Sustainability Through Green Manufacturing System: An Applied Approach

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Lecture – 20
Green Manufacturing Techniques

Good morning welcome back to sustainable manufacturing course where in we are trying to learn how to get a sustainable system using certain techniques that is green techniques starting from very (Refer Time: 00:27) process to final manufacturing concern.

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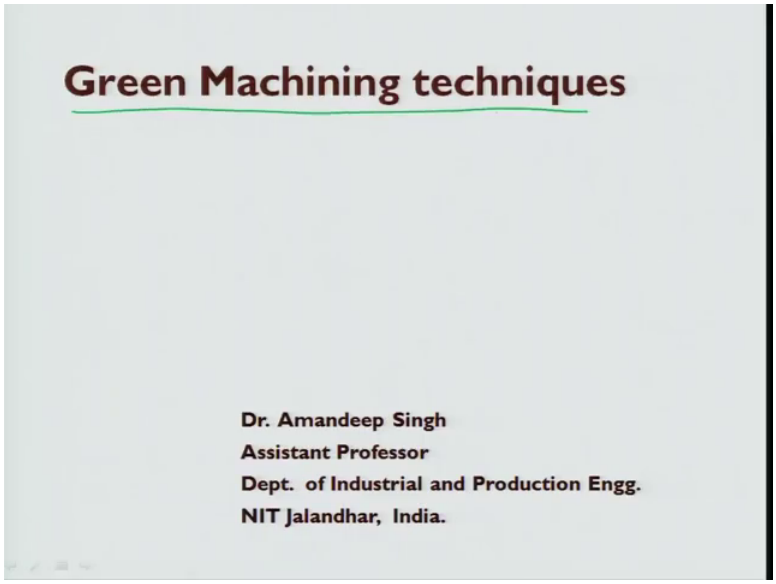

So, in this lecture I will discuss Green Machining Techniques.

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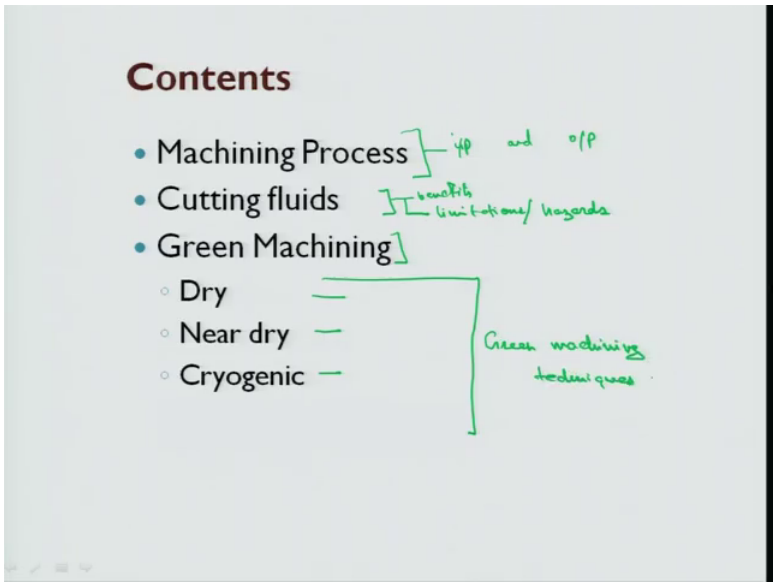

And the contents are first we will see what is the machining process and what are inputs and outputs of a machining process, and will see what are cutting fluids and what are various characteristics of this cutting fluids benefits and limitations or hazards. Then will discuss a few machining techniques which are termed as green techniques.

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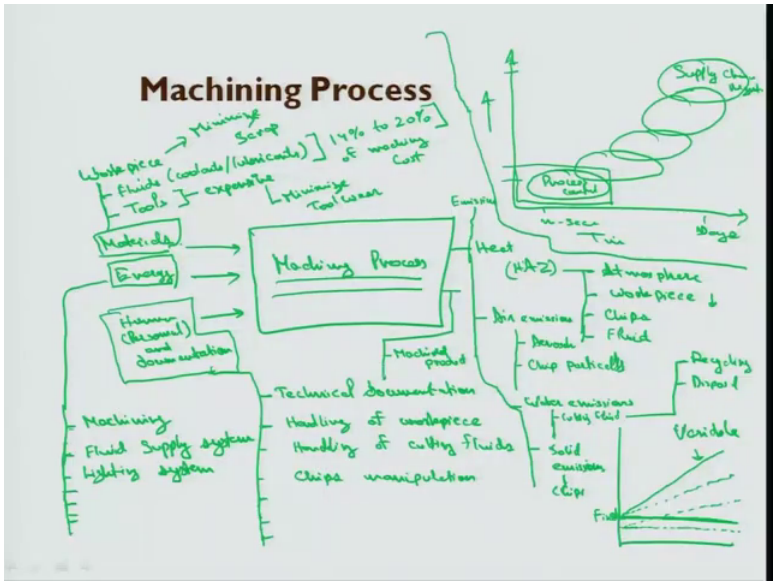

Now, I will start with the machining process. What is a machining process? If you could remember we had that temporal aspects of a system in which we have the very process control to the whole system level, control here and we see that here we had the time from

milliseconds today's and we saw that here we had the process control. And we have certain other things and here we had the supply chain management. Now, there we will talk about this thing process control only.

So, in machining process, machining process is a process which has materials energy and human or personnel or the operator that works on it that has do the machining, has its inputs. Here in the material may be my work piece then fluids, that is coolant and lubricants, coolants or lubricants and tools. So, what is this? In this case the tools are expensive and the cost of the cutting fluid also varies from 14 percent to 20 percent of the machining cost. Regarding tools we need to minimize tool wear and regarding work piece we need to minimize scrap that is a chip sets are produced. So, this is our purpose. So, this was my material.

Next is energy now energy is consumed in machining, in machining itself and other components other systems in my machine tool that is fluid supply system then lighting system and similar systems also consume energy. So, here what we are more concerned about is the variable energy the energy is like this in machining that there is some fixed amount of energy that are cooling, in incase of flood machining the coolant system has to keep on (Refer Time: 05:30) these are fixed energy. So, there this machining is my variable energy. So, our purpose is to reduce this machining energy is variable energy to minimum. And even this energy in some system we can omit, this energy can be brought to the lower side. So, the total energy would be like this.

So, in case of human and also I would say human and documentation here. So, what do we have here is technical documentation then human has to handle or work piece he has to handle the cutting fluid then may be chips manipulation and certain jobs like this. If our machining is very conventional machine in case of automated machining for example, in CNC machining certain things are automated. So, in case of CNC machining or certain automated machining the worker involvement is less. So, in that case the cutting fluid etcetera, all are controlled by an automated system even the machining is done by that the worker do does not have to control the flow or the speed of that tool. So, the most of the machines which we have used in our lab demonstration are automated machines only. So, this machining process has these inputs, these major inputs are materials, energy and human resource. So, these are further classified have further detailed a bit.

Now, we have outputs, these outputs are heat. I start from the environmental outputs here only. The heat goes to atmosphere, work piece, chips, coolant this is actually we have heat affected zone where this heat is dissipated to atmosphere then it goes to the work piece as well that may deteriorate the quality of my work piece may be surface finish and chips also carries away some heat and most of the heat is carried away by cutting fluids which is one of the fundamental purpose of using cutting fluids.

So, next with heat we have certain other emission these actually comes under emissions, if I say emissions. So, one is heat second is air emissions. Air emissions are the aerosols if produced the chip particles that are too small that goes into air and we have other emissions that is water emissions. Water emission that is my cutting fluids goes away here it goes for here either for recycling or for disposal.

Then chips are a kind of solid emissions solid emissions are chips, then I directly came down to the environmental outputs here. The major outputs here would be my machined, machined or processed material or I would say I could even say product of this process only then we have scrap. So, these are our major outputs. So, next before discussing the green techniques I will have to put some lights on cutting fluids.

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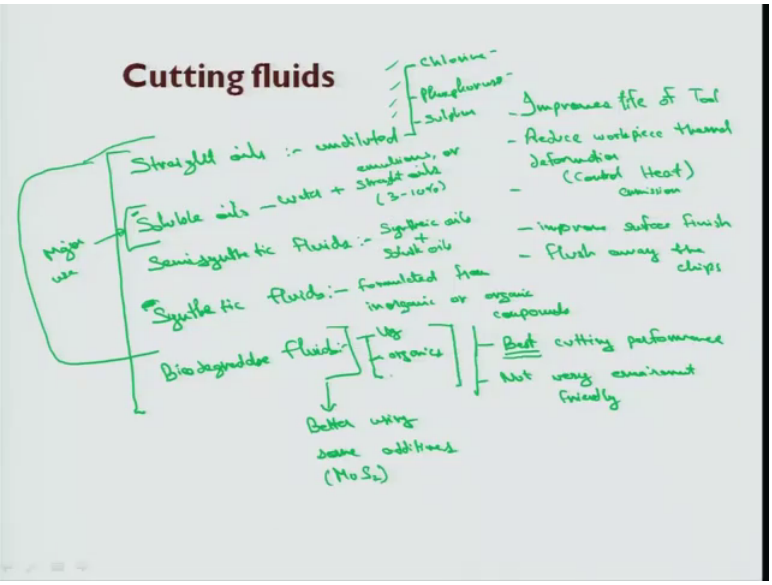

So, what are cutting fluids? Cutting fluids are used in metal machining for a variety of reasons such as cutting fluids improves life, improves life of tool then reduce work piece thermal deformation reduce work piece thermal deformation. That is it controls the heat

emission and on the top of it, it also improves surface finish and flush with chips and flush away the chips.

So, the major kinds of cutting fluids are straight oils, soluble oils, semi synthetic and synthetic fluids and synthetic fluids. These are very general kind of cutting fluids those who are available in the market since the machining process started. So, these days also we have bio degradable fluids. Now straight oils are non emulsifiable and used in machining operations in an undiluted form. So, these are undiluted.

They are composed of a based mineral or petroleum oil and often contains polar lubricants such as fats vegetables oils and jesters and the major additives here are chlorine, phosphorus, phosphorus and sulphur. So, these are the elements those are not very environmental friendly this phosphor and sulphurus here, sulphur here.

So, the next kind of cutting fluid are soluble oils. So, soluble oils is its name itself suggest that they are soluble that they are used in a little diluted form. So, this soluble oils is an emulsion of water and straight oil this is water plus straight oils may be now these emulsions are made from alkaline inorganic or organic compounds along with certain additives that are used to reduce corrosion. So, these are generally diluted in 3 to 10 percent in the water. So, they are widely used in industry and are least expensive among all cutting fluid. So, these are the major cutting fluids those are used in industries major used right.

Next, we have synthetic cutting fluids synthetic fluids does not contain any petroleum or mineral oil, but they are formulated from in organic or organic compounds formulated from inorganic or organic compounds and their cutting performance is best among all we mentioned. However they are not very environment. Friendly here by best I say if I compare the four these kinds of the fluids its performance even if we do not use any modern kind of a details this performance may be said as best, but these days we have nano fluids or nano additives that can be added that even can produce better performance using biodegradable fuse as well; better using some additives one of the additive here one example here be molybdenum disulfide.

So, semi synthetic oils are essentially the mix of the synthetic and soluble oils. So, these are synthetic oils plus soluble oils. I would add here the soluble oils here may be water plus it is the straight oils or may be water plus emulsions also. So, the emulsions also be

used here emulsions or straight oils right. So, next we came to the bio degradable fluids here, so these are actually vegetable or some organic fluids those are degradable those do not affect our environment. So, we will put some more light on this later.

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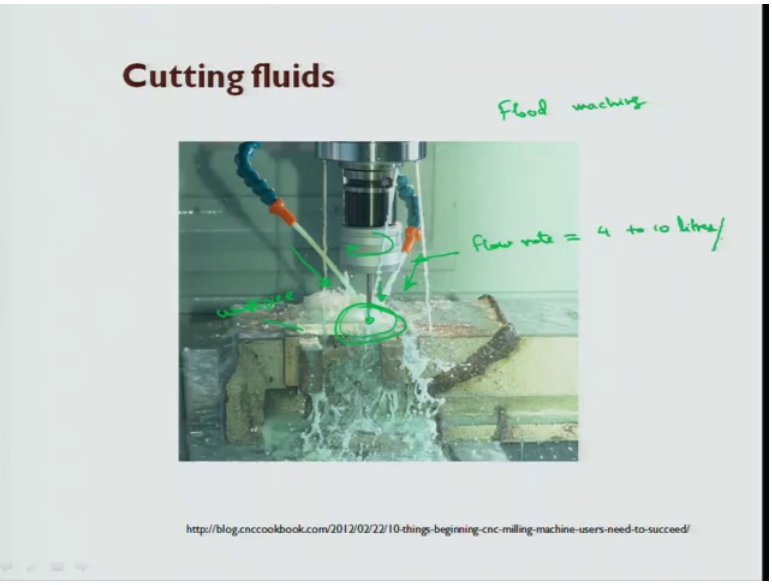

So, this is a general flood machining. In flood machining the fluid jets are flooded on the machining area, so this drilling is happening here. So, this drill is going in and this one is rotating it is trying to make a hole over here in the work piece this is my work piece here. So, these jets are put on the work piece the work piece here at the tool work area to flush away the chips to dissipate heat at they perform its other functions. So, in this case the fluid flow rate is from 4 to may be 10 liters per minute. So, you can see that two jets are heavily flooding this work piece. So, this is taken from a reference.

So, now these cutting fluids are to be selected using some criteria. So, the fluid selection criteria may be its performance its heat transfer performance, I would say cutting fluid selection criteria.

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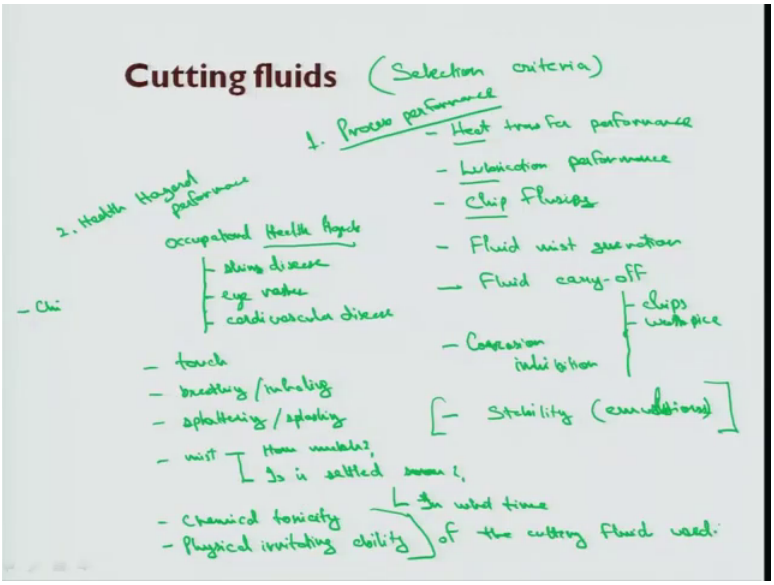

Then we have lubrication performance then chip flushing. So, what I am trying to say is that in case of chip flushing is when we do some fine machining the size of chip that you produced is very small. So, in that case a very small jet or very slow speed jet can also work. But when the chip size is very large even when that is when the depth of cut is high and that the core chips are produced or when the metal that is being used has some properties that the chip is trying to stuck to the work piece. So, in that case this cutting fluids also helps in flushing away the chips this is one thing, dissipating of heat is the other thing, lubrication is another thing. So, there are certain other criteria here.

For example, if you use mql then fluid mixed generation note even in mql the fluid when there is flushed away, flushed on the work piece some mist is produced that is how much mist is produced in the atmosphere that is also one of the criteria. The mist generation property of the fluid that how much mist is generated, what is the viscosities one of the factor would play a key role here.

Now, another criteria here may be fluid carry off in chips, fluid carry off by chips may be by work piece if lubrication is there, some fluid is even carried off by this one only then another criteria here is how much corrosion is inhibited by this one and in some cases this stability of the fluid that is my emulsion stable or no. In case of emulsions this is my mixture that I had made it with water thus that remain homogenous or does it separate after some time and after how much days does it get separated.

In general the cutting fluids those are filled in to the reservoir are disposed of in a week time in general, but in some cases of machining may be in a day may be multiple times in a day the fluid reservoir may be refilled with a new fluid with a with a fresh fluid here. So, this stability of emulsion is important here as well.

Next, this kind of performance were just be process performance. So, this criteria is the process performance criteria I would put it number 1. Now, number 2 is my health hazard, health hazard performance I would say. So, there are certain occupational health hazards associated with cutting fluids, occupational health hazard for example, skin diseases, eye rashes, may be some cardio vascular disease. So, these mechanisms are based on the external or internal contact involved in machining work that is does are worker touch the fluid physically or is the breathing or in healing this cutting fluid, then is how much he is fluid being splattered splattering of cutting fluid and may be splattering or splashing as well. Then is mist able to be is settled very soon mist first would say how much mist amount, so is it settled soon, now in what time. These are the factors that affect the occupational health here the health of the operator who is using this machine.

Now, the mechanisms include the chemical toxicity of the fluids as well where chemical toxicity of fluid also place an important role I will put it here only chemical toxicity and physical irritating ability of my cutting fluid, of the cutting fluid being used. So, what cause is this toxins, what causes this chemical toxicity in my fluids, what made it physically irritate thing. So, it is essentially the metal particles itself. It is the major contributor here.

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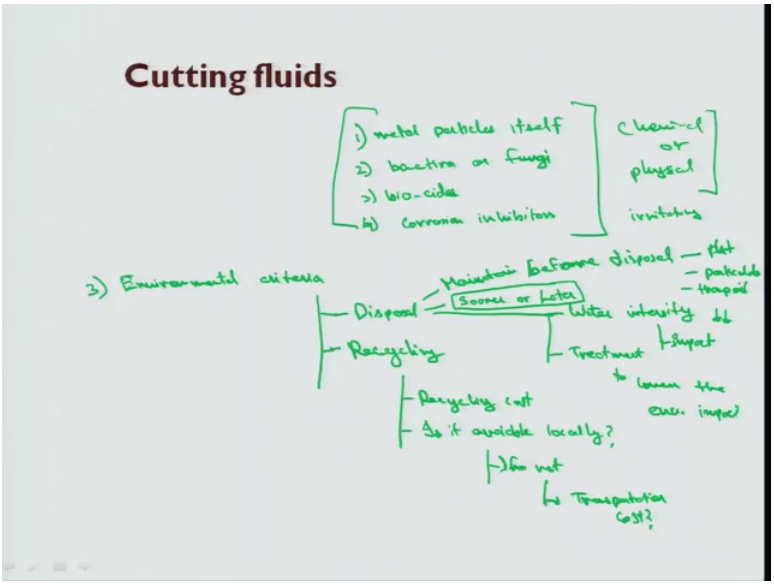

So, along with this other attentive and inhibitors those are added also have certain bacterial or fungal populations bacteria or fungi. So, these atoms in the fluid, then may be biocides right, then the corrosion inhibitor those are added. So, these are the things that make it chemical or physically irritating to the human being.

Along with this the next criteria this criteria for selection of cutting fluid is environmental criteria. Environmental criteria mainly involve the disposal or recycling of our cutting fluids. Now disposal means, so cutting fluid has to be disposed in water how much water intensity or I would say intensity or impact. So, what is environmental impact of the water that is being getting dirty because of our cutting fluid and what are recycling cost, then is it available locally, the recycling plant if not what is if not I can have a secondary factor here what is transportation cost then.

So, regarding the disposal of fluids it is also important to maintain, maintain the cutting fluid characteristics before disposal, maintain before disposal. The maintenance involves the checking the concentration of soluble oil emulsions may be ph value the contrary of tramp oil that is leaking into a cutting fluid system and may be the quantity of particulates those are in the fluid I can put it here the ph value then particulates then tramp oil. So, this is important here.

Now, action that those are ready to maintain the fluid includes adding make up of concentrate of water and skimming of tramp oil adding biocides and some process to

prevent bacterial growth, then filtering the particulates by may be by centrifugal forces. Now, the cutting fluid within a coolant system degrades with time and has to be disposed sooner or later. So, this disposal does happens, sooner or later this would happen.

Then comes this water intensity the water impact when it is disposed what is the impact on our environment. So, with time the bacterial growth and contamination with tramp oil and fine metal swap from machining operation the fluid becomes very bad and it cannot be used. So, then it becomes essential to dispose this fluid. So, this is then dumped, now prior to letting the fluid to flow into the severe system it should be treated. So, the treatment is also done here. So, as the water intensity or water impact here is lower treatment to lower the environmental impact.

So, generally the toxicity or the chemical or the physical irretentive ability is not very high, but its sometimes enough to cause problems like this respirator problems which I mentioned here and eye rashes skin diseases, then certain elementary tract could also come in then energy occupational acne, then asthma these kinds of thing then hyper sensitivity this kinds of health hazards could come into picture.

So, going to all these the cutting shoes were called as necessary evils in machinery. So, this statement was being said a few decades back why necessary because they have these functions without which good machining cannot be performed. Why evils because it has these hazards and environmental impact as well. So, then there are certain approaches those eliminate the use of cutting fluid.

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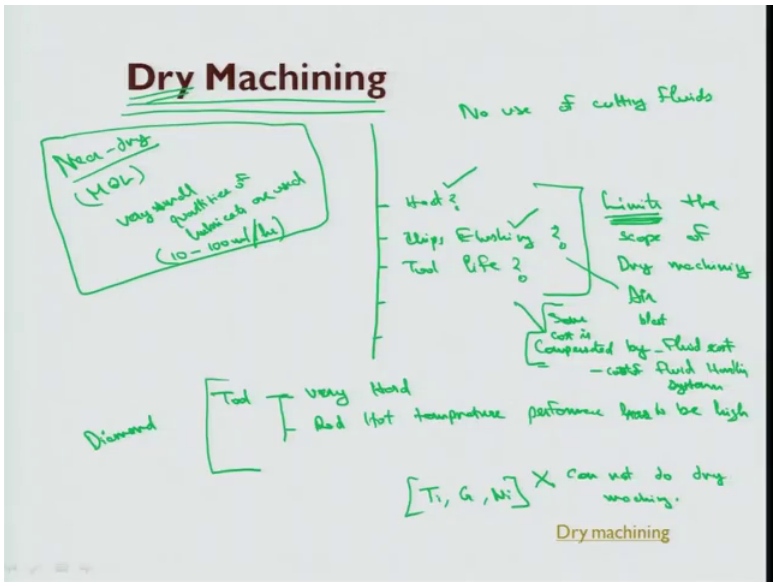

For this is the most radical approach is do not use the cutting fluid at all, a dry means dry machines that is no use of cutting fluids. Another process similar to this may be near dry, in near dry process that is also called as minimum quantity lubrication process in which very small quantities of, very small quantities of lubricants are used. This is near dry process. Now this small quantity may be from 10 to 100 milliliter per hour.

So, dry cutting is made possible by recent developments, but there are challenges what about these things, what about the heat transfer, what about the lubrication. So, when the heat is very high the work piece it would go to tool that tool life would become less even the heat flows to work piece as well no chip flushing happens and certain similar problems are associated that is heat where would our heat go. Then chips flushing how would this happen. Then tool life what about my tool life if tool is heated too much heating machining how do we work on that. So, this limits the scope of dry machining, all this limits the scope of dry machining. That is we need to have a tool that is very hard and it has at red hot temperatures it has good performance, performance has to be high or good.

So, one kind of cutting tool that is cutting material that is used here is diamond. So, diamond can perform at high temperatures, but limitation is always there the depth of what we cannot have as good performance as we had in flood thing. So, this can work at high temperatures the chip flushing can be done with the help of air blast then tool life is

compensated by fluid cost not only the cutting fluid cost, but the cost of fluid handling system this is actually a onetime cost, but some of the cost is only compensated at some cost is. However, the dry machining cannot be applied to the tools which have titanium or chromium or nickel based alloys. So, here we cannot do dry machining.

So, I have a dry machining video here would like to show. So, this machining process first performed in manufacturing process lab in IIT, Kanpur. So, you will see a dry machining that is dry milling of a work piece we are just cutting the straight slots a CNC machines M co concept 250 was used here I would even show you the CNC program which we have which I made because in the demonstration process we will like you to know the maximum details at how cleaning machine is being carried, how do we select the material, how do we do machining and everything simulation all the things would be covered over there.

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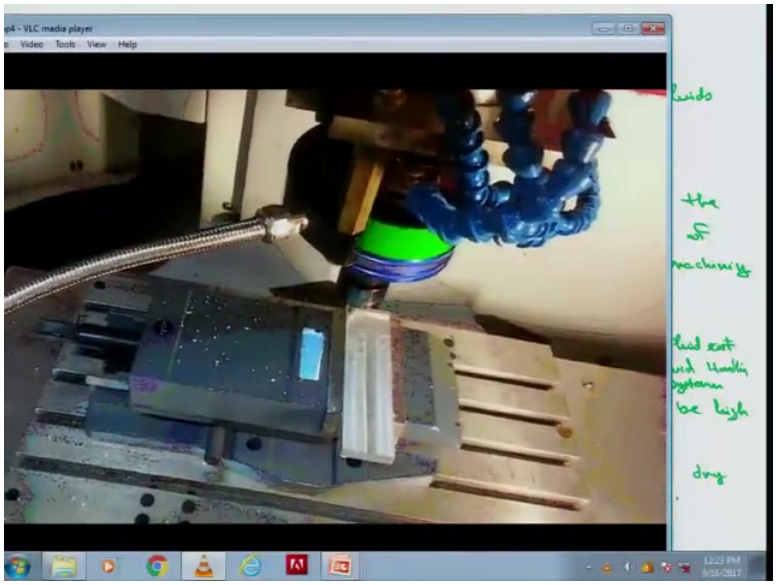

So, in this case I will just run my machining process. So, this is my machining being carried out here. So, end mill is here held in a chuck, not chuck here it is held in collate here and we have in this green color you can see the dynamometer this is a drill dynamometer it is 5 axes dynamometer. So, you can see that it did machining and rapidly it came back to its original position, now it will again do machining some depth of cut is given it is cutting a slot. So, this is dry machining no fluid or no mist is being spilled over it. So, it will move up and rapidly go to the third position here.

So, if you noticed there was noise that was produced here. So, the noise here is of the machining only. In dry machining the noise of machining is higher. In case of coolant there is some noise of pump and in case of mql there is some noise of the air if we use the air system flushed system to supply the fluid. But in case of dry if I divide my noise into two categories that is the average noise that is produced during machining, second is the peak noise if there are some peak pulse is those are produced those are high in dry machining. For instance at higher depth of cuts the noise like (Refer Time: 41:07), this kind of noise comes that is very high. The intensity of noise or the noise pressure is of the order of 130 decibels. So, that is very irritating to the human being to the operator over there. So, dry machining also have these bad affects associated with itself.

So, this all was about dry machining. I would like to take a break here and would continue in the next part of this lecture where in I will discuss near dry it is minimum quantity lubrication and cryogenic machining.

Thank you.