Non-traditional abrasive machining process: Ultrasonic, Abrasive jet and abrasive water jet machining

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Lecture - 13
AJM - Numerical and Machine Configuration

Welcome viewers to the 13th lecture of the course Non-traditional Machining Methods with the help of abrasives and today we are going to take up some of the numerical problems in a basic jet machining, we have already done a number of problems in that field. And we will also discuss some aspects of the machine configuration the different you know modules in the machine which are essential for the abrasive particle what we call is the abrasive jet and if possible some MCQs as well.

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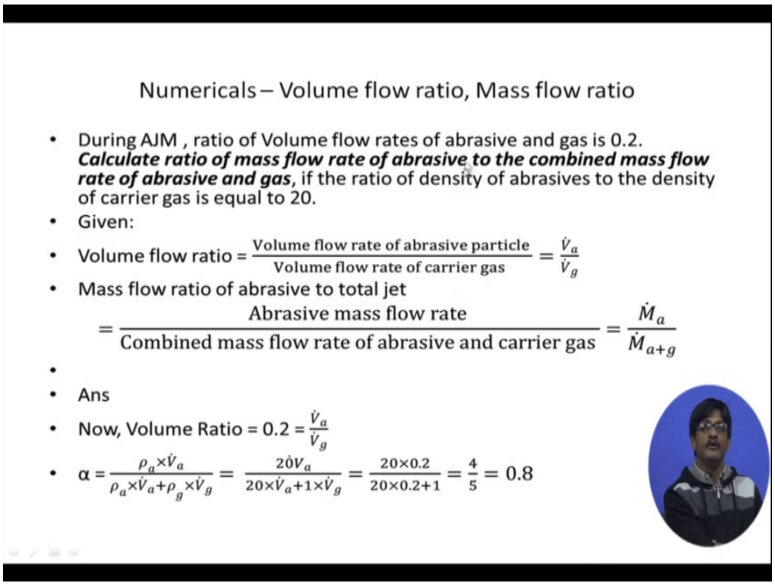

This is on volume flow ratio and mass flow ratio viewers, please remember we are talking about volume flow ratios and mass flow ratios during AJM ratio of volume flow rates of abrasives and gas is 0.2; that means, volume flow rate of abrasive particle divided by volume flow rate of carrier gas is equal to 0.2. Now calculate ratio of mass flow rate of abrasives to the combined mass flow rate of abrasive and gas. If the ratio of density of abrasives to the density of carrier gas is equal to 20 this seems to be quite simple only we have to be alert that we do not make any wrong assumption. So, given volume flow ratio been given to the 0.2 and we have formally defined it volume flow rate of abrasive particle divided by volume flow rate of carrier gas.

Next, so that is V dot a by V dot g. Now mass flow rate of abrasive to total jet mass flow rate is equal to abrasive mass flow rate which is M dot a like combined mass flow rate of abrasive and carrier gas which is M dot a plus g let us say. So, if the volume flow rate is 0.2 alpha which is mass flow ratio it is equal to rho g into sorry row e into V dot a divided by rho in a into V dot a plus rho g into V dot g equal to we are dividing through, we are dividing through by or rather we are putting in the values of the density ratio.

What is density ratio? Density ratio means abrasives are much more dense than the carrier gas and therefore, density of abrasive by density of carrier gas is 20. So, let us divide the whole equation here by density of carrier gas. So, we will have here in the numerator we will have rho a divided by rho g and here also we will have rho a divided by rho g and therefore, here we will have here 1 into V dot g.

So, rho a by rho g value we put in as 20 and therefore, that is why we have 20 into V dot a plus 20 into V dot a plus 1 into V dot g and therefore, this becomes 20 into 0.2 which is 4 and 20 into 0.2 plus 1 which is 5 and therefore, this mass flow ratio is 0.8 mass flow ratio is 0.8. Therefore, we have found out effectively the mass flow rate ratio which is defined as abrasive flow rate divided by combined mass flow rate of aggressive and carrier gas.

Let us move on to the next one.

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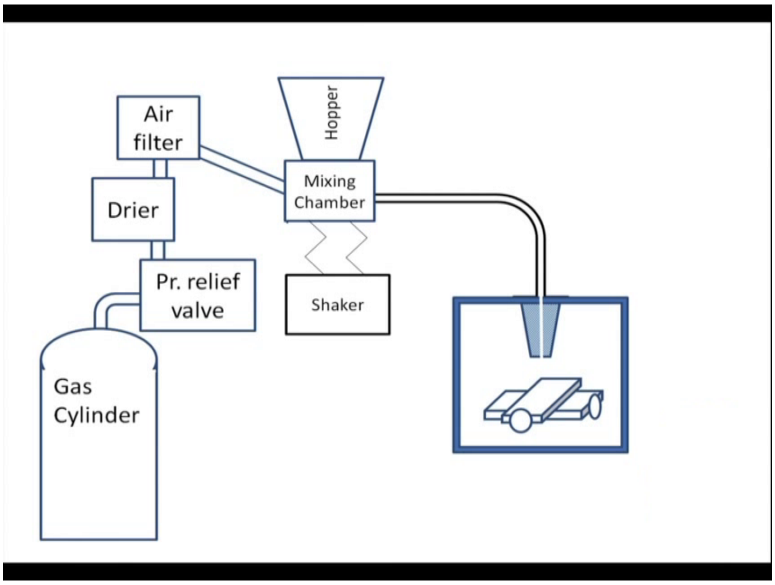

So, now after all those numerical values we have now a good understanding of what is going on you know at a mathematical level, but up till now we have not seen the different parts of the AJM setup. This is the AJM machine setup, and let us have a quick look at the essential equipment which has to be provided.

So, first of all is a gas cylinder, from this gas cylinders we are going to have a supply of gas at high pressure and the pressure relief valve will ensure that you are going to get whatever pressure you set the machine to. Do we always have to work with a gas cylinder? No, we can have a compressor and however, whether it is a gas cylinder or whether it is a compressor we have to make sure that this particular air is first of all completely free of any moisture and it is completely free of dust particles.

Why is moisture going to create a problem? This is because if even if there is a trace of water vapour present in the gas once it is present it can ultimately you know give rise to agglomeration and clogging. Agglomeration means that if there are abrasive particles of size to the tune of 10 microns to 50 microns. They will have a tendency to agglomerate; that means come in contact with each other and get stuck with each other and at the micro level it is extremely hard to separate them from each other.

But what is the problem if they are agglomerated? The problem is that this particular nozzle diameter that we notice here it is from 0.2 to 0.8 microns. Why they are very small in diameter? That is because if the diameter is small the jet of abrasives which will be you know emanating from the nozzle that will have a jet diameter limited to say 0.3 to 0.9 millimetres and therefore, it itself will be able to give rise to a very narrow cut or group or diameter of drills like that. So, we cannot have a large diameter large outlet diameter of the nozzle and therefore, we cannot have you know agglomeration of the abrasive particles which are 10 to 15 millimetres sorry 10 to 15 microns in diameter. Moreover when the air is entering the mixing chamber it might be entering with a still small diameter, but that is a different story altogether because at that time it is not mixed up with abrasives.

So, first of all there is a drying chamber through which the air has to pass, air or nitrogen etcetera we will discuss that later on whatever is the carrier gas tight when it has to pass in that case I mean if it has to go to the mixing chamber first of all it is dried, so that the water vapour is removed and it is filtered. So, that dust dark etcetera all these things ducks in dirt will be first remove from the air the air is still at very high pressures and it enters the chamber called mixing chamber what is this mixing chamber for, the mixing chamber is the particular place where abrasives are going to be injected into the air line.

Now, what is so special about that? The speciality is this that air being still at a very high pressure after this point if we introduce abrasives into it, the high pressure air will you know not allow the abrasives to enter it is like you know if you try to put in the abrasives to a particular say you make a hole and you are pouring the abrasives just like pouring from a say bottle and immediately you find that the mixing chamber will push them out we push them out and maybe to go to your face if you are nearby you are very careful. So, we have to have a method by which the abrasive particles and we made to enter inside the mixing chamber.

How can that be done? That can be done by the principle of the jet form where the air is made to enter this chamber with a very small diameter, the exit diameter here is a very small diameter and the air comes in it fills up this particular mixing chamber and then it goes out to be finally, you know finally, get emitted to the open atmosphere. So, here there you have atmospheric pressure. So, it will have a particular the output velocity.

Here what happens is as the air is coming out through a very small diameter and expanding here the pressure energy gets converted to kinetic energy, so it develops a definite velocity of very high velocity here the velocity with which the abrasives come out which it will be a liquid low, little you know lower because this velocity is coming out defined by sorry as defined by this particular diameter. And also this velocity to continuity conditions this velocity if this diameter slightly higher it has to be give me 0.2 and 0.8 and therefore, you will have a negative pressure being created here which will suck in the abrasives through this hopper. The abrasive gets entrained into the air because here there is a very small diameter entry and there is a slightly higher diameter here so that vacuum pressure is created. So, these abrasives gets entrained and they travel together get accelerated to the velocity of the final jet and reduce needed at this particular place.

So, there are other ways of putting the abrasives into the chamber for example, you can have a back pressure line; that means, from the cylinder itself you can have a line of air I mean a pipe of air feeding in at the back side of the hopper with a higher pressure than this one so that it will drive the air inside. So and there is also a shaker which vibrates the mixing chamber, so that the mixing of the abrasives and the air it is made easier after that the air and abrasive mixture they go down the line and ultimately get emitted at the exit of the nozzle.

So, let us have a quick look at the different aspects of this particular machine.

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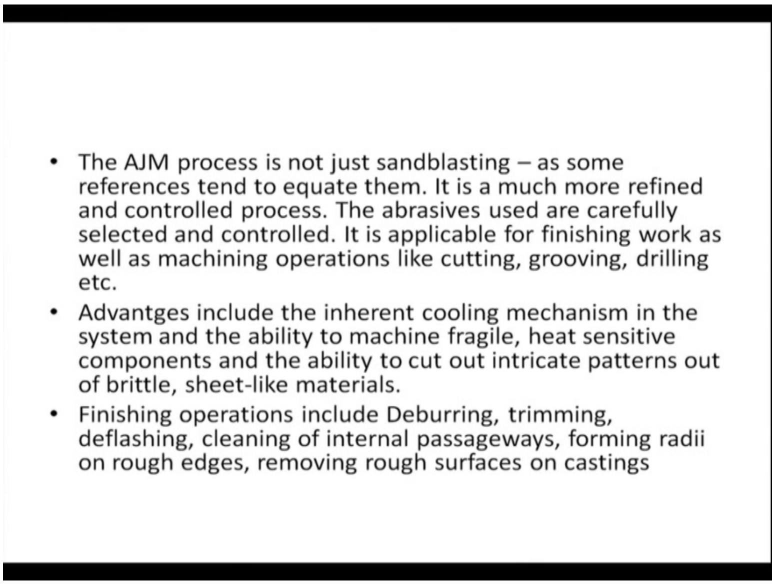

So, sometimes what happens is aging is you literally equated to sand blasting, but sandblasting and AJM they are not the same sandblasting rather AJM is much more refined and in. So, much more control process the abrasives which are used at carefully selected and controlled and is applicable main, and not really applicable to finishing work as well as missing machining operations like cutting, grooving, drilling etcetera with sandblasting we cannot do cutting moving etcetera.

And advantages which are you know which can be mentioned they are the first is advantages can be mentioned as say inherent cooling mechanism in the system. The air jet which is coming out which it has automatic in the cooling mechanism incorporated in the particular process and it is also able to machine fragile heat sensitive components and cut out intricate patterns and on brittle sheet light materials which is not possible by other beings. So, these advantages make it possible for us to use AJM in special applications and sandblasting is you know absolutely not comparable with this particular process in these respects.

Further, finishing operations like and so these are machining operations and it can also do finishing operations like differing, trimming, deflashing, cleaning of internal passageways, forming on rough edges and removing rough surfaces and castings etcetera definitely list and study the advantages at a later stage.

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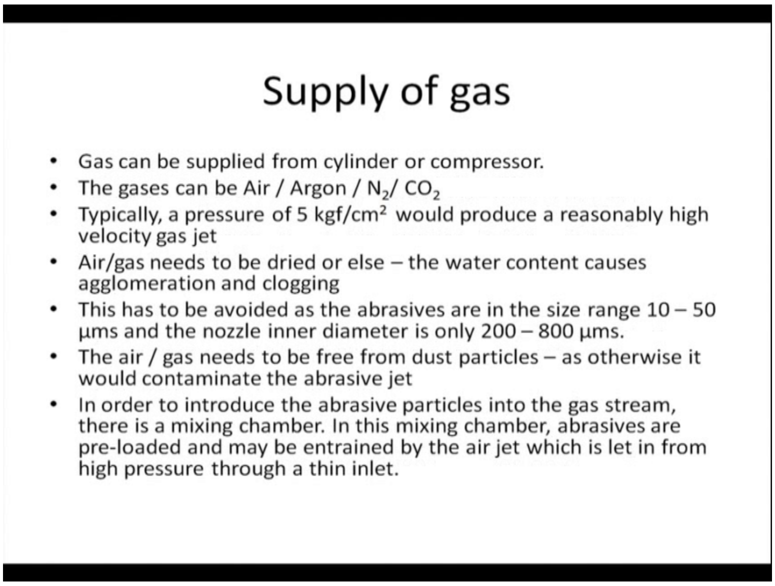

So, supply of gas, so gas can be supplied from cylinder or you know com compressors and the gases can be air, argon, nitrogen, carbon dioxide, but not generally oxygen because oxygen may create a condition of you know sort of burning and fire hazard and other things can occur. And what be the pressure like? The pressure can be no typically 5 kgf centimetre square is good enough a pressure for creating reasonably high velocity of gas jet.

And as we have discussed the air or gas needs to be dried or else the water content causes agglomeration and clogging. And agglomeration and clogging we have already discussed, we already know about that. The gas needs to be free of dust particles as you know to reduce contamination and in order to introduce abrasive particles into the gas stream we have already discussed this point also.

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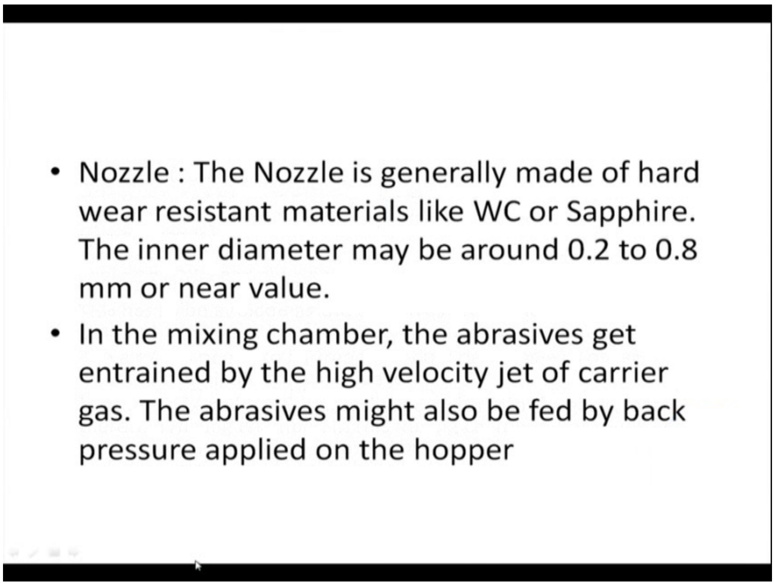

The nozzle, the nozzle is one of the most important parts of the equipment and the nozzle is generally made of very hard very instant materials like tungsten carbide or sapphire. Why so? Because all the abrasive particles are getting you know they are flowing down the internal passage inside the nozzle and unless these are highly very instant they will ultimately be of no use after say a few hours of service say 10 to 20 hours of service for tungsten carbide and somewhat more hours of service for sapphires and about the mixing chamber we have already discussed it.

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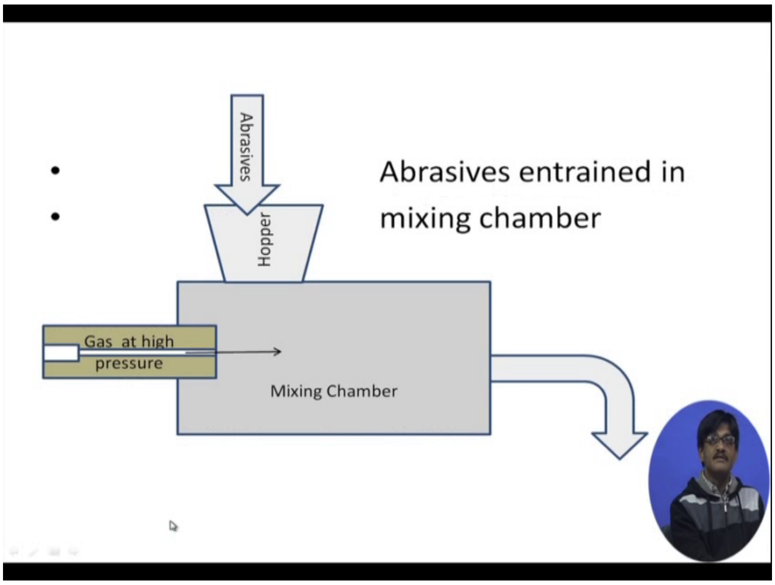

This is the figure of the mixing chamber, gas is coming in at high pressure and inside the mixing chamber abrasives are coming through the hopper and they are getting entrained here. At the end of the hopper there might be are you know a sieve a sieve through which the abrasives can pass and this whole thing might be mounted on a vibrating chamber so that the abrasive feeding becomes easier.

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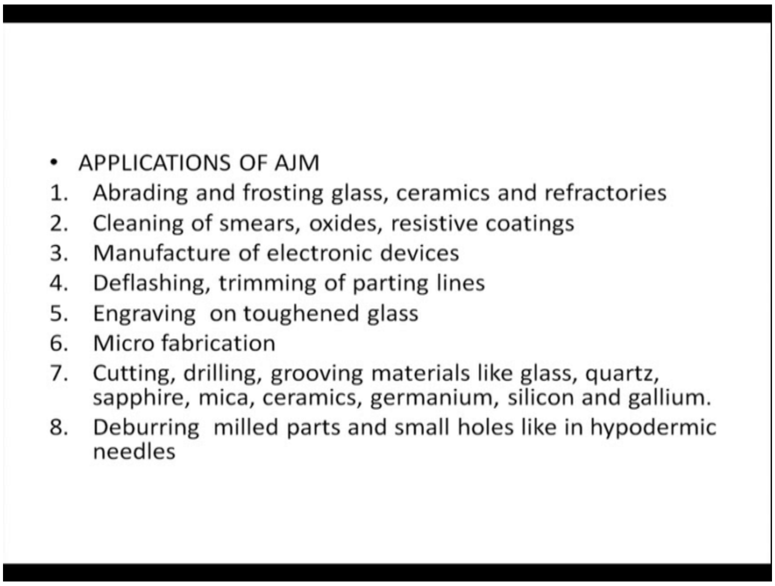

Let us discuss some of the applications of AJM you know we can have not only cutting, drilling and grooving and other things, but we can also have you know use abrasion or the abrading action of abrasives to create frosted glass appearance. So, if we are having say a glass one in which we need of frosted glass appearance apart from other methods which might be existing, abrasive jet machining is definitely capable of doing it. You can also produce a matte finish by using special kind of abrasive particles like aluminium oxide, (Refer Time: 19:15) dolomite they can give matte finish frosted glass appearance etcetera. So, this can be done on glasses, ceramics, refractories etcetera.

Then it can be used for clearing purpose also cleaning of say metallic smears on ceramics etcetera then oxides, oxide layers can be cleaned out and resistive coatings which have been put they have to be removed they can also be done by abrasive jet machine The manufacture of electronic devices, deflashing and trimming of parting lines you know whenever there is a injection moulding or you know casting etcetera. Deflashing, the flash of material which comes out that can be removed by AJM and parting lines can also be you know trimmed from castings and moulds I mean injection moulded material.

And engraving can be done on toughened glass, micro fabrication can be done and then we have a list of materials on which the regular you know machining operations can be done like cutting, drilling, grooving what are these glass quartz sapphire mica all of these are essentially you know either hard and where what you call hard and brittle materials then valence in materials and they might be you know glasses ceramics then semiconductors. So you have mica sapphire, ceramic, germanium that is; that means, semi conductors, silicon, gallium etcetera.

We can also carry out the deburring of milled parts that is after we have done milling or if we have made small holes etcetera, they might be having some materials sticking to their surfaces which is called the which has to be removed very carefully and two of these processes can be deburring first of all and also putting the abrasive jet into inaccessible places like inside small holes or inside you know some pipes internal passageways etcetera small holes in hyper hypodermic needles etcetera where cleaning and deburring can be performed which is not possible by other prophecies.

So, this means we come to the end of the discussion in the 13th lecture in the next lectures we will take the remaining aspects of abrasive jet machine and move over to abrasive water jet machining. But before that we will also have a session on you know multiple choice questions which are ultimately the forms of questions that you have to answer.

Thank you.