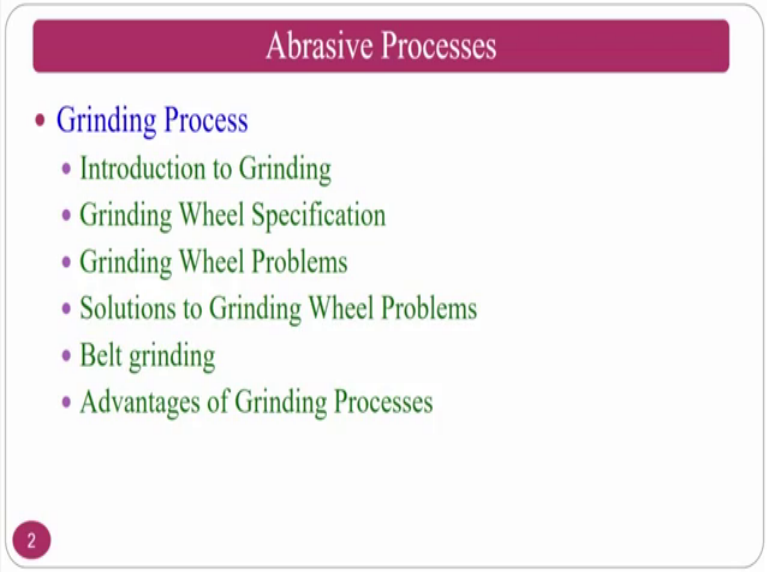
Introduction to Machining and Machining Fluids
Dr. Mamilla Ravi Sankar
Department of Mechanical Engineering
Indian Institute of Technology, Guwahati

Lecture - 24
Cutting Fluids in Grinding Process

We are discussing about the abrasive processes. In this abrasive processes till now we have seen the grinding process, in which grind introduction to grinding wheel specification belt grinding, what are the problems? What are the solutions of the grinding wheels and all those things?

(Refer Slide Time: 00:35)



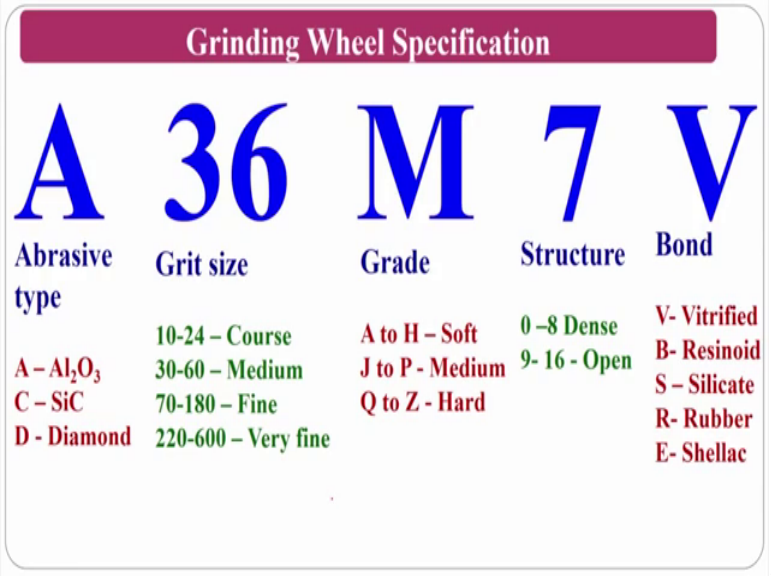
Now, we proceed to the grinding fluids, that is also a part of our syllabus that is called machining fluids. So, in this aspect we are studying the grinding fluids.

(Refer Slide Time: 01:00)

The grinding fluids basically if you see in a machining operation other surface grinding, here in this region you can see lot of spark is generated because of the friction that is between the grinding wheels as well as the workpiece surface. So, in order to reduce the temperate generation and the heat affected on the workpiece and all those things always people will use the grinding fluids.

Grinding fluids can be lubricate based or it can be coolant base. So, both are there depend on what type of application, whether you are going for high speed or whether you are going for very low speed or whether you are going for medium this will decide which type of cutting fluids you are going to use in the particular bending operation.

(Refer Slide Time: 01:54)

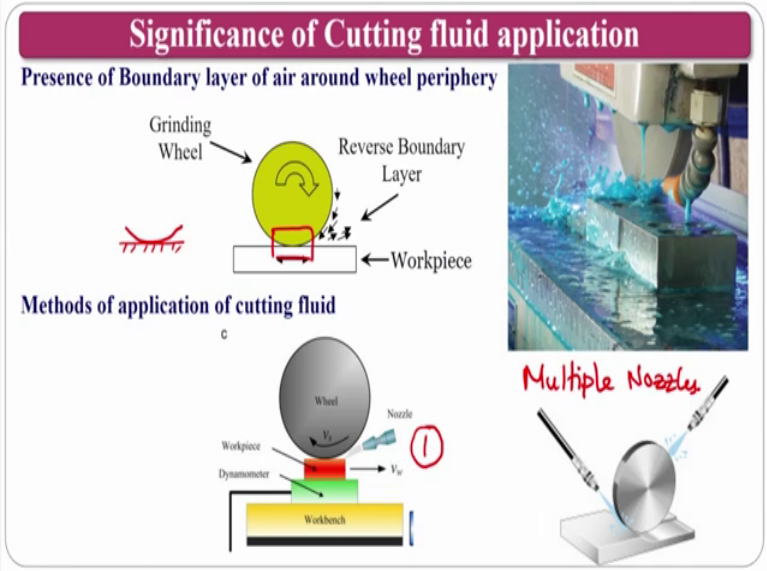


But as you have already seen the grinding wheel specification in this one, which is the most important one that will have influence with respect to the grinding fluids that we have to see as abrasive type you do not have any much thing because whether it is alumina or a silicon carbide or diamond whatever the things. So, whether is a grid size you know it will have much effect because what are the grid size you are using whether it is you are using medium or coarse or something.

So, grid is the bonding between abrasive particle and the bonding material that is called wheel bonding material. So, whether hard bonding or soft bonding so, it do not it also do not have structure. The structure if you see what is happening if you see the structure the structure is nothing, but open structure and dense structure. If you are going to apply the cutting fluid are the grinding fluid basically it tries to enter or it will tries to help the grinding wheel to not load.

And it also helps the grinding wheel in terms of cooling and all those things that is why most important factor whenever we considered about the grinding fluids, you can say the structure is the only parameter that can have some influence compared to other. Anyhow the bonding different bonding's are there vitrified bonding to the shellac bonding rubber bonding and all that those also do not have much fluid well only particular specification that is called the structure, which is having some influence whenever you apply the grinding fluid.

(Refer Slide Time: 03:46)

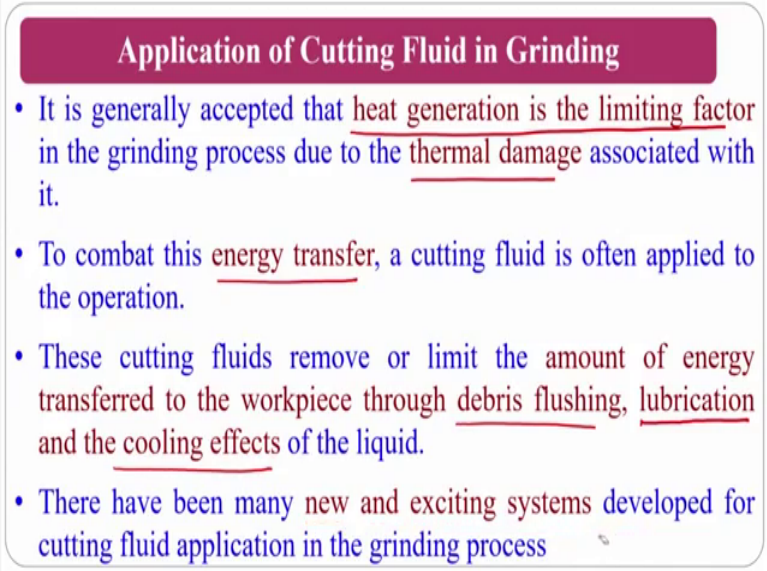


The grinding fluid significance the presence of boundary layer are air around the periphery if you do not use the cutting fluid normally we consider it as air will be there between if you see this region you have workpiece as well as the grinding wheel. So, the air can penetrate into this one. If you are applying cutting fluid normally if you see the cutting fluid plays a major role in terms of a burning of a workpiece it will reduce the burning effect and chip burnishing. At the same time it also cools down the machining region and all those things lubricates a machining region. So, that the temperature generation is very less and all those things.

There are varieties of cutting fluid application people can go for a one nozzle application or people can go for the multiple nozzle also, here you can see here multiple nozzles. So, this will enhance the particular grinding operation efficiency by dislodging the wheel loading and all those things, wheel loading as you have seen the chip materials are clogging between the two successive abrasive grinds that is called wheel loading.

So, the grinding fluids will help to not clog the materials.

(Refer Slide Time: 05:09)



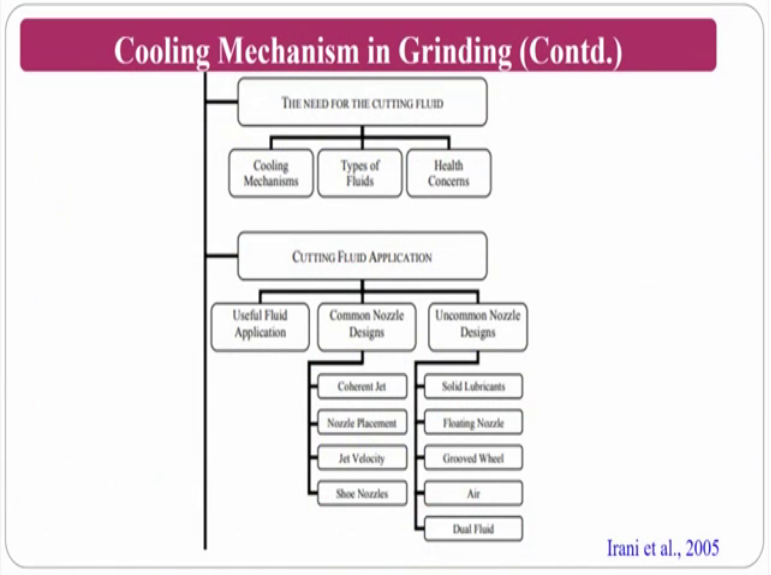
Applications of cutting fluid in grinding it is generally accepted that the heat generation is a limiting factor in the grinding process due to is the thermal damaging and what will happen, if there is a heat generation in the grinding process there will be thermal damage with respect to the workpiece heat combat energy transfer, because the thermal energy transfer takes place. And whenever you use the cutting fluid what will happen the thermal energy it will extract from the machine region.

So, this cutting fluid also remove limit amount of energy transfer to the workpiece through debris flushing, and lubrication, and the cooling effect. What will happen it will take the temperature generation in the machining region by debris flushing; that means, that you are flushing the debris that is between the your grinding wheel as well as the workpiece and the cutting fluid also help to dislodge the clog material, it will help in terms of lubrication because the proper lubrication if you provide what will happen the friction between the grinding wheel as well as the workpiece will reduce. So, the heat generation will be less the cooling effects the workpiece has to be cooled. So, that the it would not go for thermal softening region and all those things ok.

There have been many new and existing systems of so; that means, that not this cooling applications like there are many varieties of techniques are there flood cooling is there multi-nozzle that we have seen in the previous slide single nozzle. So, nozzle positions also can be varied whether you can go from 0 degrees, whether you can for 15, 20 or 30

or something and the same time standard distance between the wheel as well as the nozzle and solid lubricant also used minimum quantity lubricant it is called sustainable grinding also can be used in the cutting fluid applications.

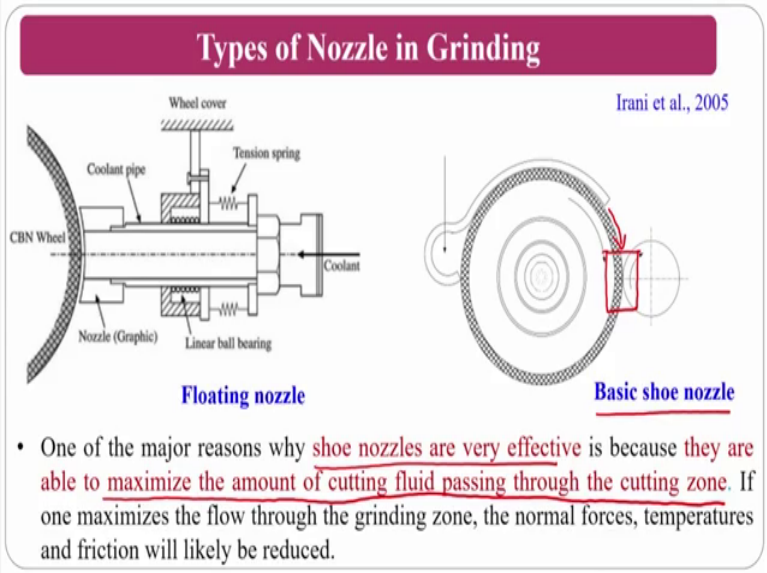
(Refer Slide Time: 07:10)



Cooling mechanisms in the grinding if you see, the need of cutting fluid the cooling mechanisms the need of the cutting fluid if you see the cooling mechanisms, type of fluid health is you can divide into three segments; then the cutting fluid application. So, useful fluid application normally common nozzle designs is the one at the same time uncommon nozzle is basically whenever you are going for the solid lubricants are floating nozzle there are some varieties of nozzles are there.

So, this type of uncommon nozzles also will be there. So, you have to choose according to your requirement what is your requirement; what piece my requirement? Whether it is whether I want to remove the material in a bulk amount, whether I want remove the material for the surface finish, whether I have to do the form grinding or normal grinding or centralized grinding, which type of grinding that I want to use depend on that you have to choose your nozzle as well as the cutting fluid.

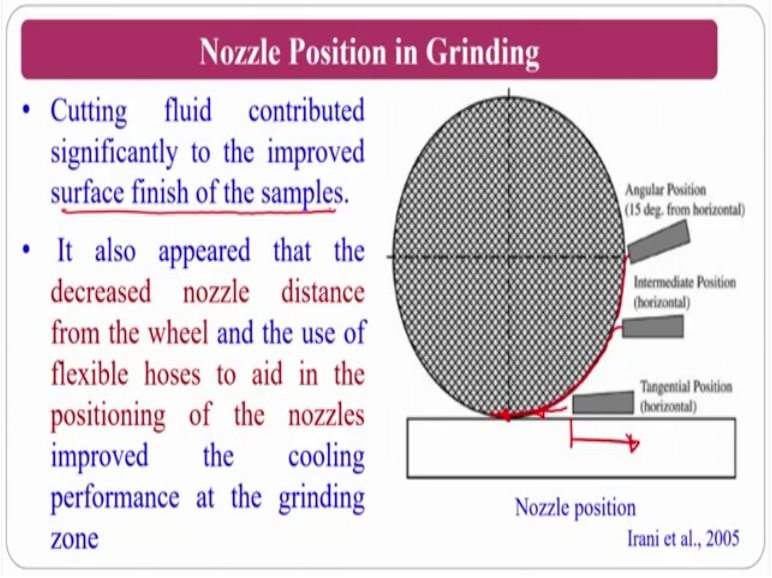
(Refer Slide Time: 08:14)



So, the types of nozzles if you see the first one is the basic shoe nozzle this is the one of the common and commercial type of thing, where if you see normally this shoe nozzles are very effective because they are they able to maximise the amount of cutting fluid passing through the cutting zone this is the cutting zone. So, this a workpiece interface and the grinding wheel interface. So, that it can pass through the grinding fluid and it maximise on the periphery of the machining region.

The other variety is floating type of nozzles here the floating type of nozzles will have the tension springs will be there. So, that it can float as per the requirements of that one so, that you can send the cutting fluid into the machining region.

(Refer Slide Time: 09:06)



Nozzle positions in the grinding if you see there are some researchers working on or worked already on the nozzle positions, you can use tangential position at the same time you can use intermediate position because you need certain boundary basically what will happen if you are using here the cutting fluid goes like this. So, it will occupy the machining region if you use here what will happen it comes through the boundary and goes like this ok.

If you are using here what will happen it goes like this. So, the nozzle stand up distance; that means, that how far you are keeping this is one of the thing at the same time, how incline you are keeping this a nozzle; So, that the cutting fluid carry all the periphery of the grinding wheel also studied by many researchers ok.

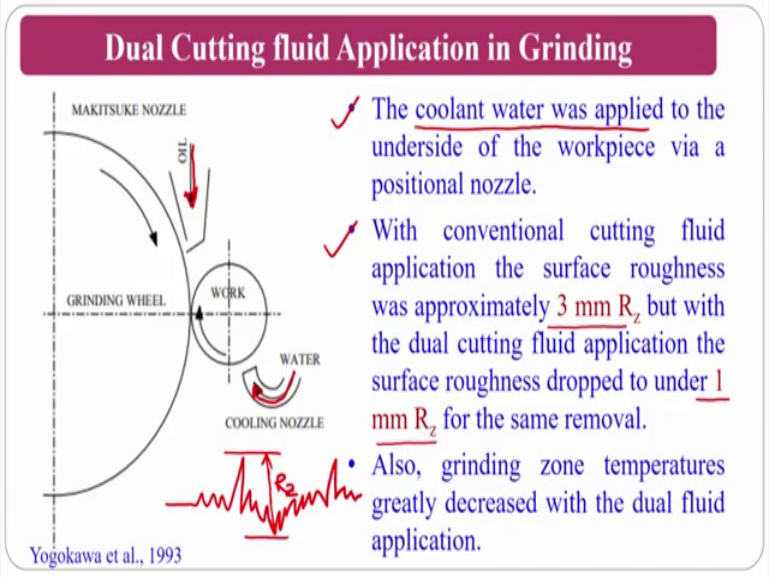
The cutting fluid contributed significantly to improve the surface finish of the samples because the cutting fluid the conventional grinding process is considered to be one of the finishing process that is why people uses it for the finishing. So, the output as a operator that I will look is I have to kept a good surface finish on my product, that is that is why normally you play with the nozzle.

It also appeared that the decreased nozzle distance from the wheel that is nothing, but the stand-up distance how far your nozzle is standing away from the wheel, at the same time flexible hose to the positioning of the nozzle.

So, how flexible you are hoses that is previous slide we have seen the floating type and this can also improve the surface space people have studied. So, those people who want to study you can use existing things you can go through the literature, you can go through the what are the type of cutting fluid they have used, what are the workpiece materials is if there any drawback or if you can understand some good mechanics of this one.

If you can understand some are temperature measurements are experimentally are if you think there is some things can be further done you can take up this work as a research program for the masters and PHD people.

(Refer Slide Time: 11:21)



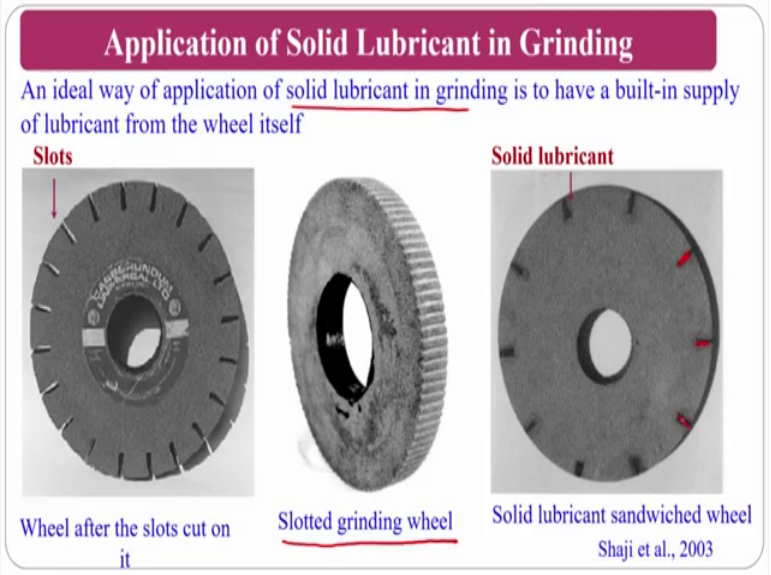
There is another nozzle type that is called dual nozzle which we have seen the schematic in the previous slides. So, here also you can use the coolant there is oil which is coming from here at the same time there is a water also coming from here dual nozzles are there the oil will help in lubrication at the same time water will help in cooling.

So, the coolant water was applied to the underside of the workpiece via the positional involved. So, that it can cool second is with the conventional cutting fluid normally the R Z the R Z if you talk about whenever I was talking about the surface roughness in the machining process R Z is nothing, but the maximum peak to minimum valley if a surface roughness is like these. So, this is nothing, but your R Z.

So, maximum peak to minimum valley is nothing, but your R Z. So, this is will be normally the maximum that is why. So, this is the 3 mm in normal single nozzle whenever the authors are using multi-nozzle it is reduced to one mm; that means, the surface roughness is decreased means surface finish is improved that increase; that means, better surface is achieved.

Other one is also the grinding zone temperatures are greatly decreased, whenever the grinding zone temperatures are decreased what will happen the thermal damaging on the workpiece decrease. So, not only it gives a better surface finish it also decreases the temperature. So, thermal damaging also it is reducing to benefits the authors guard by using the dual cutting fluid application technique.

(Refer Slide Time: 13:13)



So, there are authors who have used solid lubricants. So, on ideal way of application of solid lubricant into the grinding is putting this material are built in supply lubricant solid lubricant can be done ok. There are varieties wheel after slots cutting on it. So, you can put the solid lubricants by cutting a slots, another one is a slotted grinding wheel where you can now put the slots as well as you can fill these slots with solid lubricants at the same time you can also put the solid lubricants and which in the wheels.

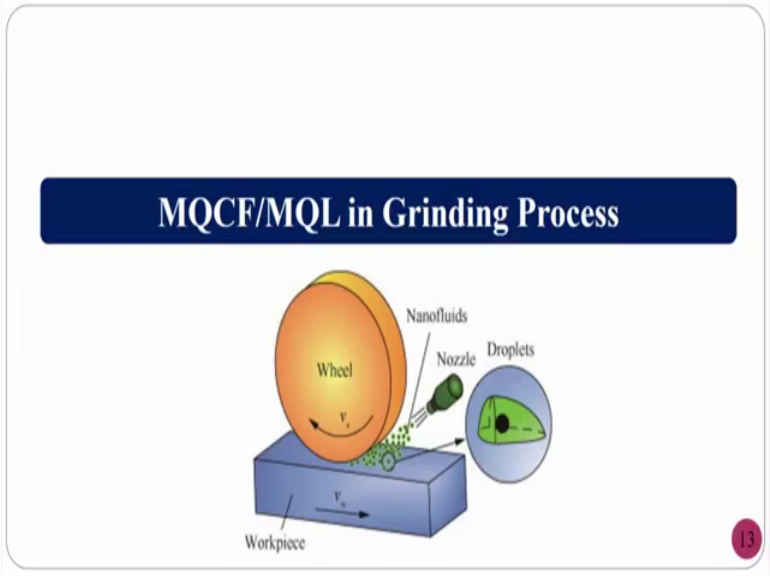
So, basically you can put you can sandwich here and you can use the solid lubricants. Not only these people have used like a flood cooling; they have just taken the air like minimum quantity cutting fluid that you have seen previously. So, they are sending the

solid particles along with the air. So, that jet of solid particles will go in to the grinding operation people worked on the solid lubricants also, but some people who are interested they can explore more and more in this area.

So, far references you can see some of the papers on solid lubricants for metal cutting applications, as well as grinding applications by Professor PV Rao of IIT Delhi. So, the Professor Rao's group works extensively on the solid lubricants and other things. So, if you are interested those people who want to explore about all these things you can refer Professor Rao's papers.

So, and those papers also explain lot of mechanics what are the usefulness and all those things. So, those people who would like to do the research in the solid lubricants in metal cutting as well as grinding operations can go through those papers.

(Refer Slide Time: 15:10)



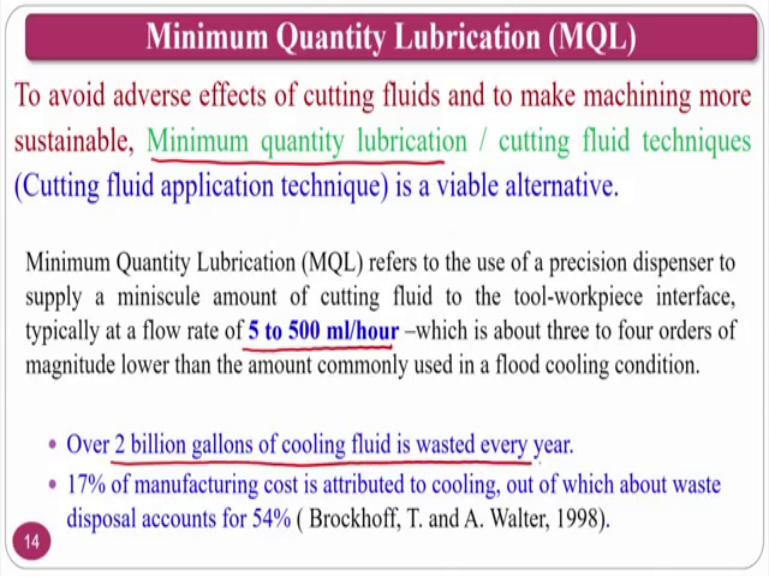
So, sustainable whenever I was telling many times that the course title says machining conditioning fluids. So, at last what I want to say is whether whenever I teach about machining as well as whether I would teach about machining fluids at last my ambition is towards sustainable, how sustainability I can incorporate. So, that a better output can come at the same time I can also help the operator in order to safeguard him as well as in order to make him healthy with respect to the emissions and all those things.

Even though emissions are there how to protect that was one of the concern if there is, if

I cannot generate or if I do not generate any emissions that will be better that is why always I try to emphasis for the sustainability aspects. Here also I am going to talk about the minimum quantity lubricant or minimum quantity cutting fluid in the grinding process.

Here you can see here in this grinding wheel is there at the same time the workpiece is also moving that is table feed will be there. So, in the previous one what will happen the cutting fluid is a liquid, which may not penetrate into the machining region between the grinding wheel and workpiece. That is why, if I can send the atomized cutting fluid that can penetrate into the machining region and extract the heat by forced conviction as well as it also can lubricate that region that is what the intention of MQL.

(Refer Slide Time: 17:06)

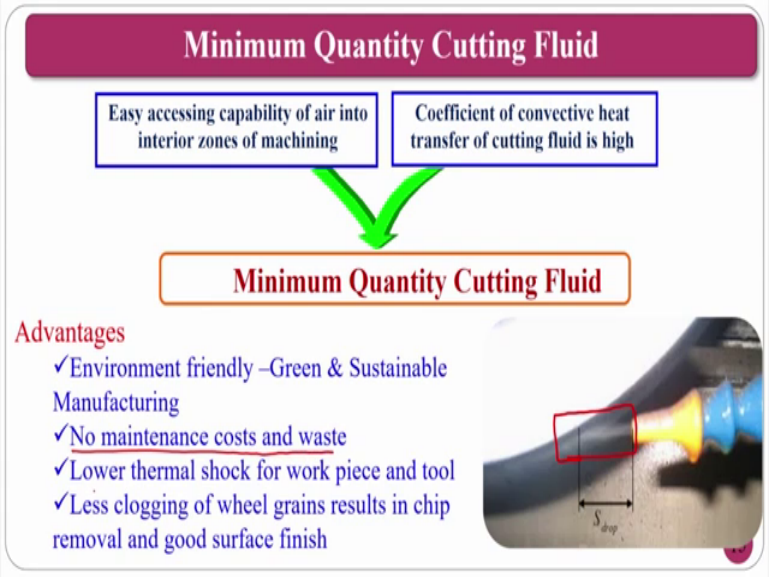


So, minimum quantity lubrication if you see. So, to avoid the adverse effect of the cutting fluid the minimum quantity lubrication or the minimum quantity cutting fluid techniques are came into existence, the minimum quantity lubrication refers to use of very minimal cutting fluids that is 5 ml per hour to 500 ml per hour. So, normally people will talk about 50 ml per hour and all those things. So, ml 50 ml per hour means very very less quantity with respect to the flood cooling where you spend per a minute half a litre of something ok.

Here per hour you are spending half a litre so, maximum. So, this is about the minimum quantity over 2 billion gallons of cutting fluid is wasted per every year. So, in order to

keep the resources for the next generations, we have to minimise the cutting fluids utilisation also at the same time 17 percent of the manufacturing goes to the product basically. So, if I can minimise the cutting fluid I can be competitive in the market by selling my product at minimal price.

(Refer Slide Time: 18:23)



This is a known slide to you because I explained already whenever I was talking about minimum quantity lubricant are cutting fluid.

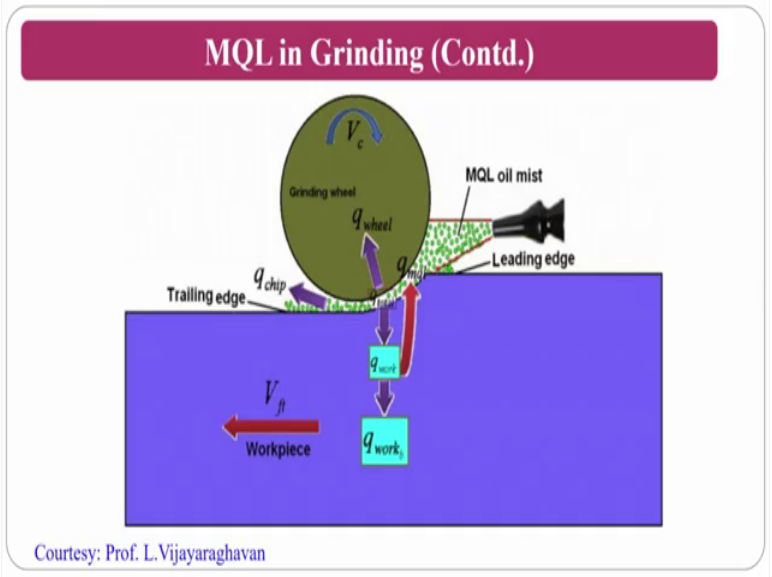
So, there you have two things one is the easy accessibility of the air one side at the same time high convective heat transfer coefficient of the cutting fluid is mixed and form a mist and it is injected between the grinding wheel, as well as the workpiece you can see here say the mist is coming in and in between the workpiece as well as grinding.

So, the this mist will help not only in terms of providing lubrication cooling, because of this force velocity, because of this high velocity particulates are the molecules, because of the high velocity of this z what will happen the clogging also can be removed that is reloading will be minimised.

The advantages is environmental friendly one the see there is no maintenance are the cost or the waste lower thermal shocks less clogging of the wheel I I was saying that if there is any clogging it can penetrate and it can take out the clogging. So, in this way you can enhance the grinding efficiency of any particular process compared to our normal

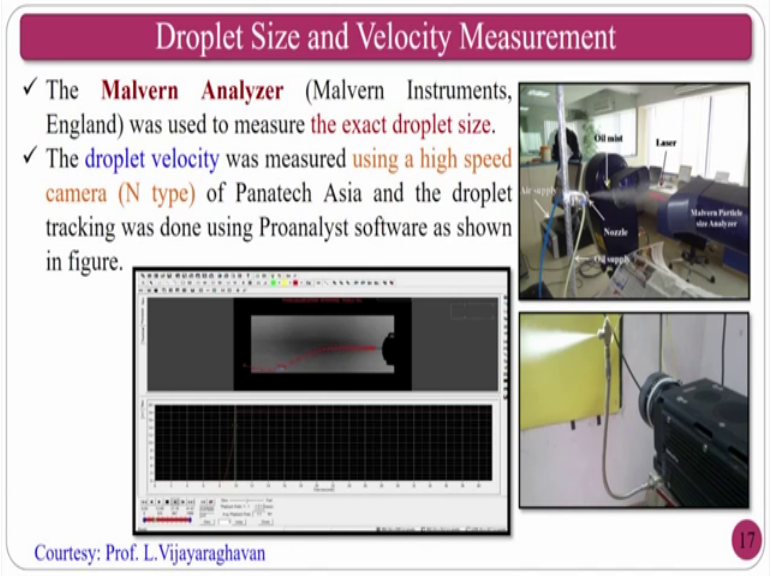
process.

(Refer Slide Time: 19:55)



This is how you can see here the grinding wheel and the minimum quantity lubrication the fluid is occupying here and the abrasive particles will be there and this will remove the workpiece material ok. These slides are taken from one of the senior professors from IIT Madras so, thankful to the professor.

(Refer Slide Time: 20:18)

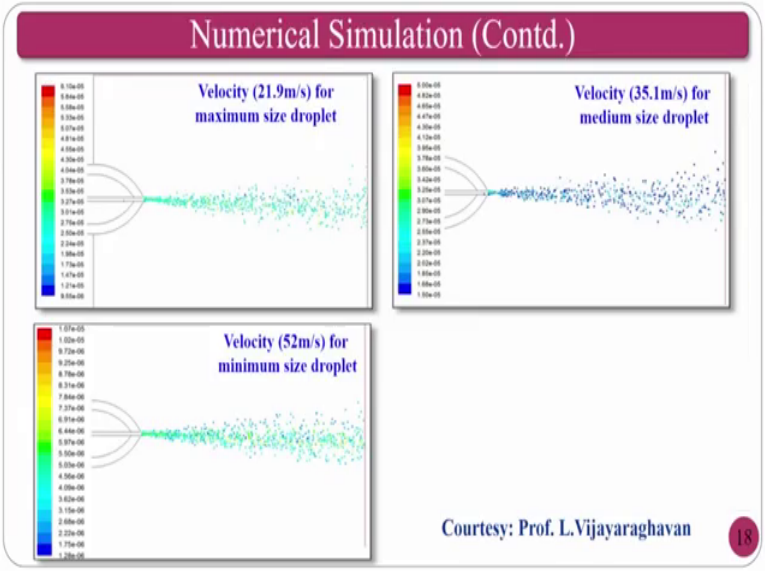


So, the researchers also studied about the droplet size they experimentally validated the

droplet size the question is whenever I am sending the cutting fluid and air compressed air, and I mixing it internally and I am sending it what will happen I am sending a atomized gas which is having high convective heat transfer. Now the problem is how to calculate the droplet us this is the biggest question for the purpose.

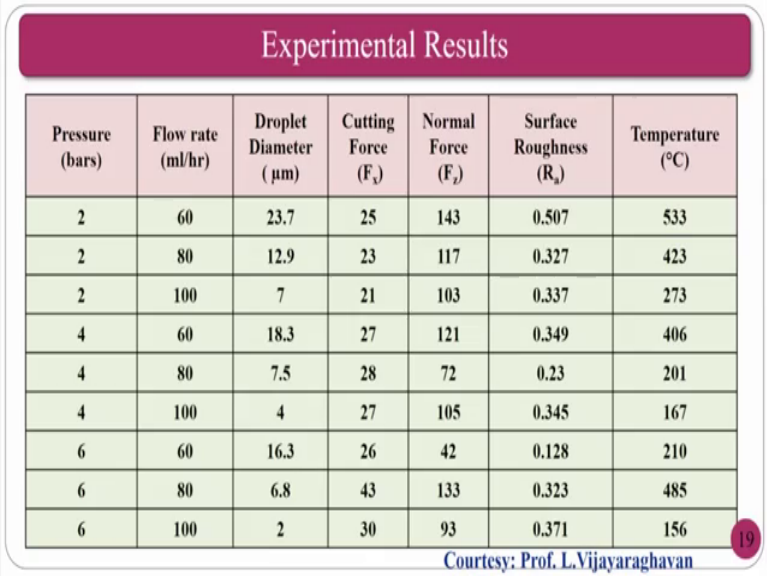
Malvern analyser is there. So, you can if you have that equipment you can measure the particle size or the droplet sizes the droplet velocity also can be measured using high speed camera ok. So, if you see here in the figure one this is an least jet is there the jet is falling in the grinding operation you can see from the other view in the figure number 2 and the velocity can be calculated by high speed camera at the same time you can also measure the droplet size by Malvern analyser once you have done.

(Refer Slide Time: 21:33)



Once you know the physics if the people who are having some knowledge about fluid and all those things who works in the fluid and thermal area not only the manufacturing they can simulate the droplet sizes. So, they can check the droplet sizes as well as they can also simulate using the standard software's and they can validate it.

(Refer Slide Time: 21:59)

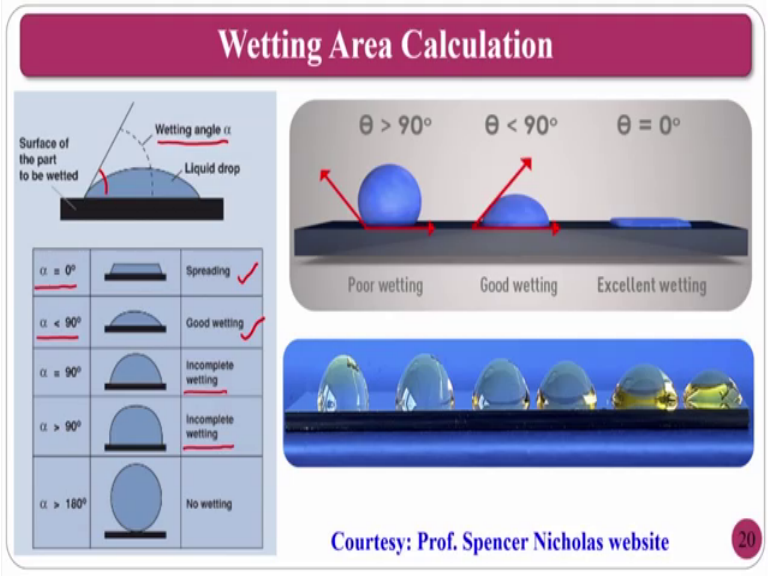


So, in the experimental results, if you see as the people who has done; So, flow rate they have varied like 60 to 80 at the same by keeping the pressure constant then they have varied the pressure 2 to 4 to 6. So, this varied in this way and they have seen the droplet diameter. So, as you increase the pressure basically what will happen you will get the smaller droplet size; obviously.

So, at the same time you can also correlate with respect to the temperatures what is the minimum temperature that you recorded is about 156 degree. Like that what is the effect of the flow rate, what is the effect of the pressure, and all those things with respect to output parameters like surface roughness, output parameters like temperature forces that is called cutting force normal force you can plot the graphs and you can check in the preliminary experimentation hopefully the authors might have done experimental details.

So, you can go through Professor L. Vijayaraghavan papers on grinding with MQL; so, that you can get more details about this particular thing, because I have taken it from his papers.

(Refer Slide Time: 23:21)



Wetting area calculation this is the another important area, where whenever the droplet us are falling in the machining region whether it is occupying the complete area or it is not occupying the complete area that is one of the concern for that purpose you have to play with your particular cutting fluid.

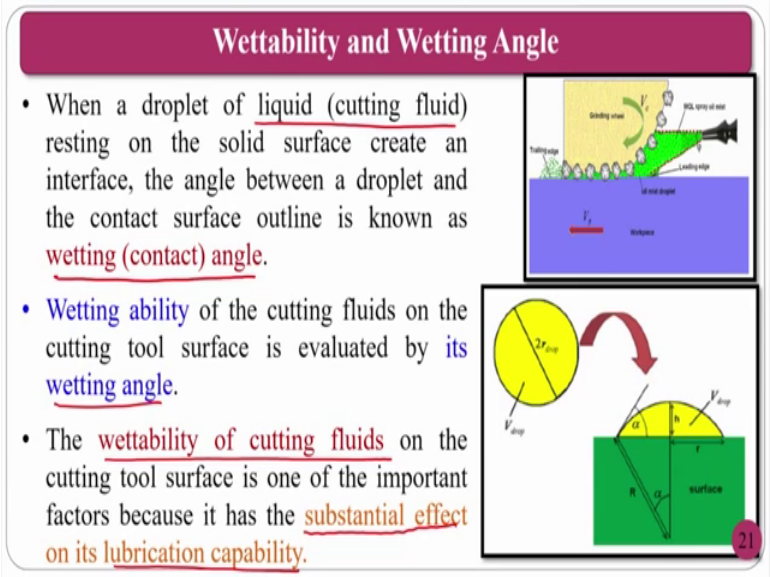
So, what will happen if you are alpha is 0 normally the angle will be here. So, it is completely spreading, if it is alpha is less than ninety that is good wetting; that means, that it is spreading the complete surface, if it is ninety incomplete wetting, if it is again incomplete, if it is more than 90, if it is more than 180, it is no wetting at all ok. So, this is called where alpha is called the wetting angle ok. So, you have to measure you are contact angle; so, that you can say whether my cut particular fluid will have better wetting or not and all those things.

Some of the surfaces are there. So, this is taken the picture last picture is taken from Professor Spencers website this is not exactly for the contact angle measurement also there is a gradient surfaces, but my intention here in this particular slide is to show you how a droplet if I am putting a individual droplet on the surfaces? How the contact angle changes? That is why I have shown here you can see the practically how the contact angle look like, how a liquid if you are putting on a surface look like with respect to the contact angle?

So, if my cutting fluid has a good spreading ability what will happen it will occupy more

of the area of the machining region and it can extract more amount of the heat?

(Refer Slide Time: 25:24)



That we will see here the contact angle if you see the alpha what will happen if you it it occupies this much. So, it can extract more area assume that it occupies this much only what will happen this much extract only this particular area ok. That is why as spreading as possible you have to spread on the surface, if the better spreading is there then the better wetting will be there ok.

So, when a droplet of a liquid of the that is nothing, but the cutting fluid resting on a solid surface create the interface angle between droplet is nothing, but the wetting or the contact angle will and wettability of the cutting fluid on the cutting evaluated by the wetting angle and wettability of the cutting fluid on the cutting tool surfaces one of the important factor, because substantial effect of the lubricating property as well as cooling property also you can show ok.

If it is a better wetting ability and the surface what will happen it can have a better lubricating property, because you will have a boundary lubrication or hydrodynamic lubrication or mixed lubrication depend on the type of lubricant that you are sending at the same time, how pressure you are sending at the same time if it is occupying more and more area the cooling ability in that particular area also increases.

(Refer Slide Time: 26:50)

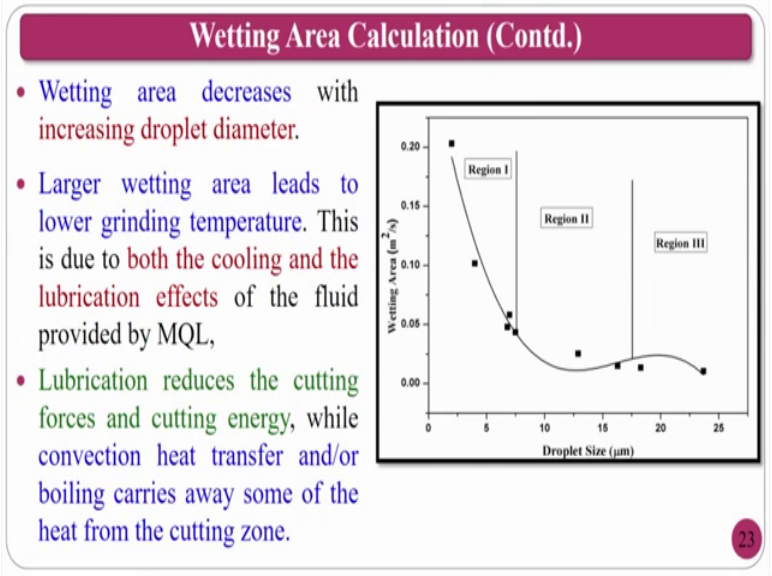
Wetting Area Calculation (Contd.)

Air pressure	Mass Flow rate	Droplet diameter (r_{drop})	Droplet radius	V_{drop}	No of Droplet n_d	Deposited Radius (wetting area)	Wetting Area	% cover
bar	ml/hr	µm	µm	μm^3	$\mu m^3/s$	µm	m^2/s	(%)
2	60	**23.7**	11.85	6972.9	2390178.4	37	**0.0103**	1.68
2	80	**12.9**	6.45	1124.5	19762640	20	**0.0252**	4.11
2	100	**7**	3.50	179.7	154607297	11	**0.0580**	9.47
4	60	**18.3**	9.15	3210.2	5191849.4	29	**0.0133**	2.17
4	80	**7.5**	3.75	220.9	100561167	12	**0.0433**	7.07
4	100	**4**	2.00	33.5	828598485	6	**0.1015**	16.58
6	60	**16.3**	8.15	2268.5	7347042.4	25	**0.0149**	2.44
6	80	**6.8**	3.40	164.7	134923425	11	**0.0478**	7.80
6	**100**	**2**	**1.00**	**4.2**	**6.629E+09**	**3**	**0.2030**	**33.15**

So, wetting area calculations again the same thing 2 4 6 bar they have used and the flow rate also they have used. Here if you see what is the best thing that they have achieved is wetting area is 0.203 meter square per second is the wetting area and it is covering around 33.15 percent; that means, that it is covering one good amount of area compared to the other percentages.

So, in this way if you can cover more area what will happen you can lubricate more area and you can extract heat from the more area ok. At the same time droplet diameter also you can see here, if you are increasing the air pressure it is gradually decreasing, if your droplet size is decreasing and the same time if you see the wetting area it is increasing. So, the more surface area and it is increasing because if your droplet size is less the surface area of this one will increase.

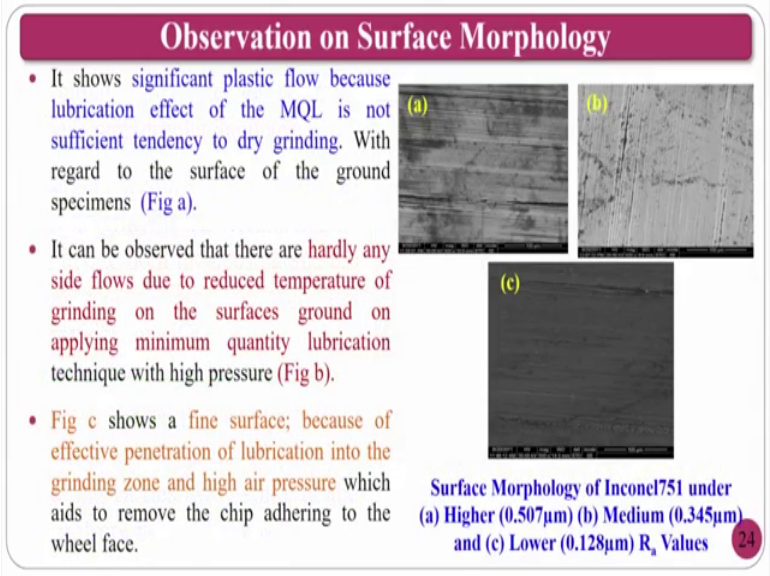
(Refer Slide Time: 27:56)



The same thing is reflecting here the droplet size versus wetting area as the wetting area as the droplet sizing increases what will happen the wetting area is decreasing. So, wetting area decreases with increasing droplet the larger wetting area leads to lower grinding temperature ok. If you can if you can decrease this one particle size or the droplet size you can occupy more area and more area. So, that temperature of that particular area you can take out easily.

So, lubrication reduces with the cutting forces and energy. So, if lubrication also improves with respect to particle size decreasing. So, that or the droplet size decreasing. So, that lubrication also improve the same thing is reflecting from the region 1, region 2, region 3, as the region moves on what will happen the wetting area is decreasing as you increase the droplet size.

(Refer Slide Time: 28:56)



The observations on the surface morphology you see basically everything boils out to be what is the surface roughness that I got, if your particle size decreases what will happen there is no side flow in the first one if you see the surface roughness gives very higher side flow is there.

In the second one if you see the side flow is that there, but surface roughness is very high, in the last one your particle size is very less what is you are going to get you are going to get a better surface and surface morphology and there is no heating at the same time there is no side flow and all those things. For that purpose the better thing you can go for the as minimum as possible the droplet size.

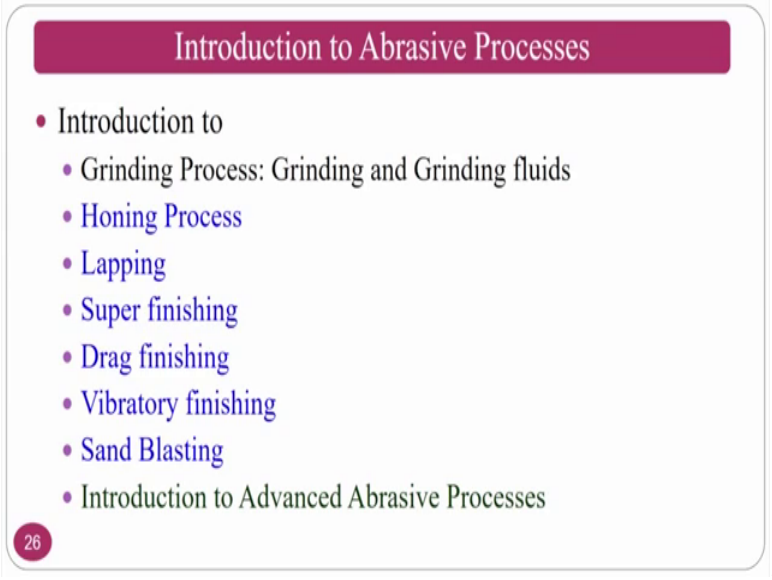
This is about the cutting fluid application in terms of grinding, you can go for the flood cooling you can go for different type of nozzles, whether straight nozzle floating nozzle shoe nozzles and all those things you can go for a solid lubricants, where you can in built in the grinding wheel, at the same time you can go for externally like minimum quantity, lubrication also like solid lubrication.

That you can people those who are interested they I already said you can go through the some of the papers of Professor Rao that is called minimum quantity solid lubricants are lubricants also solid lubricants based grinding and metal cutting.

Another one most important thing is minimum quantity cutting fluid in terms of grinding

also, this is about the grinding fluids and it is applications. Next we move on to the conventional abrasive processes the there are other conventional abrasive processes are there; which we see now is we have till now seen the grinding process, wherein grinding we have seen the grinding fluids we have seen.

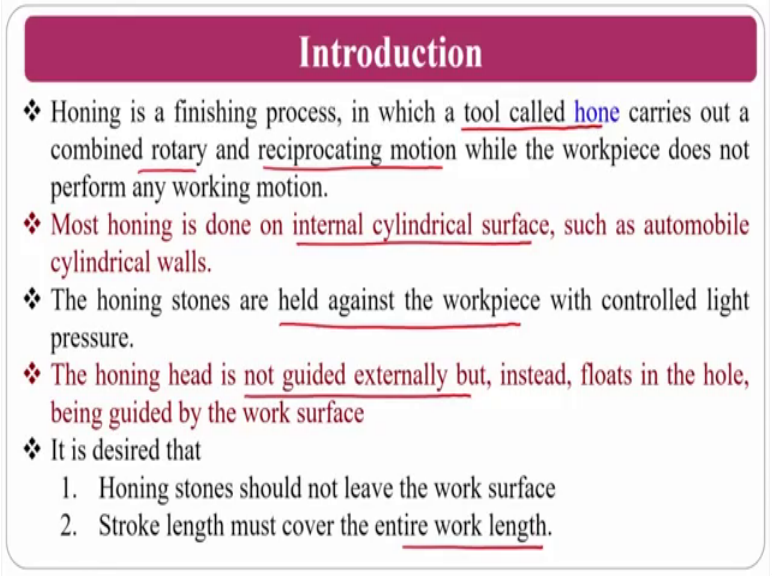
(Refer Slide Time: 30:53)



Now, we move on to the honing process, then followed by lapping, super finishing, drag finishing, vibratory finishing, sand blasting, and if time permits we also see some of the introduction to advanced abrasive finishing processes.

Move on to the honing process honing process is one of the conventional finishing processes exclusively this is used to finish the cylinder liners and cylinders.

(Refer Slide Time: 31:29)

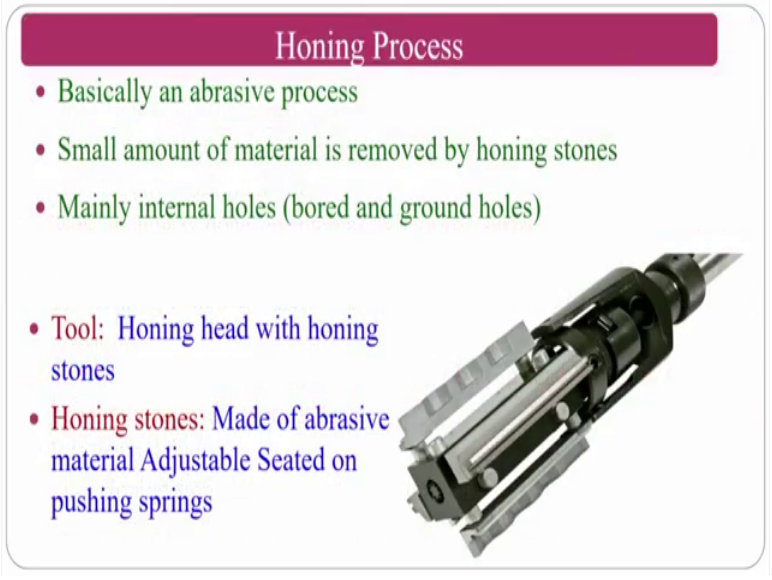


Honing is a finishing process in which tool is called hone ok. The tool which you go in to see in upcoming slides that is called hone it will have a rotary as well as reciprocating motions, while the workpiece does not perform any type of motion workpiece will be stationary and the tool will not only reciprocate it rotates and goes inside and rotates and come inside this helical path it will follow.

So, most honing done in internal cylinder surfaces such as automobile cylindrical walls, mostly the application of this one is in terms of automobiles cylindrical and cylindrical line it is application. Where I will tell you why you have to use this the honing stones are held against the workpiece with controlled light pressure, because these are loaded by the spring load and you can vary the this pressure and you can perform the finishing operation.

The honing head not guided externally, but instead floats are being guided in the workpiece inside itself the honing stones should not leave the work surface and this stroke length must cover the entire work length normally if your cylinder liner is this much big it has to go throughout and it has to come the throughout. So, that it can do the complete workpiece.

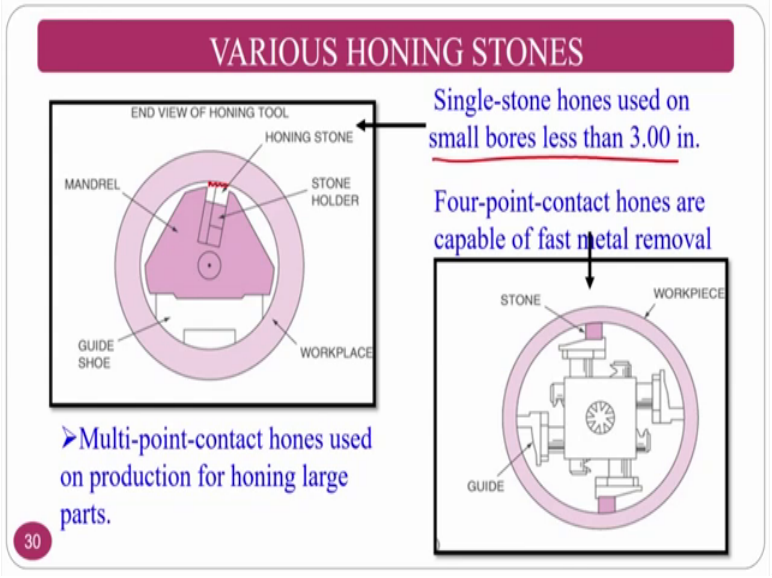
(Refer Slide Time: 32:56)



This is called the hone basically honing processes is an abrasive process.

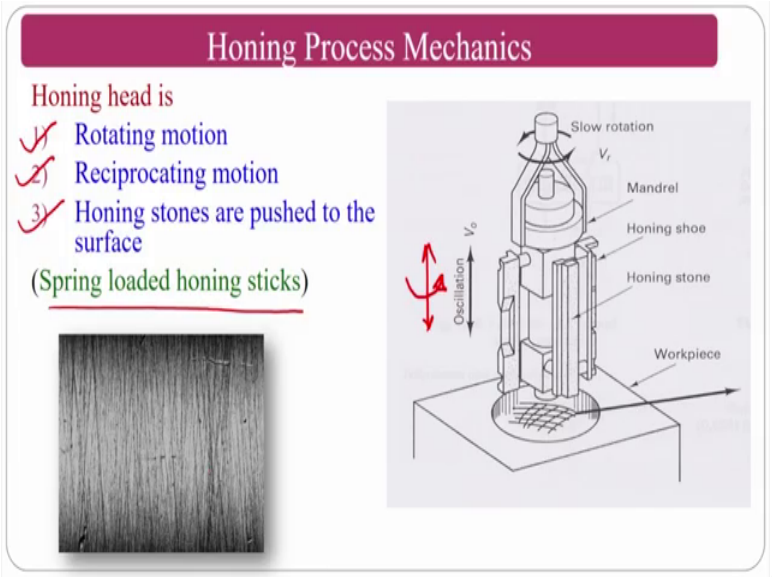
The small amount of material is removed; that means, the specific energy requirements is. So, high like grinding process mainly internal holes are done ok. The tool the honing are done by the honing stones honing head with honing stones that is nothing, but the hone and whatever you are seeing here is a tool honing tool honing stones are made up of abrasive material adjustable pushing springs, basically this hone will have the honing sticks where these are loaded by the spring loads and you can vary the this spring loads on this.

(Refer Slide Time: 33:42)



Various honing stones it is called a single stone with the small bore normally you will have only single stone that is going to finish because it will goes rotates and goes inside reciprocate. So, you can do and the multiple also. So, in whatever you have seen in the previous slide where there are 4 that is called multiple type. So, you can if at all I want to remove more amount of material you have to go for multiple storms.

(Refer Slide Time: 34:11)



The honing head it will have a rotating motion it will have a reciprocating motion honing stones are pushed to the surfaces by the spring loading honing sticks ok. So, that you can

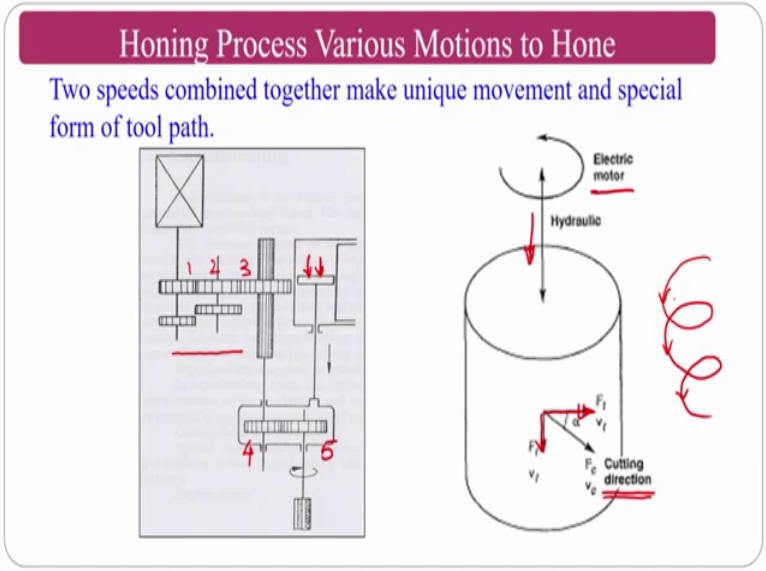
apply whatever the required amount of pressure is required, because if at all I want these are adjustable basically if I want more amount of material to remove you have to adjust according to it if I want very less amount you have to adjust according to that.

So, as I said this is called reciprocating motion will be there as well as rotary motion also will be there, because of which you will form the crosshatch pattern you can see here the crosshatch patterns are clearly visible here. So, this is called the honing process why you required the crosshatch pattern in engine cylinders, whenever if you would have gone to the patrolling stations in olden days what will happen they use to fill the petrol as well as they use to fill the engine oil also that is lubricating oil also.

What will happen, the engine the piston motion will be taking place inside the cylinder what in that circumstances this lubricating oil will come between the piston as well as the cylinder walls and smooth functioning will be taking place; that means, the reciprocation motion of the piston will be smooth for that particular application you will have the crosshatch patterns what will happen it is not only finishing process honing process is not only the finishing process, it is also generate the crosshatch pattern and this lubricant goes and sit in between the surface lay that is lay is nothing, but predominance surface direction.

So, this crosshatch micro grows or the Nano grows are there along with the surface finish this will go and sit there and helps the piston for the smooth functioning, that is why always if you see the these are all these particular honing process is used in the cylinder liners finishing

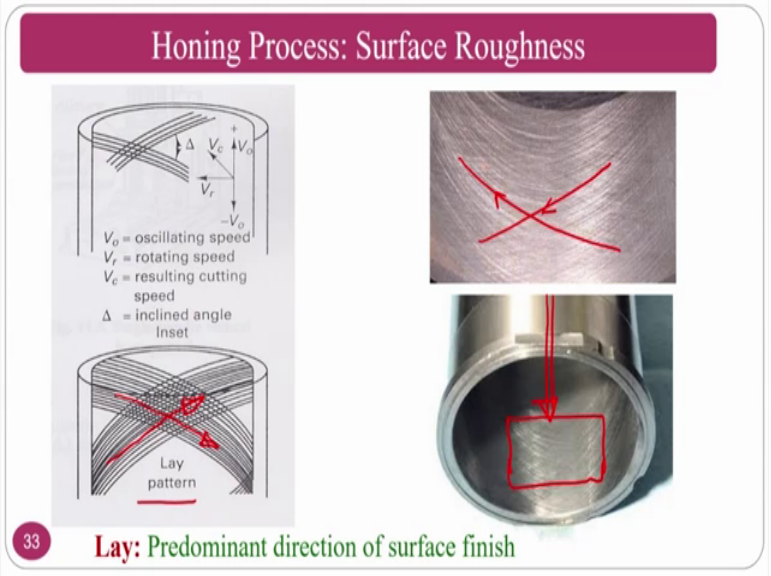
(Refer Slide Time: 36:23)



How you can give or the impart the rotary motion and as well as the reciprocation motion, rotary motion is transferred with respect to gears this gear 1 to gear 2 to gear 3. So, that you can transfer this to the gear 4 and you can transfer to the gear 5, but the same time reciprocation motion you are going to get from this ok. So, indirectly you are going to get the rotary motion as well as reciprocation motion, then if you can synchronise both you will get a helical path.

If you see here F t is the tangential force as well as F r is the radial force and if you can combine normally V c is nothing, but F c is the cutting force electric motors are normally used for the rotary motion as well as hydraulic systems are used for the reciprocation motion. So, that you can get the helical path and at the same time the it will come in a reverse direction also.

(Refer Slide Time: 37:34)

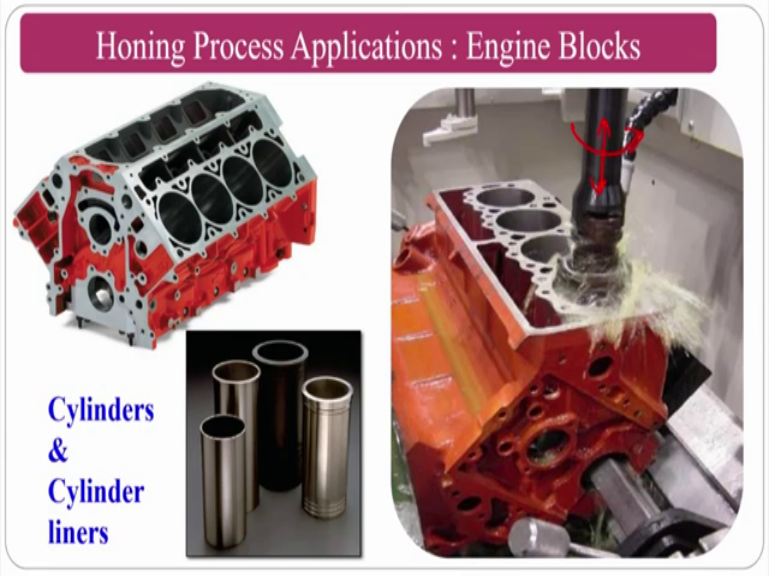


Surface roughness if you see as I said the crosshatch pattern will be generated on the engine cylinders or the cylinder liners, whatever you are seeing here this is the lay that is nothing, but predominance direction of the surface roughness or the surface finish you can see the this is reverse direction and this is going direction.

So, that you can get the crosshatch pattern, why was talking about the lubricant stays in this crosshatch patterns. He as I said this is not only a finishing process it also generate certain pattern and finishing always helps in piston motion in a freeway, at the same time this crosshatch pattern helps to retain the lubricant. So, that proper motion of the piston takes place.

If you can see here this particular area of the liners cylinder liners, this if you see here what will you can clearly see the crosshatch patterns ok. This crosshatch patterns will help the engine cylinder liners.

(Refer Slide Time: 38:54)



Applications as you can see this is the honing process it will go rotates as well as reciprocates in a engine. So, you can do the honing process. As well as I was telling every previously people use to do the engine cylinders itself directly, but it is a costly process because of the piston motion the engines wear out and you have change for that purpose people find the some other solution that is called cylinder liners, what they will do they will do the honing process in the cylinder liners, these are the cylinder liners and this they just go and fit in the cylinders.

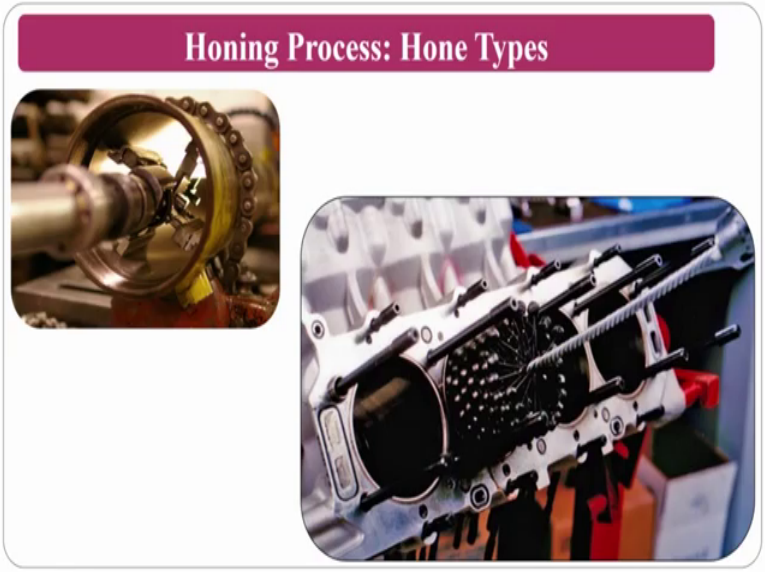
So, if there is a wear out of the cylinder liners just take out the cylinder liner and replace the with a new cylinder liners. This is the advantage and it is a cost effective method also. In this way if you have some time are nearby this companies are there engine cylinder manufacturers are there, please visit the honing process some of the colleges are some of the universities you may not have the facility of honing.

But some many of the institutes will have you can just go nearby big institutes and can visit our, if there is a small industry who manufactured the engine cylinders and all those things you can go and visit that company, for visualising the or for seeing the practical thing and all those things.

For seeing the how the honing process practically works and all those things you can feel and you can also see the surface roughness measurement here, I want to say some other thing also not only surface finish surface lay that is crosshatch pattern, but also you will

require out of roughness that is nothing, but you should have get a perfect circle if you are going to get a abnormal what will happen your piston will the life of the engine goes very bad; that means, that you have to frequently change the your cylinder liners that is why you have to take care about the out of roughness of that particular liner also.

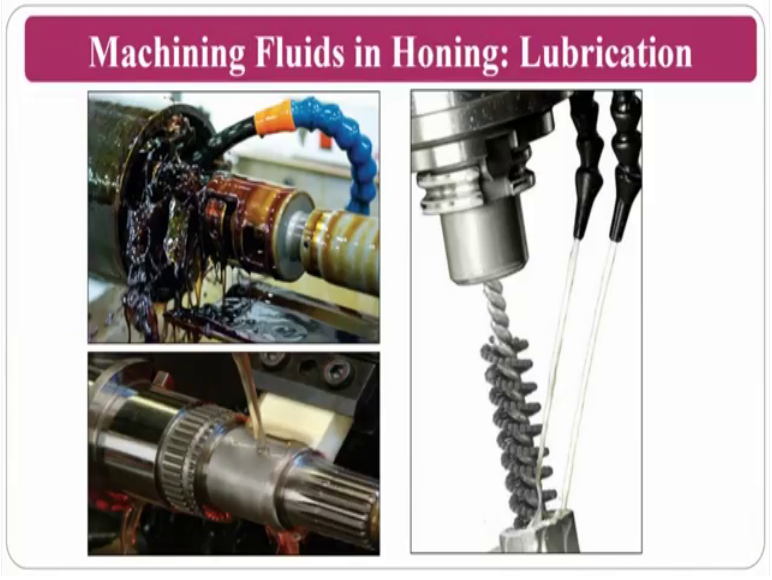
(Refer Slide Time: 41:19)



There are many varieties of hones one is solid type of things if you can see here whatever you have seen in the previous slides and all those things there are the flexible types also there. So, where you have a spherical balls will be there and you can reciprocate it through so, that you can do the honing process also. So, there are varieties of hones are there these are only 4 are there as we you can see like conventional, single point cutting tool grinding is a abrasive millions of multipoint cutting tool.

Similarly, the technology is growing in the honing process also the people are using this type of things and people also use this type of multipoint cutting tools also. So, you can go for whichever is required, and whichever is economic, whichever is causing less pollution, whichever is sustainable you can choose according to your requirement.

(Refer Slide Time: 42:20)

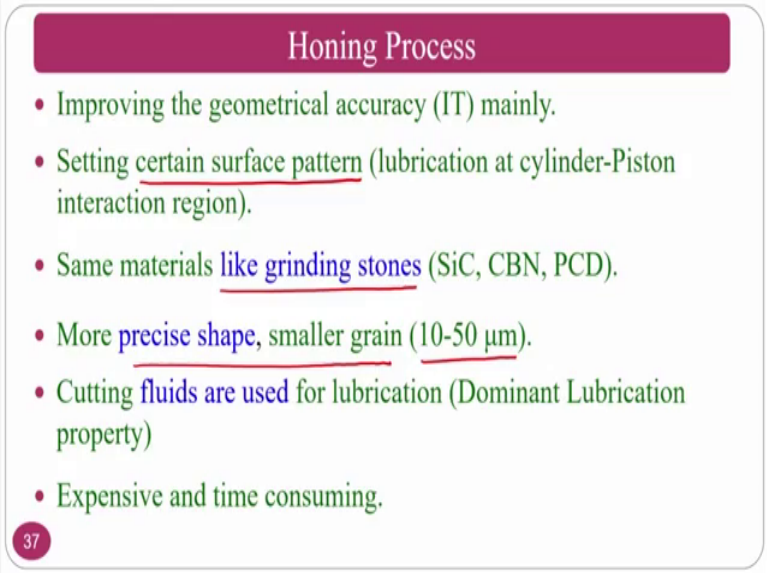


The lubrication are the cutting fluids in honing process mostly the cutting fluids here we will be used is lubricants, as you can see here these are all mostly lubricant type of cutting fluids will be used. So, water base cutting fluids are not used if at all used very less amount of water base, because a cooling is not a criteria here the lubrication is the major thing that the people want here.

That is why always if you see the lubricant based cutting fluids are there; that means, friction is the main culprit here to reduce the friction to reduce the heat generation in the honing process, this particular lubricant type of cutting fluid will be used and it is a dominating one not the coolant type of; that means, if you see the table where the lubricant and coolant is there people are going to use mostly mineral oil based cutting fluids, people who want to work on this one there are very less papers on sustainable cutting fluids for honing applications.

So, if you have expertise on sustainable green cutting fluid development, you can also check those cutting fluids for the honing process also that is can be a good area to take up as your masters are PHD thesis this is about the honing process.

(Refer Slide Time: 43:55)



The advantages of this particular process is it improves the geometrical accuracy and setting certain surface pattern that mean that to crosshatch pattern, it can generate at the same time this will help in terms of lubrication at the cylinder piston interaction region.

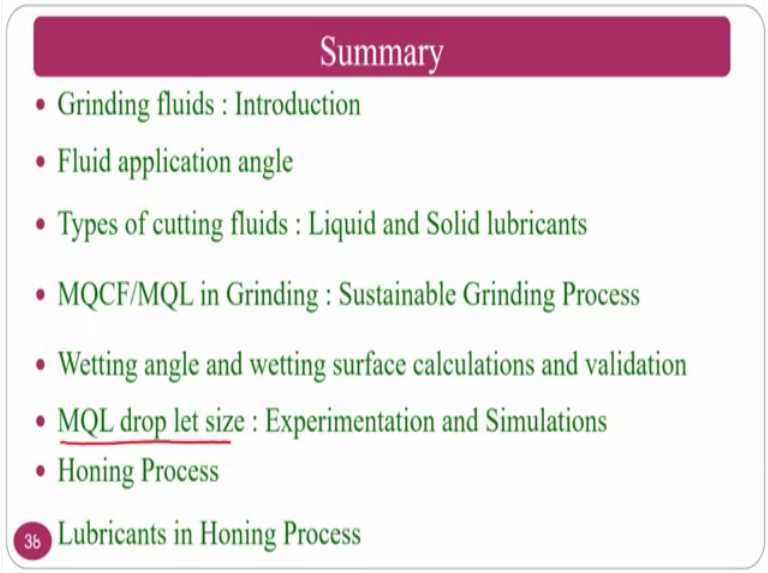
Same materials like grinding stones you can use that is nothing, but a silicon carbide CBN or polycrystalline diamond you can use similar type of grinding particles on the hones, that is called honing sticks. More precise shape smaller grain you can use so, you what are the difference here is you can go for precise shapes at the same time more finer because you need to get the fine surfaces at the same time fine crosshatch patterns.

That is why normally the people goes for fine size of abrasive particle size you might have seen the abrasive size in the grinding wheel specification. So, coarse medium and fine is there. So, people will go medium to fine rather than coarse if you go for coarse the surface roughness wills very high the piston cannot move as per the requirement. So, the piston will fail the complete automobile will fail for that purpose you have to go for the finer or a smaller grains or abrasive particles.

Cutting fluids are used for the lubrication that is nothing, but dominating the lubricating characteristics not the cooling characteristics ok, you have to choose lubricant not the coolant if at all you want to go for very high speeds of reciprocation as well as rotation in that circumstances, you can go for very minimal amount of water addition to heat if at all required, but normally it is not recommended.

Expensive and time-consuming because this process takes lot of time this is the disadvantage of this particular process because the material removal rate is too less, because you have a fine particles and the low spring relaxation will depend on your requirement with the abrasive particles will remove very very minuet chips; that means, that time for finishing will be very high.

(Refer Slide Time: 46:31)



Summary of today's class we have seen the grinding fluids after the grinding process and fluid application angles whether conventional fluid, you can use whether it can be used to tangentially 15 degrees or 30 degrees or what is the stand-off distance how far you have to keep and all those things we have seen.

The type of cutting fluids whether people have use liquid type of cutting fluid solid lubricants also people used MQCF that is called sustainable grinding process is one of the concept nowadays people are working. So, people you can also work especially those people who want to do research they can go for MQCF in the grinding operation for machining of advanced materials like aerospace alloys or biomaterials or something.

Wetting angle and wetting surface calculations as well as software developed particle sizes that is droplet size validation and all those things we have been that is in the MQL what is the droplet size experimentally people have validated using Malvern experiment at the same time they have also validated using the software's by simulating it, and the honing process we have seen and the lubricants that are used in the honing process also

we have seen. So, honing process keep in mind that it is lubricant type of cutting fluids you have to use not the cooling type of cutting fluids.

So, thank you for today's class and we will see some of the other conventional finishing processes in the next class.