for the water based cooling cutting fluids are used for the cooling purpose lubrication is the another function where the object, main objective is to reduce the friction between the tool and work piece and the tool and the chips. So, that the frictional heat the frictional heat can be reduced, this is the main purpose and that is why most of the cutting tools which are used for the lubrication purpose they are oil based, but these oil based since the stresses under which the stress applied the stresses actually are the pressure which will be present

during the flow of the chips over the face of the tool these stresses are high enough the pressure is high.

So, any lubricant if we it is applied it will be made unstable. So, that the direct metal to metal contact between the chip and the tool is present. So, in order to perform the role of the lubrication effectively the lubricant must be in position to have the separation between the chip and the tool and for that it is necessary that lubricant is stable it does not disintegrate under the cutting conditions of pressure as well as temperature and it for this purpose only the oil based lubricants are added with the sulfur phosphorous and chlorine based compounds. So, these compounds basically interacts with the machined surface as well as the chips like the chip under surface of the chip interacts with the, this is very clean very inasent and the fresh. So, these compounds actually interact with the fresh metal surface and forms the certain compounds of which are more stable and coherent.

So, when the these compounds are formed these can sustain under these can remain stable even under the extreme pressure condition, say this is the chip and if the compounds are being formed and underside of the chip and these compounds will be stable and coherent even under the extreme pressure conditions. That is why and so they will be able to when such kind of compounds are formed in presence of such kind of like sulfur phosphorus and chlorine presence in the oil based lubricants they will be able to separate the contact, they will be able to reduce the metal to metal contact between the chip and the face of the tool. So, that the lubrication effect the friction can be reduced and the flow can be more smooth hand, such kind of the compounds are called extreme pressure additives because they can sus; the compounds which is formed can sustain really the high pressure conditions which exist during the machining.

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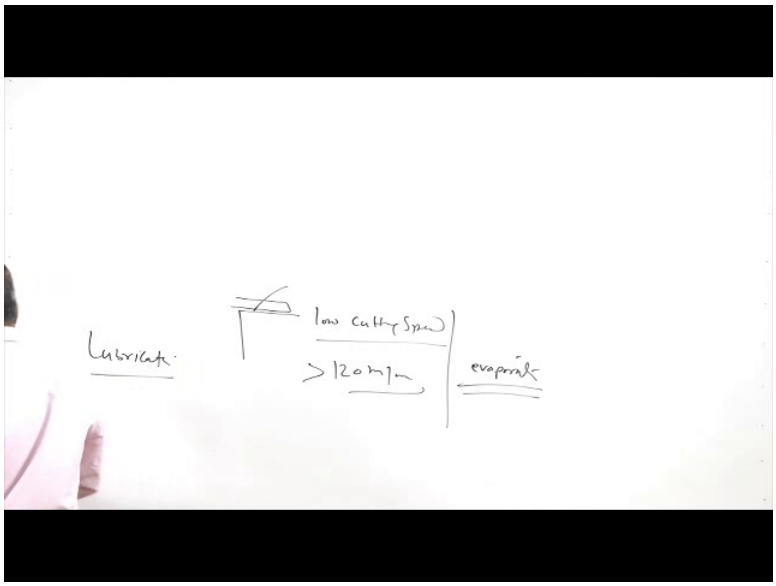

So, we were talking about the lubrication aspect so, but the lubrication you see the when the lubricants are applied. So, lubricants to perform the role of the lubrication it is necessary that the lubricant is able to reach between the chip and tool rack face during the cutting so, but this is possible under the low cutting speed conditions, if the cutting speed is high like above the 120 meter per minute a speed becomes so high that the cutting fluid cannot reach at the chip tool interface. So, it cannot from extreme the compounds which will be able to separate the chip from the tool or the which will be able to avoid metal to metal contact. So, the lubricants will not be able to perform their functions as well as under the high speed conditions whatever heat is generated that leads to the evaporation of such kind of the cutting fluids.

So, they do not remain means at high speed conditions lubrication based cutting fluids do not remain effective and that is why we need to see that the cutting tool material having the stability even at a high temperature is used to deal with those the situations.

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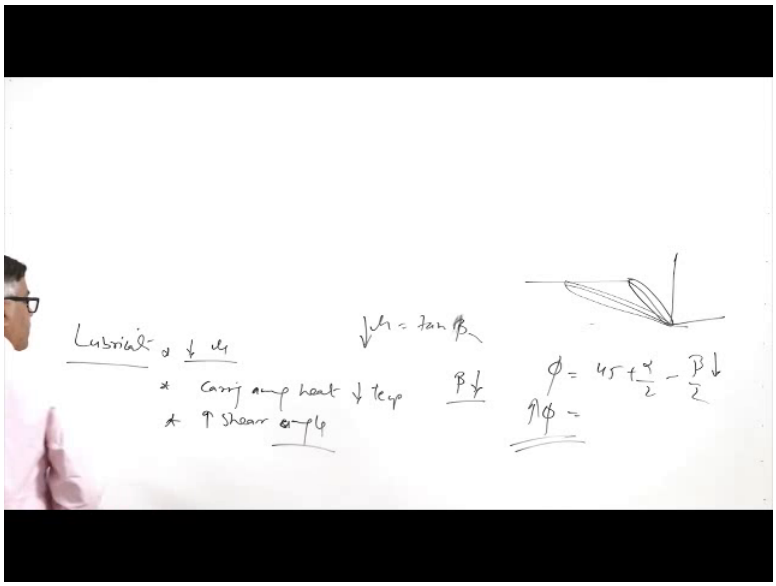

So, when the lubricants are used what we basically get lubricants will be able to reduce the friction between the tool and chip and tool and work piece is one and the second is because of the specific heat and thermal conductivity they will also be able to carry away the some amount of heat, carry away heat from the cutting zone. So, that will be helping in lowering the temperature of the tool as well as work piece.

And the third one, it will be reducing it will be increasing the shear angle. So, how it is possible for that we need to see that mu is equal to 10, 10 beta, beta is the friction angle. So, if the friction coefficient is reduced it helps in reducing the beta value and once the beta value the friction angle is reduced then according to the merchant theory what we have phi is equal to 45 plus alpha by 2 minus beta by 2. So, for a given rack angle if the beta value is reduced it will help in increasing the value of phi.

So, increasing value of phi we know that if the shear plane angle is increased it reduces the shear plane, a shear area which is required for to be sheared off during the machining as compared to the case when the shear plane angle is low. If the shear plane angle is low we need to re shear off much larger area which will require much for more shearing force, much more power consumption for the shearing purpose. So, when the lubricants are used it reduces the friction it increases the phi which in turn increases the power required for cutting as well as the forces which are required for the shearing purpose.

Now, we will see the common types of the cutting fluids which are used.

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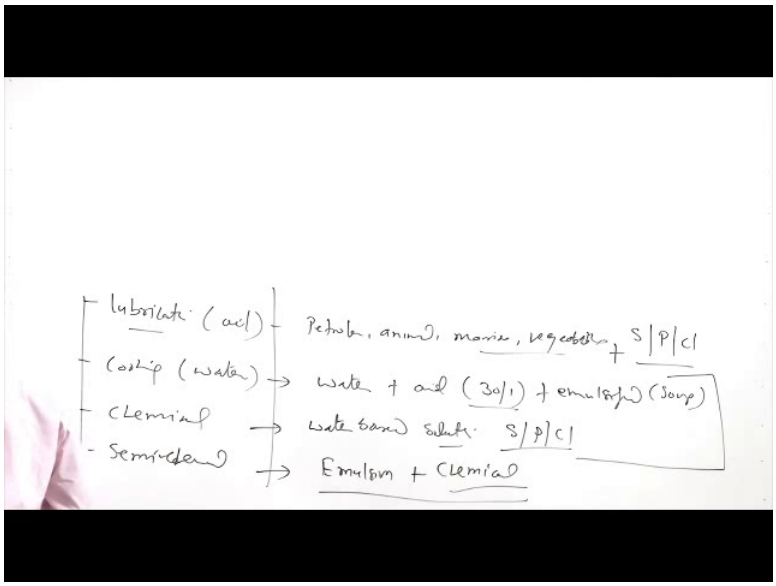

There are 4 types of the cutting fluids which are used one is like for the lubrication these are oil based cutting fluids and for the cooling purpose, these are water based then chemical cutting fluids and semi chemical, semi chemical cutting fluids. So, oil based cutting fluids are basically petroleum oils, animal oils, marine oils and vegetable oils these are the things we these are the oils which are normally used, but these oils offer the good lubrication effect, but in order to make it more effective extreme pressure additives like compounds of the sulfur, phospholor phosphorus and chlorine are also added. So, that they become stable under the cutting conditions between the chip and tool in order to perform the required function.

On the other hand the water based cutting fluids where in mainly it has water and plus same amount of the oil is added. So, that it can also have some lubrication effect where in 30 is to 1 ratio of the water and oil is used, in order to distribute the oil in water properly the emulsifier like soap is used. So, that what oil gets distributed in the water effectively and this is used for the conditions when good cutting good cooling is required, on the other hand the chemicals these are the water based solutions where in the compounds of the sulfur, phosphorus and chlorine are added in order to make them better in order to provide cooling as well as the good cutting fluids.

On the other hand on the semi, semi chemical cutting fluids they this basically these are the combinations of the emulsions wherein water plus oil is used plus chemical cutting

fluids wherein mainly the sulfur, phosphorus and chlorine compound are added. So, it combines the semi chemical cutting fluids they will be combining the advantages of both chemical cutting fluids as well as the water based cutting fluids. These cutting fluids need to be applied during the machining in such a way that they can be applied effectively. So, that desired function can be achieved.

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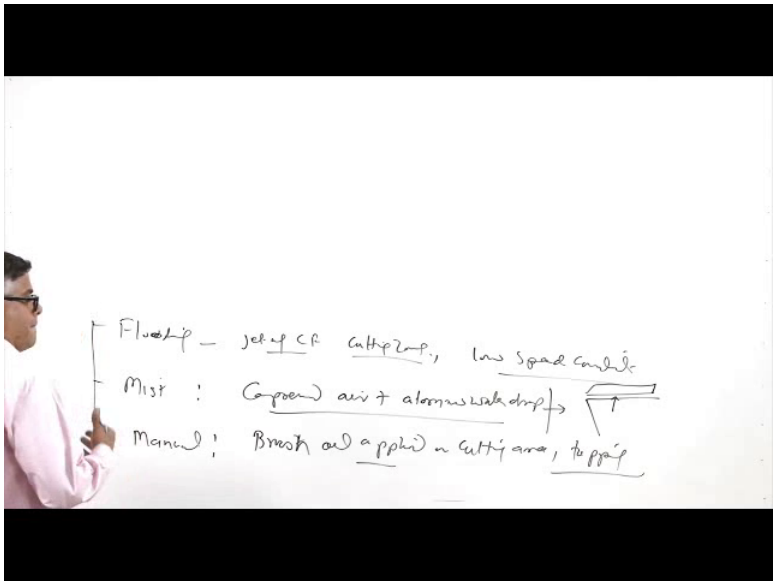

There are 3 common methods for applying the cutting fluids one is like flooding, another is mist and another is like manual application. So, in case of the flooding or continuous jet of the cutting fluid is fed into the cutting zone. So, that the cutting zone is full of the cutting fluid helps to cool down the cutting cool down the tool as well as the work piece this is effective for the low speed conditions, but at a high speed conditions the cutting fluid may not be able reach at the tool chip interface and so they may not be effective.

While on the other hand compressed air plus atomized water drops the combination of these 2 is called mist is a directed in the cutting zone, since this will be this the mist will be fed under pressure. So, a at high speed conditions this may be able to reach at the tool chip interface during the machining. So, it may be able to feed the cutting fluid at the desired location, but this does not help in much lubrication as well as the cooling purpose or the presence of the water droplets help in taking away the heat from the cutting zone, but the cob lubrication defect is not much available with this method.

And manual method is mainly used like the, in the brush the oil is applied and then it is printed or applied over the so with the help of actually brush oil is applied of the cutting fluid is applied in the cutting area and like for typical example for this manual application is tapping, where the for cutting threads like a the cutting fluid is applied manually in the cutting zone. So, that it can provide the desired lubrication, we know that it is not desired cutting fluid after some use becomes very polluted and its disposal becomes an issue.

So, in order to avoid that situation certain suggestions have been made so that the cutting fluid can be used for long or its use can be avoided, which includes there are 3 aspects one is once the because of when cutting fluid is in used it gets mixed up, it gets mixed up with the variety of the impurities chips and so like the bacteria is also generated in the cutting fluid because of that it becomes simply age an agent of the pollution. So, this needs to be replaced at regular interval, whatever cutting fluid is there.

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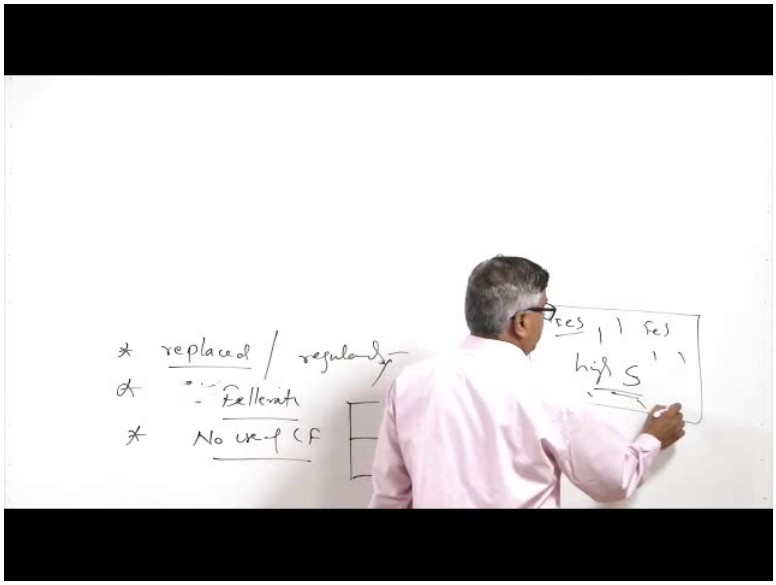

If it is in use these needs to be replaced regularly. So, that orderness and other poor performance of the cutting fluid all those issues can be reduced.

Another one is that we can filter so filtration. So, filtration of the cutting fluid in order to remove the impurities and other things which have got added during the use and the third way is that no use of the cutting fluid, no use of cutting fluid and if we do not use then there are various possibilities like that high temperature and the no clearing of the chips.

So, that can be a problem or it can be, but it is possible with the free machining steels basically free machining steels are these things will the high sulfur, high sulfur content.

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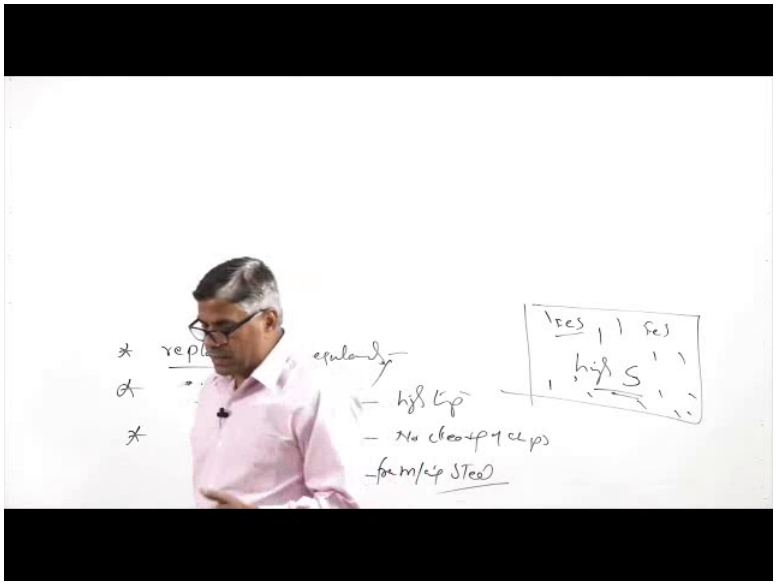

So, iron sulfide is present here and there which facilitates the production of the segmented and discontinuous chips at the same time these acts as a weak point. So, the forces required for sharing power consumption cutting temperature all those gets reduced when the sulfur is present in high concentration in the steels which makes the steel, which makes this steel easy for machining that is why the it is called free machining steel.

Now, I will summarize this presentation in this presentation I have talked about the different types of the tools and the geometries used in the inserts and after that the, what are the functions of a cutting fluid what are the common types of the cutting fluids which are used and how can we apply these cutting foods so that the required function of the cutting fluid can be achieved.

Thank you for your attention.