Introduction to Mechanical Micro Machining.
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Lecture- 32
Components of machine tool (Contd)

Good morning, everybody and welcome to our course on introduction to mechanical micro machining. In the last class, we have seen, some of the criteria of selection of the material for fabrication of machine structure and also we have seen the, what are the properties required so, that you can get the required result or the required strength of the structure so, that it should not deform or it should not create a problem during machining under the vibration or in the forces acting on to the different type of components.

So, let us further go into detail that, what are the different properties, it should purchase, so that you can get the required results.

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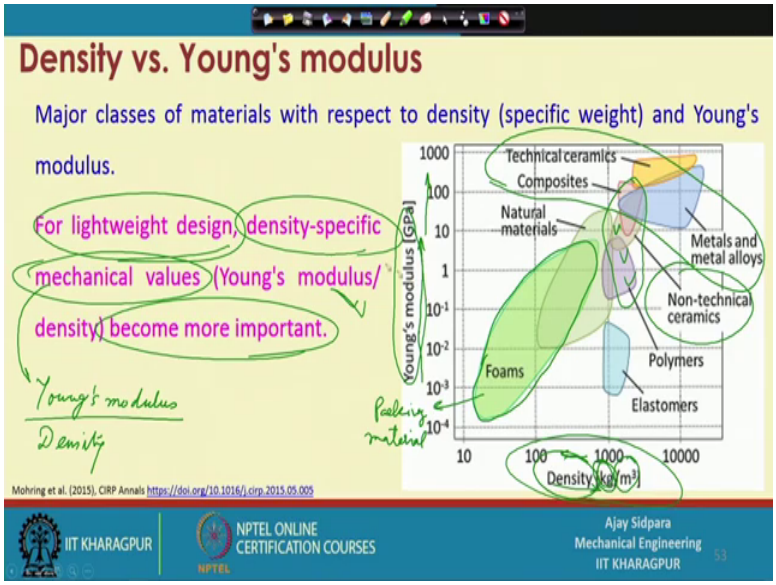

So, one of this parameter is density versus Young's modulus. Now, you see this particular graph. Now, on the X axis, it has a density written and on the Y axis, it is the modules. Now, there are different-different materials, what we need that, we need a high Young's modulus for our. So, it should not deform under any type of external forces. It is under different type of stresses and our density that mean our weight should be low if possible, because we want a light structure also.

So, to get these both the things, it is very difficult to get a one particular material, which will fulfill all the requirements. So, if you see this particular thing, foam is creating very-very large amount of, occupies large amount of it, because foam has a very-very small young modulus, because you can. It is like a rubber or elastomers like kind of thing.

So, foams is like, because mostly, it is used for packing materials, when you trans seek any components, which is very-very important or very-very delicate at that time, you wrap with this component with foam and it will sustain it, type of impact loading or different type of loading then what is our important thing is that, we are actually looking something about this area and even some ceramics are also included in their piece, because what we want is our work piece or the construction material should not deform or we need a high modulus.

But we have to also think about a weight of the component that per, volume how much is the weight. So, if you see these particular things that this particular part is the something, which is very-very important for our cares, where it has a reasonable amount of young modulus and the, density is also comparatively good. So, we have to look into these particular area.

So, major class of materials with respect to density specific weight and the Young's modulus is own in this case for light weight design, because what we need that we need light weight design also, because many times what happens that if when you are doing a machining weight as on a very-very small scale, you need a frequent travel in to and fro direction. So, if your work piece material very-very large or the, all the guide way and slide ways very-very heavy, the movement is very-very difficult, quick movement is, will be difficult.

So, what is required the, if when we are talking about light weight design. What we need that, we need a density specific mechanical value. So, that is, that Young's modulus divided by density, Young's modulus divided by [densisy/ density] density that is called, the density specific value to be become more important, because we do not want. Machine is a very-very heavy and some times, if you go with these particular direction, you have to go with the higher density also, but that is we want to, that is we do not want to do in this step. So, this is one of the criteria or by which, you can actually select a different-different types of material, which will fulfill both the thing that it has a high

Young's modulus as well as reasonable amount of density. So, that you can get the required things done.

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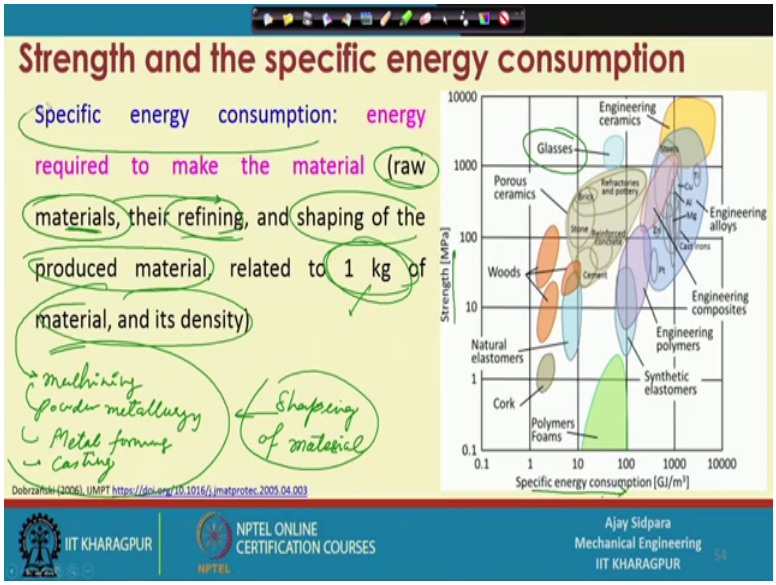

Another thing is strength and the specific energy consumption. So, this one more graphs. So, here different materials are given in the Y axis, it is a strength. So, this strength is increase, this is the specific energy consumption. So, what is this specific energy consumption, because if you see these materials that these materials not readily available; that means, wherever you are getting, you have to process this components.

So, from starting to end let me define first, this is a specific energy consumption. What is that thing, energy required to make material right. So, what you are doing? Your starting with the raw material, first is the raw material from where? What whatever, way you are getting either you are getting a, chemical rout or it is readily available in the nature.

Then what you do you have to refine these things, because whatever is the raw material, you have to remove or you have to separate all the different elements, then you have to make sure that the component was the content of this material is same as whatever material your thinking. So, refining is a second step, once refining over you have to shape this component. There are shaping the, you can do anything there are machining are also available, if it is in a powder form or something then powder metallurgy, if you are getting a in terms of very-very small-small different-different type of shape, then

there are different process available that is, called and then you are doing a actually forming metal forming, then there are casting.

So, by that you are actually shaping the material. So, this all process is are for the shaping of material, shaping of material correct. So, now a raw material how much energy you are actually spending for making a one particular material. So, starting from raw material refining shaping of the material related to 1 kg of material and it is density correct and if you are how much energy you are [vocalized- noise] spending for creating a 1 kg of material of a required step that is raw material, then refining, then shaping and all this that called specific energy consumption right.

So, now, how it is important; so now, if you see here. So, these are the, polymers foam woods and all these things are the here you do not need to spend more energy to shape these things right, because these are soft material and, but problem is a these strength is also very-very low. So, these particular category of material whatever, it is showing here these are not suitable for the constructions of the material not suitable correct.

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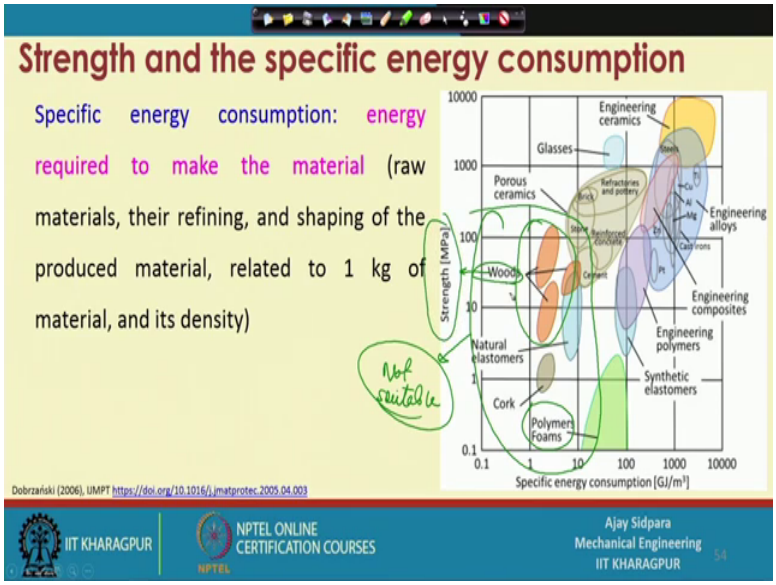

Now, what you have to think about that you need high strength, if you go in this direction. Now, see let us divide, this part in terms of strength correct. Now, these are the strength axes. So, now, you look about this particular thing. Suppose, you are going with a 1000 M P a or 1 G P a. So, at that time you have reasonably good amount of material,

but problem is that for processing. Those components you have to spend huge amount of energy. So, that is the big problem.

So, initially your cost is very-very high, because refining shaping, these things are not as easy as processing the woods and the different type of elastomer in this particular as, because glass are difficult to cut material, because you have to use special tooling for that then if you going this part particular thing. The strength is very-very high, then cutting force is are very-very high even for melting of this particular material. You have to go with the high temperature then only you can do casting and other processing.

So, this is the graph, which will tell you there at which particular location, you have to stop. So, that you can get the required results, but if you see general way, these particular trend is going in this direction. So, this is the routine that if you go with a high strength, your energy, specific energy requirement or specific energy consumption is also high in this particular direction. So, now, first you think that how much time, because whatever energy consumption, you are putting here, that will directly converted into the cost and time right.

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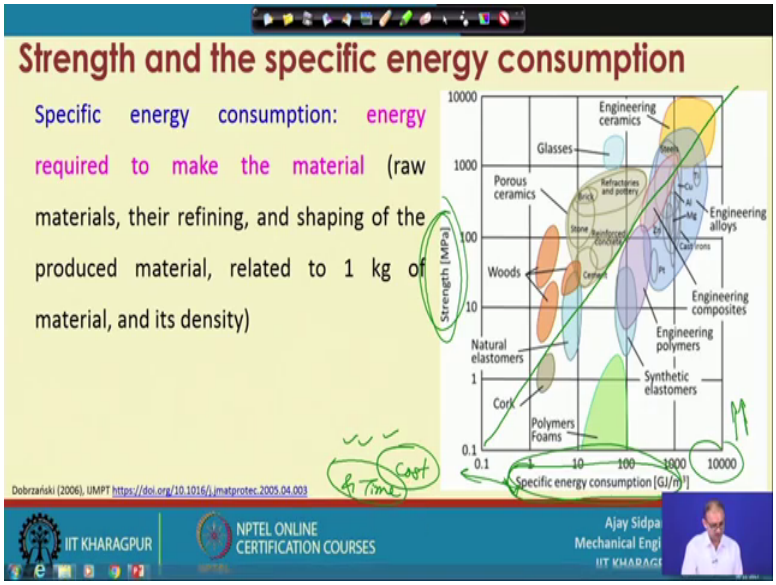

Both things are important, because you cannot avoid or you cannot ignore. These particular thing, when you are making a machine, because that is directly connected with the cost. If you want very-very stiff structure and you do not want to scarifies any of these, strength material then what you have to do that you have to go with the higher

specific energy consumption material then cost will directly go up and then you have to actually put a break even in a such, a way that, that whatever component.

You are processing by this construction material, where you have already spent lot of money, then you have to find out that if the component cost or whatever job work. You are getting through this machine, it is, should actually justify the amount of energy or amount of money and time you have spent for making this construction. So, after 1 year or 2 year or after 10 years, you should be in the profit not into the continuously, in the loss market right.

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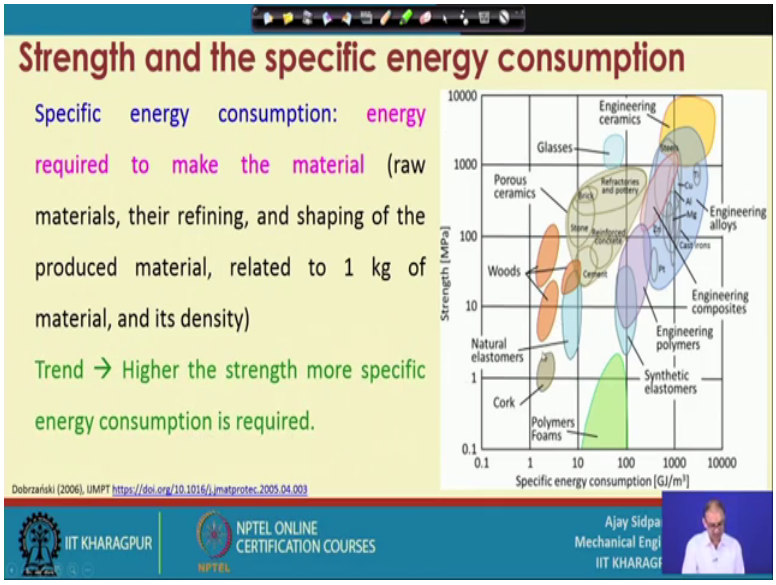

So, this is the trend; that means, if higher the strength or more the energy consumption is required that is, what is showing in this particular diagram. Just you draw these things, most of the things, it is balancing both the direction. So, this is the trend correct.

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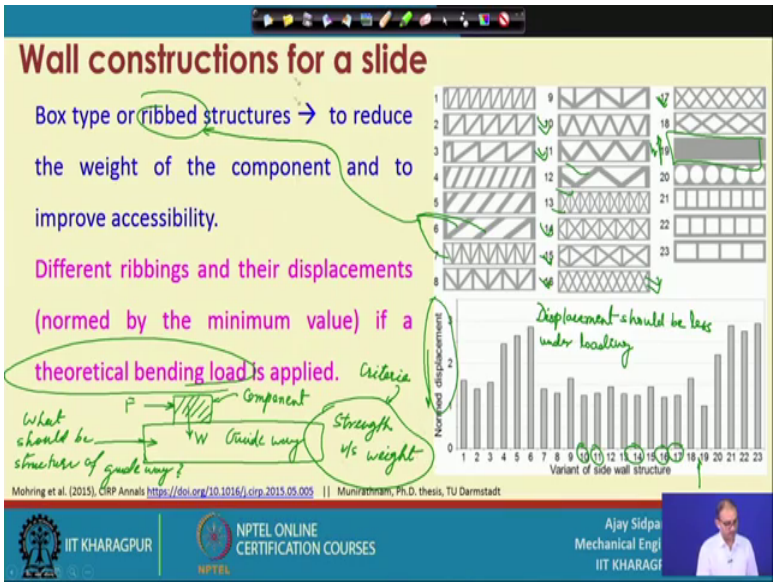

So, now, wall constructions for a slide now, what we need that this is something that very important that this consider this 19 example first correct. So, now, what is this rib that supposed you have a guide way, this is guide way on the top, you are actually moving one component. Suppose, this is the component and then you are actually moving by force. So, it has a weight correct and now, consider that what should be the structure of this particular guide way, guide way and this one is the component right. So, what should be the structure of guide way correct. So, first add with the solid one, because now, what is the criteria that we have to actually see the strength versus weight correct.

So, this is the criteria, we have to follow, if you are making a solid structure, actually your weight will be very-very high, in this case W is very-very high and then there are lot of different-different type of options, which type of ribs you required, because this have all the ribs whatever this is showing. So, this is the rib correct. So, what is design, which is important now, how you define? So, this is of one normed displacement, because if you put a theoretical bending load, at the end or at some other location, at that time what should be the displacement. So, our objective is to reduce this displacement ok. Displacement should be reduced, displacement should be less under loading correct.

So, now, if you see this one the 19th is the probably, the lowest one correct. It is the completely solid body, but again our weight is very-very high. So, now, we have to find

out, what are the other shapes, what the other configuration by this particular ribs structure, which is giving a less displacement, but let it be higher than that, but it should be within the impermissibly, because here what we are doing that whatever structure, your using these things. You are using less material here, but you are not sacrificing the strength in a large way.

So, now, you see this particular line, there are many things are there. So,, 10 11 is there and 16 17 are there, 14 also. These are the particular structure, which are important for using, these type of 1 16, this is there and 17 is also there. So, you can select any of this particular structure depending on the availability of the, machine tool or the processes, which can fabricate this type of structure, because if you go with these thing. Mostly, you create these tool bar and then you weld it that is the one of the options then, another way you can do casting also by which you can make these type of structures.

So, by this way actually, you have to find out, which one is the optimum design for a strength to weight ratio. So, that you can get the require results without any scarifies right.

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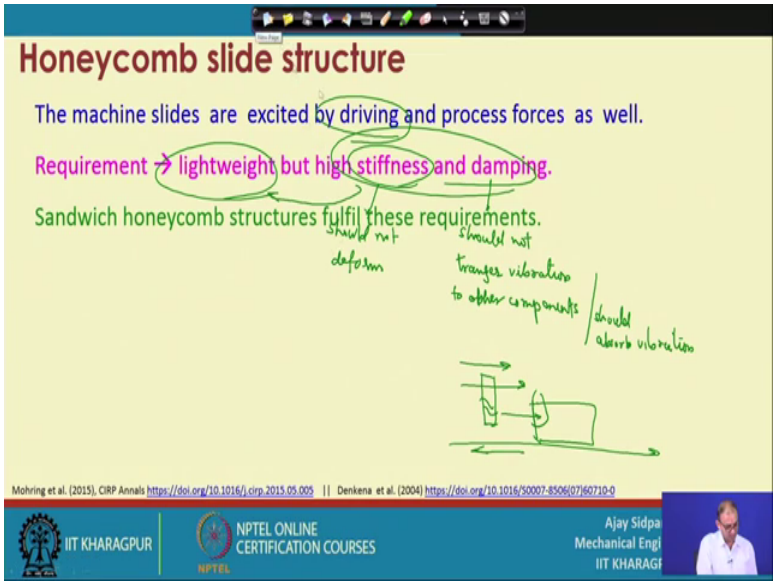

There is another category, which is called honey bomb, honey comb slide structure. What is these things? The machine slides are excited by driving or the process force [vocalized- noise], process force as well. So, there are two types of forces one is the

driving force; that means, when you are moving axis in this direction; that means, you are travelling your tool.

So, this tool is travelling and then your work is located here. So, when you are travelling at that time, what happens that, you have to spend some energy to move these thing or the tool or the work piece to, in this direction. So, at that time will create some forces and the process for; that means, when you do actual cutting and at that time you will encounter forces that is called process force.

So, what is our requirement? Our requirement is the lightweight, but the high stiffness and damping; that means,, your particular slide structure should not deform, should not deform and it should not transfer vibration to other components or you can say it, absorb vibration. It should absorb vibration, another thing it should be light weight also correct. So, you have to these two requirements are actually opposite to this one. So, you have to be in a one type of balance way. So, that. So, that you can get both the things in a reasonable good way, one is the lightweight another is the high stiffness and the damping right.

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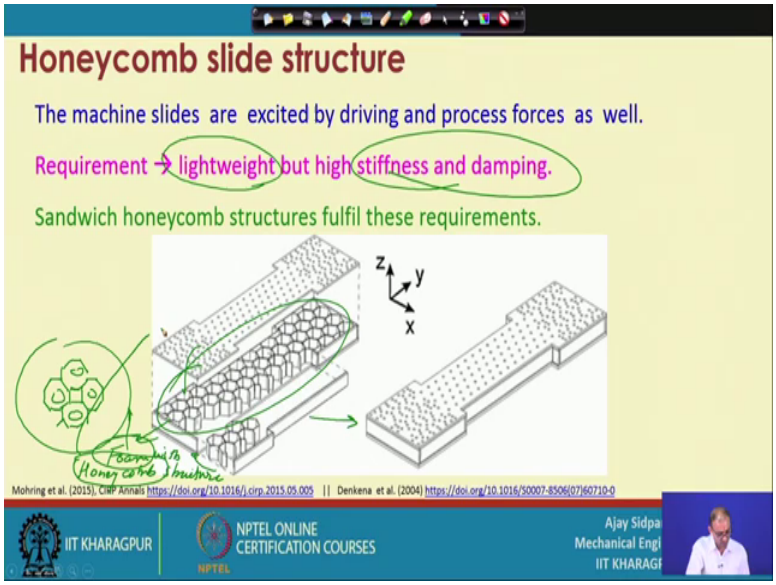

So, what is the important also, this is one of the structure, which will fulfill this particular requirement. So, what is the structure. So, this is the structure, what we are doing here that, this is the honey comb. So, if you see the, honey bee that honey bee, honey bee has that, that time you will get this type of structures correct. So, these are the structures by

which you can get the; so, this way there are many, different-different structures available.

So, this way you can get the, very-very high dent structure by this particular honey comb structure and when it is a holes will actually get a very-very high stiffness and the damping and you know that it is a mostly of the hollow part. These are the hollow thing, you are, you do not have material. It, it is not a solid body, it weight will be also less. So, once you get the structure then what you have to do that, you bolt it or weld it from the both the sides from the bottom and from the top and then you are getting a one particular structure, which can be used for making the slide structure of the machine tool correct.

So, this is the one one of the ways of doing another structure were showing in the earlier slide, but this is also very used and now, you might have seen, these type of structure in the packing, because when you pack any very sophisticated or very-very sensitive instrument at that time from outer side, you are putting these type of box. So, it is. So, it is mostly a foam honey comb structure foam with honey comb structure. So, that is use for fab, packing material, but right now, here what we talking about the construction material.

So, foam is not a right solution, because of right material, because we have seen in the two slide before, where the material respect to the Young's modulus for showing that, what was the density and this particular things. Since, the density is law, but it is young modulus also very-very low. So, this is not the correct way. So, we have to go, with the honey comb structure, but with the metal or some type of other material, which is very-very high Young's modulus right.

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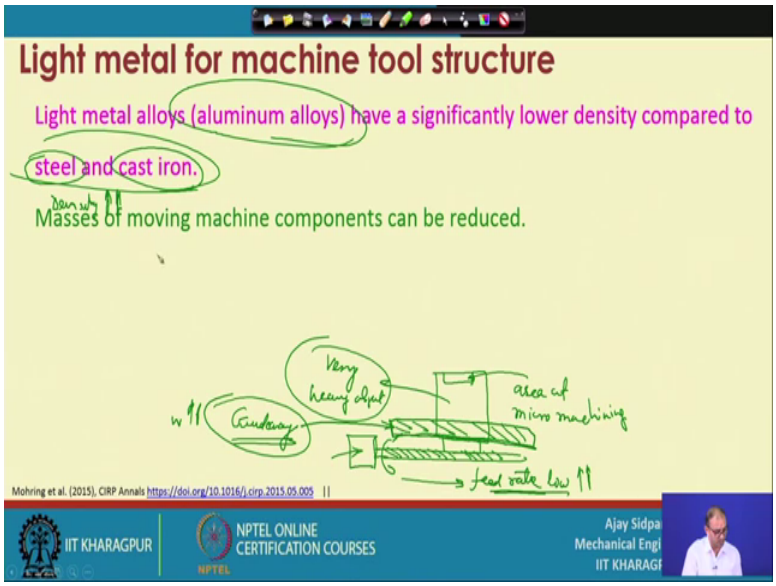

So, other than that whatever, we have seen that we can use, different type of metal, but there are light metals are also available mostly, it is a aluminum alloy or magnesium alloys. So, these materials have a significant lower density compare to the steel and cast iron, because we know for construction material mostly, we prefer for the base material, we prefer the cast iron and for other material. We prefer the steel, but the density is, density is high.

So, your weight will also increase and once the density is very-very high machining is also not that much easy. So, you have, because and ultimately you have to process it, you have to safe this material. So, that will also take lot of time and energy. So, aluminum alloys is one of the choices, by which you can replace some of the components of steel and cast iron not all.

Masses of the moving machine component can be reduced, because now, this is very important, because we know that suppose, this is you have one component here. This is the component and this is the slide on, which it is mounted. So, when you want to do some small scale micro machining here, only. So, this is the area of micro machining right. So, here, you might have a lid screw and this particular table is attached with this thing and you have a motor, which is rotating this lid screw. So, whole thing will move. So, let us give something like this.

So, this is a very heavy object correct. So, now, if you see this particular thing, this you consider as a slide way or guide way correct g u i d e, guide way. So, if you are using with a steel and cast iron your weight will be very big, because you already have heavy object and other than that, your guide ways also very-very heavy W. So, in this case when you are moving, this by load lid screw, this motor will provide a very-very, because it will be loaded more, because it has to provide such a high (Refer Time: 21:25)

So, that it can move this object in different-different (Refer Time: 21:25) maybe, in to, in pro direction or in the left or right direction, depending on your axis. So, when you are doing these things, you it you cannot get a very-very fast movement; that means, your feed rate is very-very low correct.

So, if you are using some type of light metal, at that time, you can actually increase this feed rate to a (Refer Time: 21:55) that, you can get material removal, what you can get production level is very-very high. So, frequent movement here and there it is a problem. So, one of this advantage is, is that you can use for making your machine component light. So, that it can move very-very easily without any problem right.

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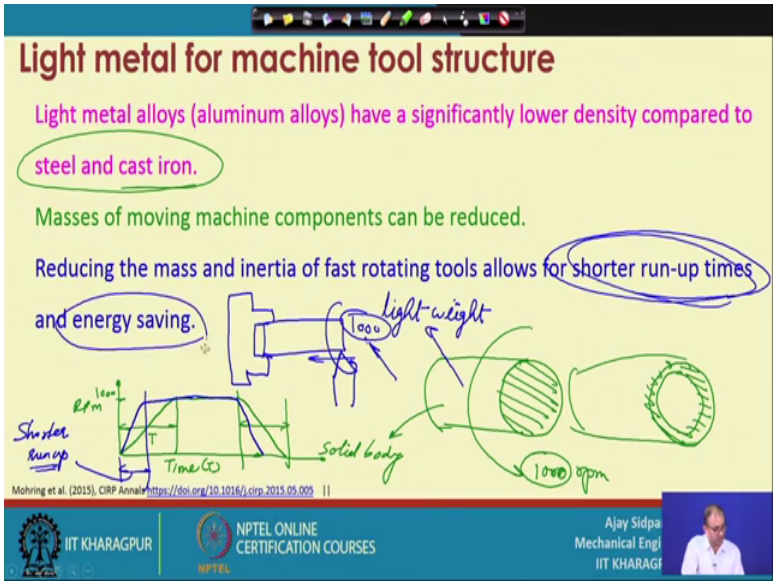

So, reducing the mass and inertia of fast rotating tools, allows the shorter run up time and energy saving. So, what does it mean that suppose, you have a solid body [body] and you want to rotate it, ok. So, when you rotate it, at the time what happens that you have now, suppose you, you are, you want to rotate it to the 1000 RPM ok. So, now, is a stationery

position right to reach to the 1000 RPM, what you have to do that this is the RPM and this is the time right and this is the 1000, you want to reach to this location. So, when you start with the heavy body.

Now, what happens that you have to spend some time, because it suddenly will not reach to that location 1000. So, this time duration required to reach to the 1000 RPM right. This is the time correct, now, because it has, it is on weight. So, you inner stage were important one, because when you are rotating it at high RPM. You have to spare more time or you have to spend more time here, to reach to that location and same thing for stopping it also. If you continue this particular line and then you have to stop this things to 0 location an again, you have to spend very-very large amount of time, in this direction.

But this is more important here. Now, consider this particular object. Now, you have a hollow object, that is one of the solution by this way, that you can reduce, you can change this particular thing, but now, you consider the this body. Now, you are changing this body. Now, it is a light weight, light weight structure. Now, what is going to happen in this case, the it may not require. So, much of time and then it will reach to this location and when it is ending here, it may not require same amount of time here.

So, whatever is this time now, the time required for shorter run up. So, this is called shorter run up right. It will quickly reach to that location, because now, you know that you want to do machining on this operation. Suppose, this is the [vocalized- noise] one work piece and it is connected with the, spindle and you want to rotate it to the 1000 RPM and your tool is located already here correct. So, this is your cutting tool, unless it is reach it to the 1000 RPM. You cannot process these particular thing right, your step is you are waiting for 1000 RPM.

So, now, consider it is now, let it be friction of second, but if you are making a 1000 of this, this component, this friction of second will be multiplied by 1000s of time correct, and may be sometimes what happened that you want change some tool at that time you stopping the work piece, but you are not changing the work piece. So, single work piece is processing two three time with a stopping and starting of the spindle. So, at that time, you are spending large amount of time, just waiting to reach to that particular, setting parameter.

So, shorter run up will help you, in this case. So, that you can quickly reach to the required time, require parameter setting an you can start the machining operation. So, ultimately, it is a energy saving without any problem right.

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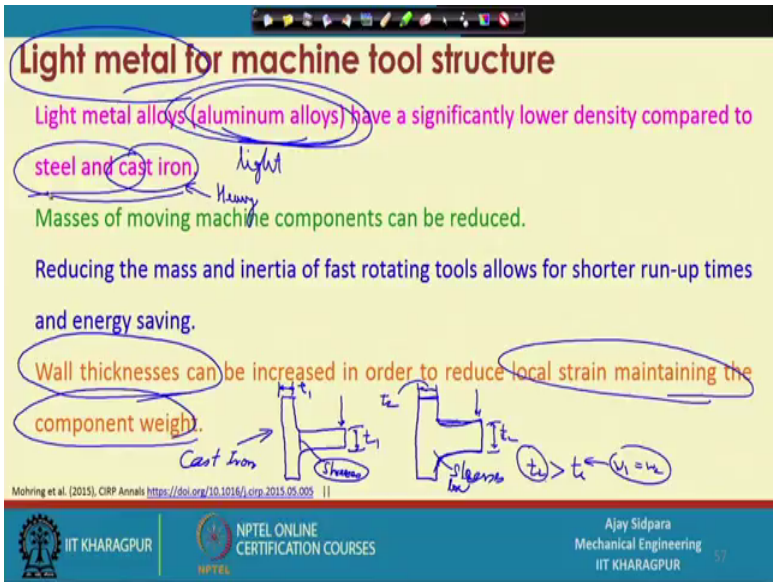

And wall thickness can be increased in order to reduce the local strain, maintaining the [vocalized- noise] component weight. Now, how it will helpful us in this case; now, consider, this is the component, let me draw it again. This is the rib and you consider here your force is at this location ok. This is right now, steel or let us make it from cast iron correct. So, now, this is the thing. So, now, when you are putting this thickness is playing important role here, because whenever your load putting. So, stressing will be very-very high at this location correct.

So, now, this is the cast iron. Now, if you use this aluminum alloy. Now, we know that aluminum alloy is light compared to cast iron, it is heavy correct. So, now, what you can do actually, you can do increase the thickness of the rib. Now, you provide the same force. Now, this t and this t t 1 and t 1, this is t 2 and t 2. So, t 2 is higher than t 1 correct, in this case what you can do that, you can actually increase the wall thickness here, whatever the reduce, the local strain in this case. So, now, your thickness is little bit more compared to the earlier case.

So, your stresses will be expectedly low maintaining the weight of the component, because now, we know the density difference is high. So, even if you increase, this

thickness your weight will not be, increase such a high rate, because there is a density difference. So, weight will be same for both the cases, even though it is a these things. So, that is W 1 equal to W 2 even though you are maintain, if your increasing the thickness of this part.

So, that is the one of the advantage of using, lightweight metal, but you can use these things for some of the components only. Not all the components, because these materials are not very-very useful for some of appli. Some of the components, which can be very-very harmful for this, that time you need to use for steel or the cast iron only to get the things done. So, let me finish this lecture here and let us continue this talk further in the next class.

Thank you so much.