Sustainability Through Green Manufacturing System: An Applied Approach

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Lecture – 12
Sustainability Framework

Good morning, welcome back to the sustainable manufacturing course. This is an applied approach course, in which we are trying to obtain sustainability through green manufacturing systems. We are trying to learn how to do that. Now in this session I would cover sustainability framework.

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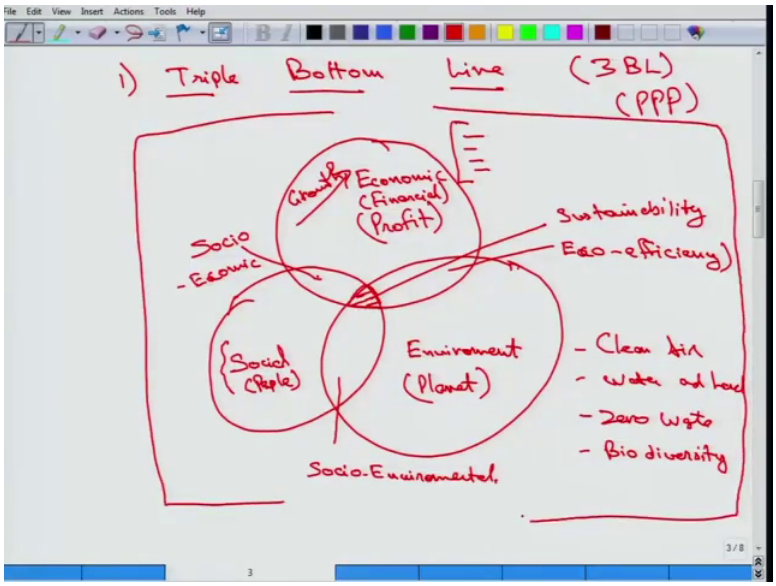

Now, I start with my first topic here; that is triple bottom line. What is this term triple bottom line? So, I will explain this with a help of Venn diagrams. Now we have three players in sustainability; number one is economic, and second we have social and third one is environment.

Now, triple bottom line, is essentially an accounting framework with three, this is three parts; that is social environmental and economic, this is actually this, it takes into concern the financial aspects, and this takes into concern, takes into consideration the

this one social, the people right. It is also known as 3 BL, triple bottom line 3 BL or PPP, we have people, planet and profit. So, we have three P's here.

So, this is the portion, when all these three work together, come together into one point, this is the sustainability. So, this becomes, this intersection becomes socio economic considerations, socio economic and this one become eco efficiency, and this one becomes socio environmental. Now the economic player here, consider about the capital efficiency, risk management, margin improvement, growth enhancement, then total shareholder return, and maybe innovations technology. All these things, this is a manufacturing. So, this is all related to the economic concerns; that is financial concerns; that is the growth of the company is considered here, growth of the company or maybe the growth of the nation that is considered here.

Then social aspects include the diversity human rights, all, then indigenous communities, labour relations, all that and in environmental, we have clean air, water and land, then zero waste, then also I could put here biodiversity. So, this is a very simple kind of, and very popular sustainability framework.

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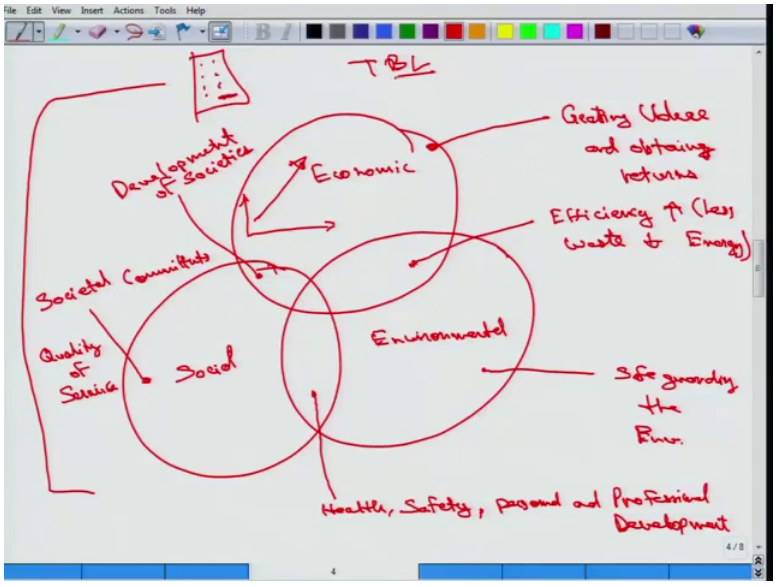

Now, one I have this three circles here. I would like to put some more detail here, this one, this player is concerned about, it is bother about creating value, and obtaining returns. And second player; that is our social player, he is concerned about societal commitments, which involve the quality of service, then availability of a jobs,

availability of social services, and the this environmental player is more focused towards the commitment in safeguarding the environment.

So, when economic and social combine, they are committed towards development of societies in which we live, development of societies. Taken into consideration, the profit levels of the companies that are providing products to the society, and those who are creating the facilities for the society; like infrastructure and other things. And this one economic and environmental, they are more committed towards efficiency; efficiency increase with waste reduction, efficiency increase implies less energy, and this one means social and environmental aspects come together, they are more committed towards health, safety and maybe personal and professional development. So, this is one of the frame work that is known as triple bottom line.

Again tradition and business accounting and common usage, the bottom line refers to the profit or loss; that is why this TBL, this is bottom line refers to the profit and loss, that is while bottom line term has come up here, which is a this one bottom line is like, the profit and losses are usually recorded at the very bottom or like on the statement of the revenue, like on the statement of revenue we have, it is the statement like this, and at the end we have what is profit or loss.

All accounting is putting here. So, that is why this bottom line is there.

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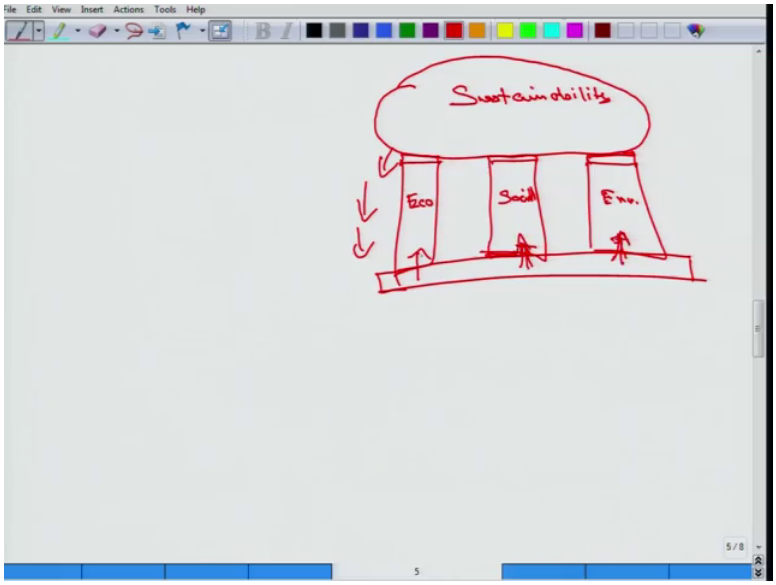

Or so these could also be said as the pillars to sustainability. If I have my sustainability here. So, this is economic social and environmental aspects. These are essential pillars, or very necessary pillars that are required, without even each one of these this sustainability would not stand, this sustainability would fall down, without even one of these two. Three of these needs to be considered all together.

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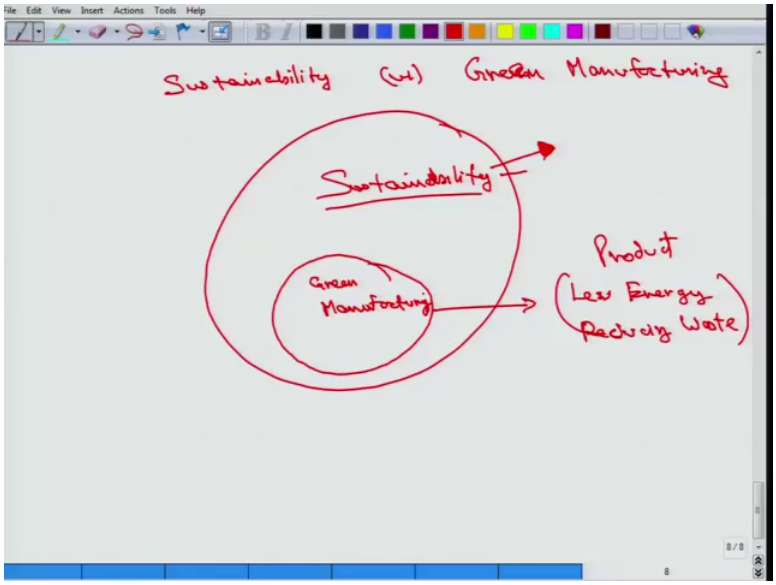

So, next is sustainability versus green manufacturing. Sustainable and green are being used intern changeably, sustainable people, said this is product is sustainable or it is green product, but what specifically is the difference here. So, sustainability is a broad term, this is sustainability of which green manufacturing is a subset.

So, green manufacturing works in the manufacturing sector of sustainability. Sustainability is to consume the resources in a way that it does not affect the future generation as well; that is future generations should also be able to produce or use these resources in the same way we are doing todays; that is sustainability. And when the products those are being manufactured for the sustainability approach, those products are produced by green manufacturing technologies. Green manufacturing is than producing the products, thus that have less waste and consume less energy. So, this is green manufacturing is consuming less energy, and reducing waste. I am talking about my product here; that is being used. Sustainability involves all other things; like echo harvesting, agriculture, then plantation, everything is part of sustainability.

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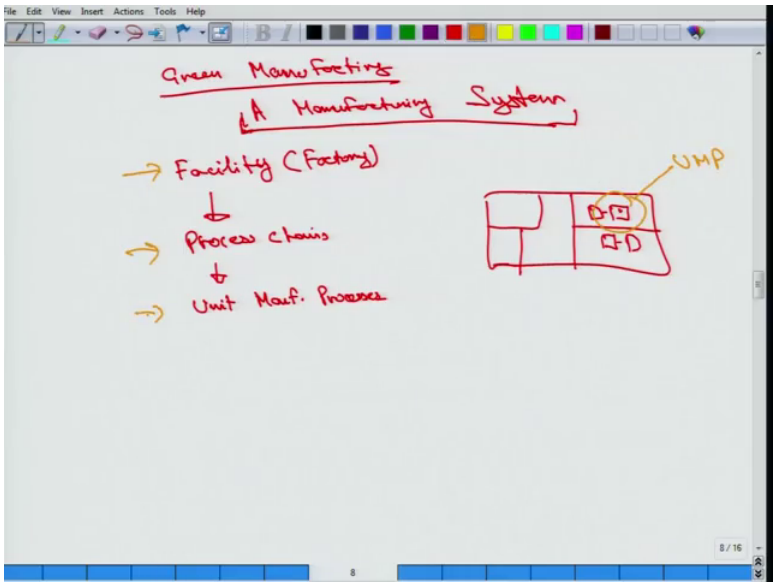

So, next I will talk about manufacturing system. For green manufacturing is done in a manufacturing system. Now what is manufacturing system? This is being discussed in the previous lecture by Doctor Deepu Philip as well. So, in manufacturing system we have a facility, that can be sub divided into process chains, and this process chains consists of a rigid unit manufacturing processes. If you could recall, this is my facility or refractory which has various sections, and we have process chains here, and this one unit, this one unit is my unit manufacturing process. So, at each level facility, process, chain and unit manufacturing, what are the consideration.

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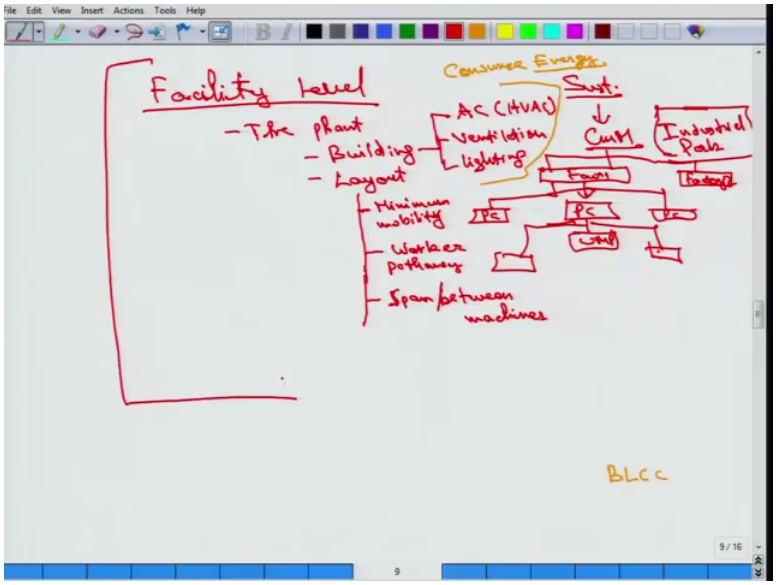

So, what we actually doing we will be trying to narrow down or scope here. So, we started from sustainability, then we are coming to green manufacturing. For green manufacturing we have, we are defining the elements, the elements, first element is facility. Then will go down to process chain, and then we will go down to unit manufacturing process. So, this has multiple unit manufacturing processes here, and this has multiple process chains here.

If I say green manufacturing, if I say manufacturing here, this is I, here say I can even have industrial park here. Industrial park has number of factories here; factory one, factory two right. So, at facility level what is my point of consideration here with respect to green. So, it is the plant, the plant design. Here plant ,the plant, in this plant we need to have building design; that is green building, then layout of the machines, then we have, in the building we have air conditioning, maybe H V A C, and ventilation, lightening. So, all these participants here consume energy. So, there are soft tools, there are soft tools available for example, B L C C building life cycle costing. The special tools that are available for designing of building, for less consumption of air condition energy in overall for air conditioning ventilation, lightning, everything is designed in a way that building is kind of green building that case. In layout design we need to consider minimum mobility; that is minimum material movement; material handling should be minimum' then we have worker pathway to move; then span between machines, at how for machines need to be placed. This facility level, just take quick class over that ok.

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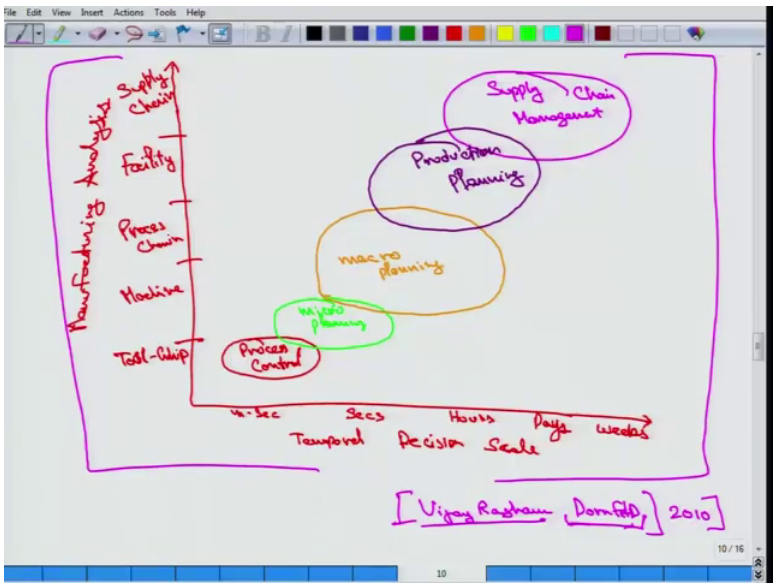

I will like to share one more thing here, the temporal effect in the manufacturing. So, we have temporal decision scale here, and this is manufacturing analysis.

Now, we can divide into certain sections. So, we have manufacturing enterprise; that is facility here, then I have process chain. Process chain is also known as flow line right, then I have my manufacturing machine, and in the machine this sub components and then further I would say, at micro level, tool cheap interface. So, this is time, I have time here, milliseconds, seconds, hours and days. So, if I had tried to widener scope here, I could even have facility has some management here, and we have full supply chain here right. So, this is, at this point, it is known as process control. And this planning, actually the plan is comes into play at this point it is, micro planning.

So, process control, is controlling the tool chip interface; like the energy that is been consumed while machining the tool that is being used, or how the tool movement is there, the moment of tool should be minimum, and the cutting fluid, kind of cutting fluid we are using, the few cutting fluid ingredients. All those things in tool chip interface. What is the energy? What is specific energy coming out; that is considered here; that is even lower than micro planning, that is process planning here, process control here. So, when I come to process chain here and machine equipment, it is micro planning here, and micro planning takes from a few seconds to hours to do. Then at facility level planning, it might take a day from few hours to a day right. So, I would even put weeks here. So, this is known as production planning.

Production planning include everything; like planning, scheduling, then implementing, routing etcetera in between. So, after that, we have here is, supply chain, it is supply chain management. So, product will fully cover green supply chain topic in the fourth coming weeks. So, what is green supply chain, all the purchasing can transient of the goods I have to be done with lesser carbon food print; that is green supply chain, how would do that, and what are the elements of that information would that, would be given by Doctor D Philip in the fourth coming sections. So, this is temporal effect in our manufacturing concern. So, this is taken from a book by Doctor Dornfeld, and this illustration was brought up by Vijayaraghavan. So, this was published in 2010.

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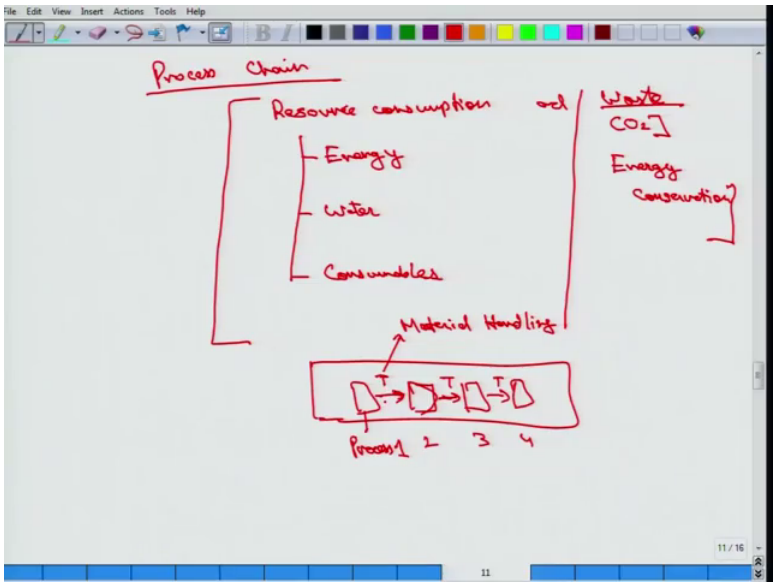

So, next I have is, in my facility I have my process chain. In the resource consumption in process chain, is to be considered. What is resource consumption here? The thing which we have been discussing since the beginning of this course; that is energy, water and because I am talking about manufacturing concern here, I will put here consumables right. Then we have resource consumption, and waste, its wastage carbon dioxide right, then solid, liquid and air waste, then energy conservation. I am putting it in energy conservation in this waste category only. So, this thing needs to be controlled in my process chain. So, process chain is nothing, this is one process chain.

We have process one, process two, process three and process four a material is growing in, and this transport of material, this also consumers energy, this is known as material handling right. So, this also consumes the energy. So, this also needs to be considered here.

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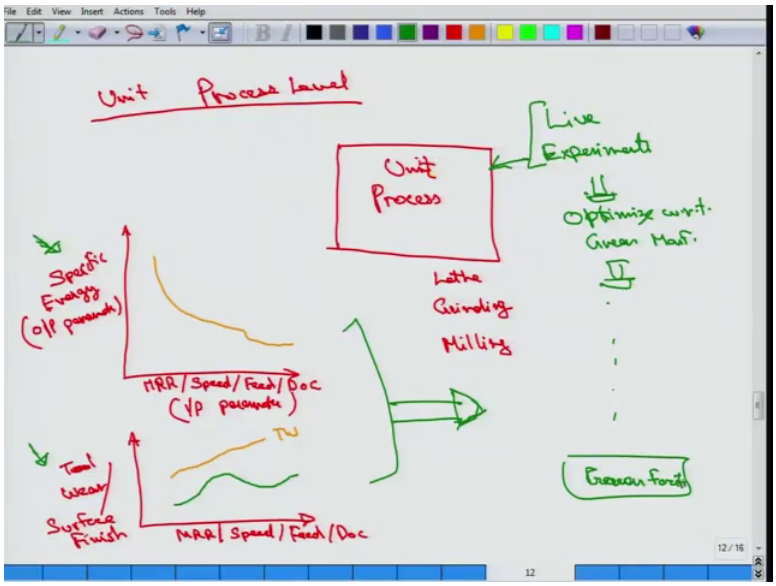

So, next I have is, my process level, rather I would like to say here unit process level. So, unit process is my one process. So, it is one machine, may be it is say, it is a lath. Lathe is a machine that produce cylindrical jobs, or may be grinding machine or milling machine right. So, this is one machine here.

So, in this case we are working here now, one machine at this point, machine. So, this is micro planning, even we would work here tool chip interface. So, what are the things that needs to be controlled here, what are the factors that it would be controlled, it is the energy. Here we have for. It is from this point the a green manufacturing process starts, it is actually we say energy or specific, energy per unit volume that is removed, specific energy per unit metal removal rate or per unit depth of cut, this is the point form where green manufacturing starts, and from here we can produce unit green manufacturing process or the process that consumes less energy origin green, or produces less waste, and this can be taken forward to the process chain level.

Like unit processing process can be combined together, then we can see what is the energy level total energy consumption in that case. Then these process chains, which are now green process chains that can be taken forward to my facility level, to convert whole facility into a green facility right. So, in this case I would say, I can have plots like this, specific energy right. And this is, on this case I have, this is my actually output parameter, and I have input parameter here, that can be metal removal rate or speed of

my spindle tool or field of cutting, or maybe depth of cut. So, this plot; say it is like this, some kind of plot would come. So, this is specific energy. So, this can be compared with the quality parameters. In quality parameter I could even say tool we are.

Right, or it can be surface finish right. And here also we can have the same kind of input parameters right. If it is tool wear, tool wear has to be minimum, tool wear needs to be minimum for example, with M R R. Sorry it would be always like this, with more M R R tool wear would be high, or this is tool wear. Surface finish can have transited behavior for example, surface finish can be like this, something like this. So, this is my energy parameter, and my quality parameter, these needs to be combined together. So, we can even have multiple parameters here. I have only considered two parameters, but other parameters may be specific energy, cutting fluid consumption waste, or that is produced in the machining, then solid waste, chips that are produced, then water bond waste here.

Then tool wear quality parameter, it could have any surface integrity, then tool is one of the criteria very important here. So, what we do here in the forth coming sessions, we will do labs demonstration, and show you how do we conduct experiments on this unit manufacturing process right. We will conduct live experiments, then we will optimize with respect to green manufacturing. So, there is another steps to finally, obtain a green facility, I will let you know when we do this, manufacturing facility.

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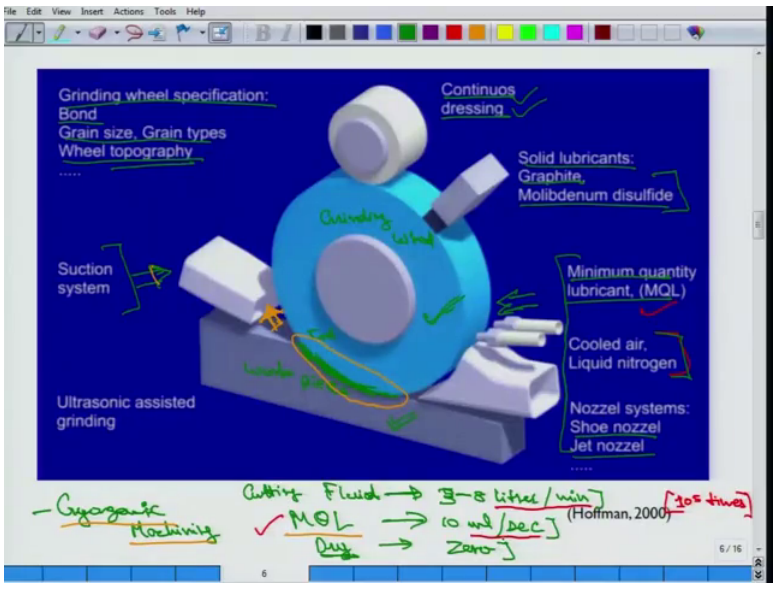

So, next I have an illustration here; that is trying to explain the different techniques that can be used to have green grinding. So, this is a grinding wheel here, and this is my work piece. So, grinding is typically a finishing process, after doing any kind of machining for example, may be turning or milling, grinding is the final process to obtain the final shape. The grinding allowance is always kept during rough machining, may be in milling some grinding alliance kept, and grinding produces finish surfaces.

Like the type of purchase of surface which required, the wheel, type of wheel is selected in that way. And there are specific wheels, specific wheel of Brazil, that can machine be specific work space is here. Hard wheel for example, C B M wheels can be used to machine titanium work species, and aluminum oxide brail can be used to machine mail spiel, or some other kind of soft materials. So, this is grinding wheel; that is machining my work specie. Generally what happens we do the grinding, we do a few runs of grinding and then we dress the wheel with help of a diamond dresses.

Diamond dress is nothing, it is just kind of this man, and the tip has a diamond over here. So, what we do the wheel is rotating, this wheel is rotating and this diamond dresser would, dress the wheel; obviously, the hard material wood cut this soft materials. In this case this grinding wheel is hard, and my work specie is a soft material. So, it is cutting this one. So, in this case this dressing is being done by wheel dresses, which is the diamond tip dresser. So, what this illustration is explaining here. It is doing continuous dressing here, like machine has to be stop, the overall, actual production that is the production time; that has to be stopped for grinding in a regular practice; that is machine has to be stop here, the work specie has to be taken away, and then we do this dressing, and which repair the wheel for further sessions, and then we again bring up the work specie together. So, in this case time is consumed. So, to minimize this one, minimize this wastage of time, this continuous dressing is one of the criteria, but this, these dresses are not very commonly used.

So, also we have solid lubricants here; like graphite or molybdenum disulfide that has to produce better surface finish here, and this solid lubricants would even keep the wheel life better. Then there is a process called as minimum quantity lubrication, we will come to this, in regular practice what we have, a cutting fluid. In the normal practice we have a cutting fluid; that is supplied in a flow rate of maybe 5 to, may be, I would say 3 to 8 liters per minute. So, in minimum quantity lubrication, what we do, a mash or a resource

are produced, with the help of some arrangement, some set of, some readymade nozzle can be precede for that, or some set up can be made to produce a resource, to produce the mash. Flow rate in MQL the flow rate comes down to even 10 milliliters per second. Please note here carefully, this is liter per minute, and this is milliliter per second. So, the difference might be 10 raise to power 5 times, lesser fluid is used.

So, what are benefits of this? One thing is, the furious, other benefits will discuss in the further sessions. So, this is of the technique here right, then we have cold air or liquid nitrogen, heat is produced at this tool, this is my tool and work interface heat very high heat is produced. So, this liquid nitrogen and cooled air can help us to control this deterioration of my work peace surface here. So, also there is a process known as cryogenic machining. In that case also, it is done at very low temperature.

Then we have kind of nozzles here; shoe nozzle, jack nozzles, those nozzles are used to supply this fluid here right. Then also the grinding specification, says grinding specification is like bond grans size, wheel topography. Actually grinding wheel is having the cutting in the grinding in that, and also to bind that we have bonding material. So, it is a Brazil, and the bond, all together make a grinding wheel, solid grinding wheel here. So, this bond can be face enter body centered, the similar kind of bond we have in our crystal structures right. So, the type of bond also depends.

On wheel topography also could affect my quality here. Also we have put here suction system. Suction system would suck my chips that is produced. In this case, the chips are very small, I would say the kind of dust is produced, and that dust includes the abrasives, the cut abrasives (Refer Time: 34:22) and my work piece material; that is there in. So, if that would enter into this tool work interface that can also contribute to poor surface finish. So, this suction system would help to suck these dust; that is produced here. So, that does not enter in my tool work interface here.

So, with this, I would like to conclude this session, and in the fourth coming sessions, I would discuss these kind of techniques; minimum quartile lubrication for a cryogenic machining, and this is actually minimum quantity lubrication, there is also one method that is known as dry machining; that is do not use cutting fluid, this just right. No cutting fluid at all. So, this is 3.83 to 8 liters per minute, this is 10 milliliter per second, in this it is 0, but what happens to my specific energy, what happens to my surface finish, what

happens to my tool wear in this case. In this case, if it is a dry machine, the temperature would rise, because cutting fluid is also helps to keep the temperature in control while machining. So, what are implications in that that will discuss in the fourth coming sessions.

For today thank you.