Introduction to Mechanical Micro Machining
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Lecture - 54
Micro machines

Good morning everybody and welcome again to our course on introduction to mechanical micro machining. So, till now, what we have seen that we are using a big machine and we are doing some type of micro milling operation; that means, the size of the machine is not a small scale and the size is almost same as the convection c and c machine or the convection machine which we are using routinely in our workshop and some production unit.

So, now objective of this part, today's class is that what happens if you reduce the machine size itself because we know that we want to fabricate a small component and in terms of few millimeter or few microns only, then why we need a big size of machine because there are lot of problems related to the cost as well as space also if you use a big machine. So, here our objective is to find out; what are the reasons that we can select a smaller machine and we can further improve the space ability as well cost issues. So, let us continue our topic on micro machines.

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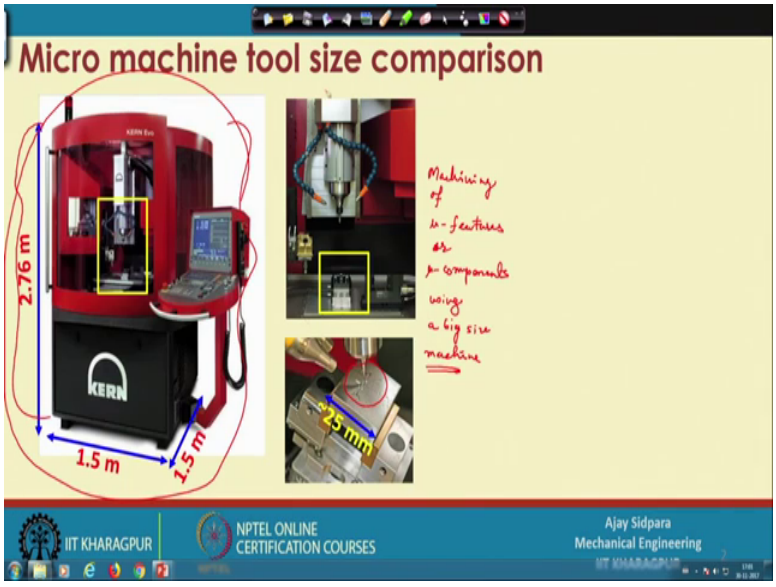

So, what we are doing? So, this is our one of the micro machines which is available with us and now if you see the size, the size is almost height is 2.76 meter and the width and the length is around 1.5 meter in both the size.

So, size is very very high and if you see this particular spindle part; so, this is the spindle and this is the work spice location where you can do some type of micro machining operation and this is the one of the components which is being machined in the same machine and the size of the compound is around 25 millimeter or something; now you can understand that when you want to do machining at this such a scale when you are looking at a 10s of millimeter only, then actually you are using a very large amount of space for doing same thing.

So, what to do in this case? So, what is the problem with this particular system is that machining is machining of micro features or micro components using a big size machine, right. So, this is what is problem because you are cutting a small geometry, but you are using actually very large amount of space in the workshop or whatever production the space you have.

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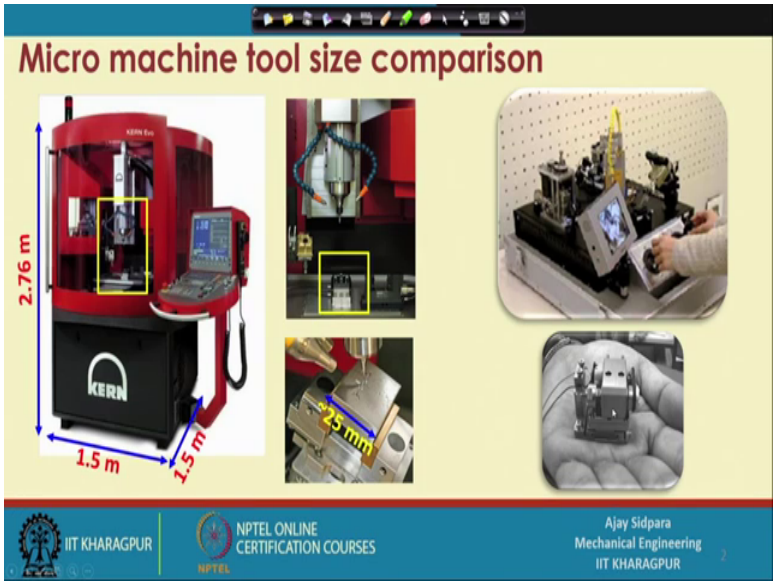

So, now what is the objective of this today's lecture is that what happens that if we reduce the size of the comb machine itself. Now, here you can see the this is a micro factory consist of many different machine, it has a micro milling is a available micro punching is there, then robotic arm is there which moves the component from one

location to another location and this is you consider; this is an lath and you consider micro less.

So, it can do machining turning at a micro scale and you can see the size of this lathe hold. So, it is a almost a palm top size. So, here we will see that what are the different problems associated with this and what are advantages of going with this type of micro machine components or the micro machine itself right.

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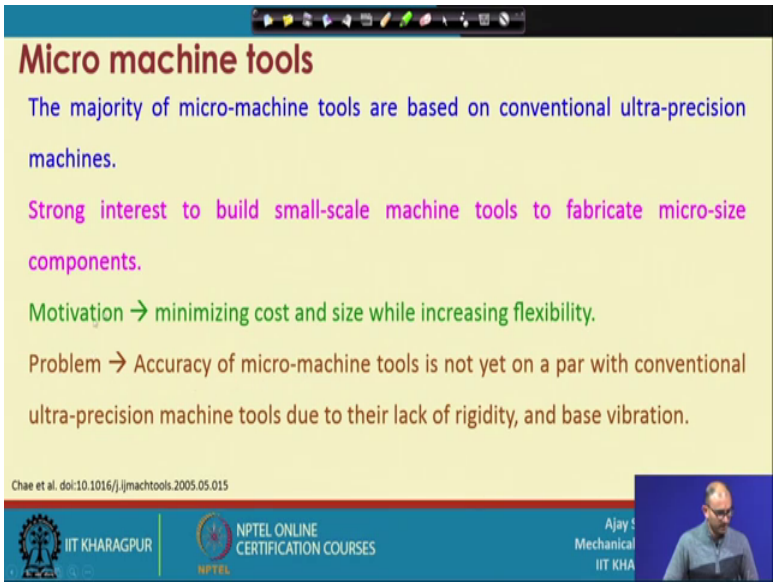

So, what is the today's situation, then majority of the mech micro machine tools are based on the conventional ultra precision machines. So, they have size almost same as the convectional c and c machine or the machine which we are using in our day today life.

So, now there is a strong interest to build a small scale machine tools to fabricate micro components, right. So, now, because we know that we have to get small components only. So, let us try and see that whether it is feasible to reduce the size of the machine also along with the size of the component. So, what was the machinery in the motivation of the doing this thing that it minimizes the cost and size while increasing the flexibility.

So, we will see all the advantages also and some disadvantages also when we go with micro machines, but there are problems also associated with this that because accuracy of the micro machine tool is not yet on a par with the convectional ultra precision

machine tools due to their lack of rigidity and the base vibration because we know that size of the machine itself is very very small.

So, even a small amount of vibration is enough to disturb the whole situation of the com machine tool micro machine tools and rigidity is also very less here because we are going in a small scale of the machine itself we will see this things in more detail in the next few slides right.

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So, why we need this particular micro factories or the micro machines because the measure importance is saving the energy in the manufacturing because we know that if you reduce the size of the component you can save many things. So, let us see this thing the first is a physical plant and its running cost right.

So, here advantage is here that if you reduce the size of the comp machine, then what you can, it will echo; echo, it can be accommodated in a small space of the physical plant. So, that is the advantage of that you can mount more than one machine with its space which is already consume sometimes consumed by the bigger size machine.

So, physical plant and running cost is also low in this case cost to the environment is the because now if the size is very very small, then you can use a small amount of cool hot and some type of temperature related things also. So, environmental point of view also cost is very very less here and difficulty in harmonizing machines and peoples. So, that is

the things which is related to the bigger size machine because if the size of the machine is very big, then what happened that you have to actually move around the work machine and then you have to find out the what things are there and sometimes, it is difficult to operate also when the size of the machine is very very big.

So, at that time it will difficult to actually come mate harmonize the machines and people, but if the size of the machine is small then what happens that you can actually get more closer loop to the machine by operator and some other person also right.

So, when the part to be assembled and the process are small excessive space will be inefficiently utilized and the lead to the higher cost now we know that our components are very small and if it is in the single component it is going to use for the later application then we are just working with a single component, but if there are many components which will be assembled at the later stage then what happens that then you have to prepare assembly session also there.

But, if you do all this thing with a bigger size of machine what is going to happen that actually you are not utilizing the space and the other things very efficiently. So, by using micro factory what we are doing we are actually efficiently utilizing the space and then it leads to the lower cost of the space and some other things also. So, good idea is to use more machinery for production of small parts to better meet the current industrial demand because now you can see the cost of the land is also very very high and if you can install only 2 or 3 machine, then the total output will be the efficient of that machine only.

But if you mount hundred machine like that in a small machine and those machine can do the same work of that three machine then; obviously, your output will be very very high and you can actually increase the total product profit out of it.

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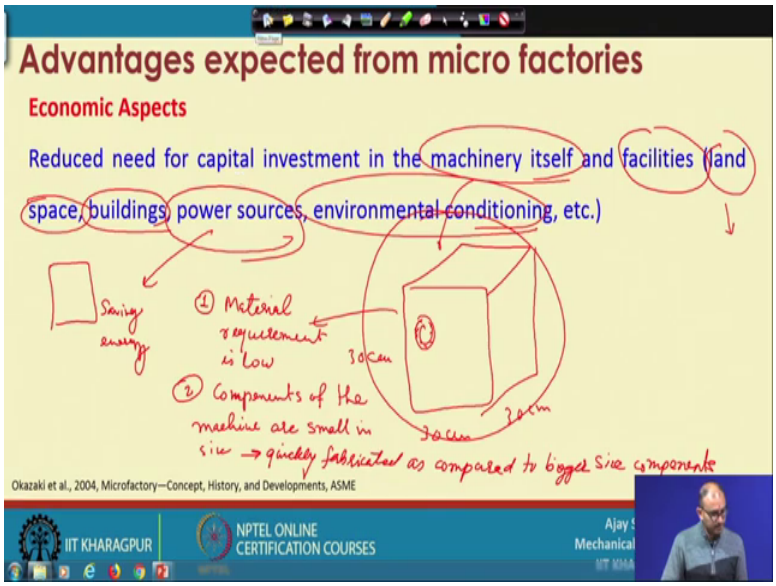

So, let us see what are the advantages of expected from the micro factories because if you see the there are not so many machines available in this particular size of the machine tool, but still people are trying very hard to get these things matching with the convectional machines which are very big bigger in size first thing let us see about the economical aspects that how it is better in terms of economics first thing is the reduced need for capital investment in the machinery itself and the facility something like this. So, land space building power source environmental condition this things are also be very important.

Now, if you see this first thing that machinery itself now why it is that because now if you see that your machine is consider it is in 30 centimeter by 30 centimeter by 30 centimeter, right. So, it is a one foot by 1 foot by 1 foot. Now consider that you want to make something out of it then; obviously, our material requirement is low material requirement is low first thing is that now second thing is there when you become ultimately, this is also machine.

So, you will find all the components which are available in the bigger size machine, but then; that means, you have to machine these component then you have to assemble. So, second is the processing sequence will be very less because now you want to do machining of a very small component.

So, component of the machine are small in size. So, what is the advantage then you can actually quickly easy not easy, but you can actually write the quick because still we are working with the micro domain only quickly fabricated a compared to bigger size component correct. So, this are the advantages going with this thing then related to facility.

Because now you have to spend less money in the land because whereas, small land itself you can start operating this machine land is; obviously, the space is; obviously, related to that thing then space in the building because now it is not that you can directly operate this machine in the operand. So, you have to actually create one type of envelop and that envelop will be very very small power source is a less because now all the motors or whatever rotating elements are available in this case that will require very very less amount of power because the power requirement is very very less.

So, you can actually save the energy saving energy and the environmental conditioning that is related to how you are actually making the space for this particular machines machine can be constructed with the more expensive material that exhibits better engineering property.

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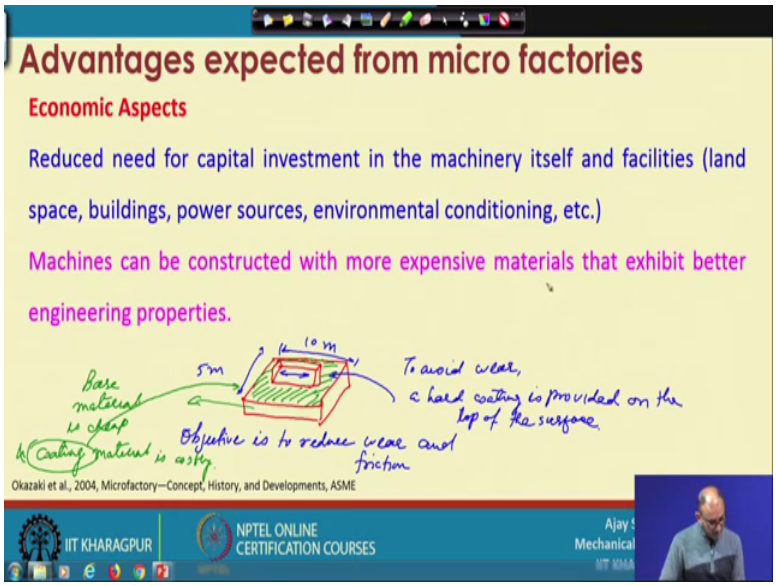

Now, till now what we were doing now suppose we take the example of some type of surface now which are in the relative contact now you can see that this is one surface and there is one surface on the top of that. So, this is the another surface now what happened

that this both surfaces are in relative contact now this is in moving in this direction both the ring.

So, so, there is a very large amount of contact there our objective is to reduce the reduce wear and friction. So, now, there is this material size you consider this size is very very big. Now, you consider this size is 5 meter and this size is 10 meter now because of this size what happened that you cannot actually make this particular component with a very costly material because now what happened that you will now end up with the amounts amount of energy or amount of material which you are putting here it is very large because what happens here that contact is on this top surface only rest of the material does not play any important role in the particular process. So, now, here what we have to do that mostly we do that we provide some type of coating on the top surface.

So, to avoid wear a hard coating is provided on the top of the surface, right. So, we provide some type of coating here. So, that coating is there on the top surface with a few micron thickness and then you can actually reduce the friction and the wear between the two surfaces now here what is the objective of this example.

Now, you can see that your objective is to get this wear friction and wear very very less, but we are using a base material with some type of cheap material. So, base material is is cheap and coating material is costly, right. So, we are using a very thin layer of the coating which is costly and that is what is required to reduce the friction and wear, but now if you say that if you whatever material using for coating if you use the same material for fabrication of this five millimeter five meter by the 10 meter part then the cost is very very high.

But to avoid that cost what we are doing that base material is different which is very cheap, but you are using some costly material here on the top of it that is to save the material, but by saving this material what we are doing we are actually increasing the number of steps required for fabrication of this surface. So, that is the problem with a bigger scale, but now if you see that you know that your material requirement is very very less here. So, now, this thing that the; we are actually using very very small component, right.

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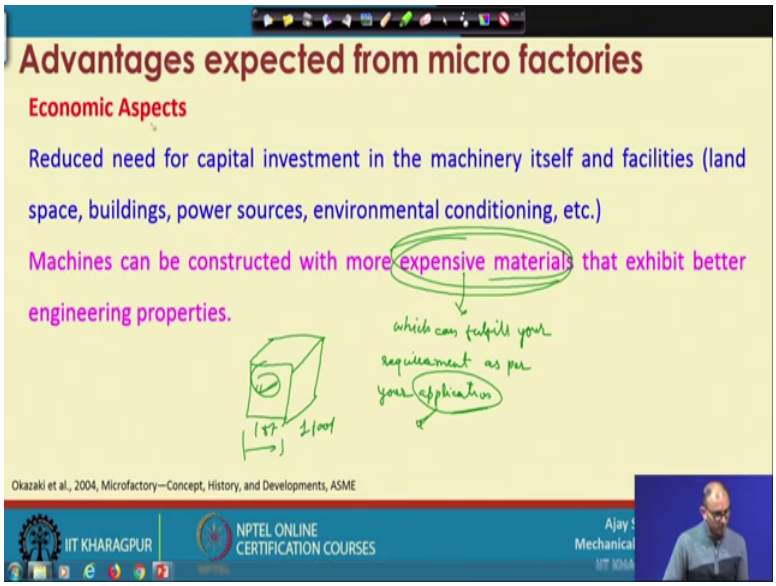

So, component requirement is suppose it is this is the component and now you see the this component is again the same thing we have what we are discussing, let us consider 1 foot by 1 foot by 1 foot in all the cases.

So, now the size is very very small. So, you can go with the expensive material why expensive in this sense that which can fulfill which can fulfill your requirement as per your application, right. So, here suppose there is a this particular application related to the two surfaces which are in contact then you can use a some type of material which are very very very very high in terms of the wear resistance.

And if there is a bending of that then you can actually use some material which are very very high resistance in the bending forces or something like that m; it is hardness you then you can you sometime very very hard material. So, here your objective is that because we know the system is very very small.

So, you can actually select some material without spending in terms of in terms of coating or some type of post processing of the component you select the base material instead of with very co expensive part and which can fulfill your requirement. So, our objective is that here you can satisfy all your requirement related to the rigidity of the component and the wear stability and the temperature controlled also.

Because sometimes we know that a temperature also play important role in our case and we can select some materials which are very very low thermal coefficient of expansion. So, those materials are very very costly if you fabricate something at a bigger scale, but here you can directly purchase those expensive material and make the whole structure out of it. So, you can do temperature compensation without any problem right.

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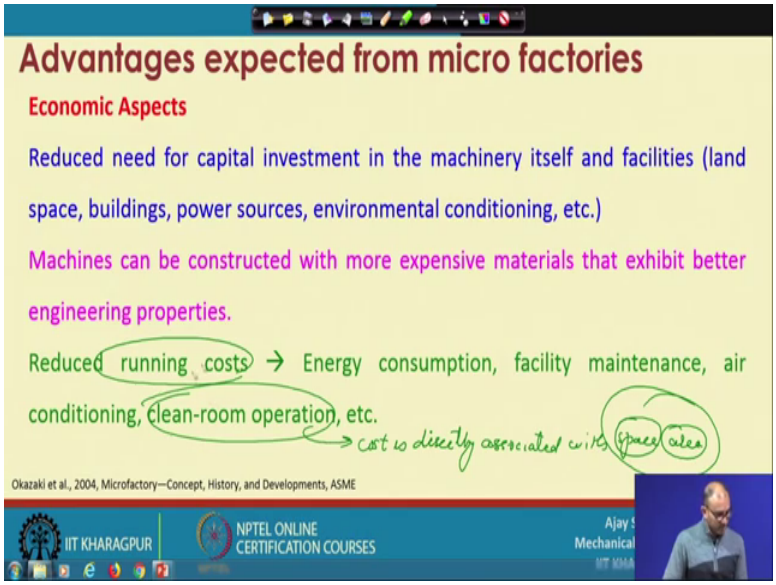

So, reducing the running cost because now we know that energy consumption is very very less because size of the motor is very very small then facility maintenance is also no issue that is you can easily get this thing done air conditioning is very less because now the space required by the machine itself is very very small and the clean room operation because now clean room operation everything depends on what is the area you are maintaining right.

So, the cost of this clean room cost is directly associated with a space area right because now you suppose, you are maintaining a class 1000 or 10,000 of cap particular rating, then what happen that the area depends on the if the small area, you have to maintain at that level then the cost is very very less, but the cost will exponentially increasing.

If the area increase because now you have to maintain the number of particle dust particle count the humidity temperature and some other things also at that time the requirement of the cool clean room is very very high with respect to area. So, here you can see the total running cost because we are considering all this parameter as a machine

parameter and. So, total running cost includes the machine consumption also what amount of energy and the cost you are spending into the facility maintenance also. So, your total running cost actually reduce very very drastically down and that is the advantage of using micro factories.

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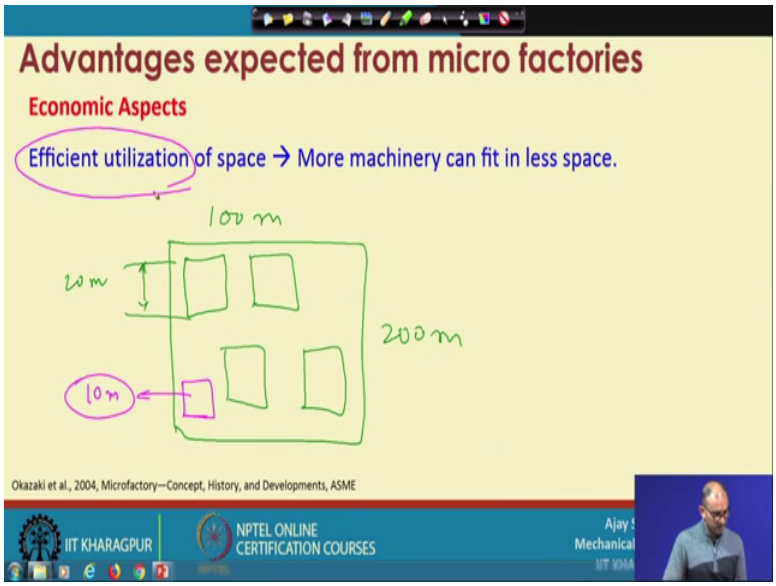

Some further advantages that efficient utilization of the space more material machinery can fit in a less space.

Now, we know that our object we have a one big space available at suppose; this space is around 100 meter by 200 meter. Now, if you see this space and you have some machine which are very very big in size. Now, if this you consider that 20 meter in size in both the direction, then what you can do the actually, you can put only 2-3 machine because you have to provide some space for the material handing also, then cleaning also you required.

So, consider you can maximum, you can put 4 to 5 machines here, but now, if you see that if you reduce the size of the machine. Now, you can actually put many machines there suppose now the size is very very small. Let us reduce this thing to the only 10 meter only still it is only big, but still let us see the in comparison of this if it is a 10, then you can actually multiply by two this term directly.

So, smaller the size you can put more machine into that. So, it can efficiently utilize the space for at each and every machines, right.

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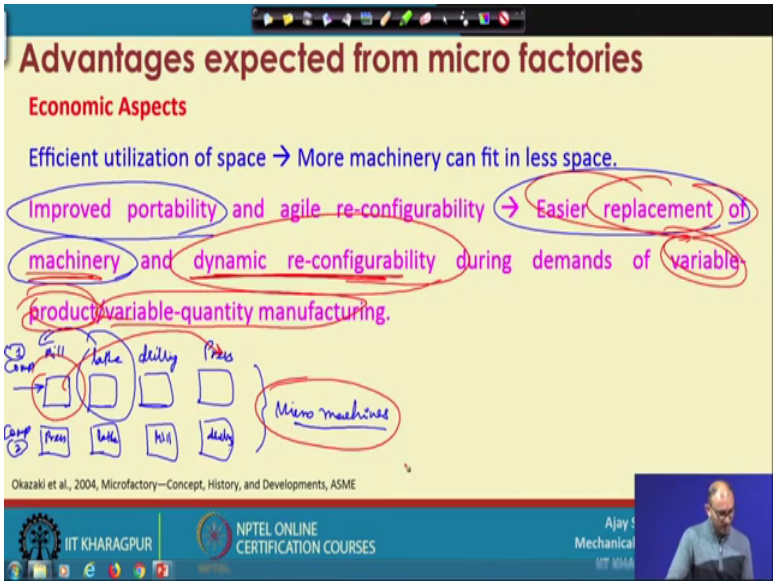

Improve portability and agile re-configuration re-configurability easier replacement of machinery and dynamic re configurability during demands of variable product variable quantity manufacturing.

So, what does it mean that suppose you have a small machines here now consider this are placed at different locations, you consider this is a milling machine layer, this is a drilling this is press and the same way, but we let us change the sequence because now consider that the one product is compound is going in this direction this direct see the component one, it is a sequence of this operand the first is first it will pass will milling lathe drilling and the press and then component cu two it has some different sequence that is what it is consider this is a press this is the lathe again.

This is a milling and this is drilling. So, this are the small small machine. So, this is a micro machines correct. So, now, what happens that it is a improve product portability; so, easier replacement of the machinery. Now see that this is the one component and this is the second component. So, one component consider, you have thousands of this component.

So, it is computing this thousand cycles completely now you are coming with some other component which has a different shape and for different shape what you have to do that you have to actually move the this machine in such a way that you fulfill the sequence of the operation. So, this is going here, then this particular milling machine is going at the last operation. So, now, what happened that when the size is small you can easily actually replace the machine with a other machine.

So, here you would do not require any type of problem in the handling about the movement of the machine and dynamic re configurability because now as per your demand now it is a variable product now we are changing the products you can easily strip the machine according to your requirement and variable quantity manufacturing now suppose one component you are making 50 only.

So, you can give less importance to that sequence, but suppose one component you are making in thousands of that then you can easily actually reconfigure the location of the machine and this will not take much time because all this things are very very small. So, you can do two things together one is the easier replacement of the machinery and another is the dynamic reconfiguration when you have a variable products and the variable quantity manufacturing. So, movement is not a problem here you can easily maintain all the things together.

So, that is the very big advantage here because if you see our convectional; that means, the micro machine at a conventional size; that means, that a meter scale size once it is installed movement is very difficult because we know that there are many issue must things which are actually demands very very high precision and no any type of vibration or no any type of disturbance from the outer impact.

So, when you move those big machines at that time; there is a chance that it may actually create some problem at the assemblies or the some type of structural problems. So, at that time mostly once machine is installed it stay there only for the rest of its strip, but that is not the situation here because size is very very small and movement will not take more than one person to move that machine from one location on the location without any damage to the components right.

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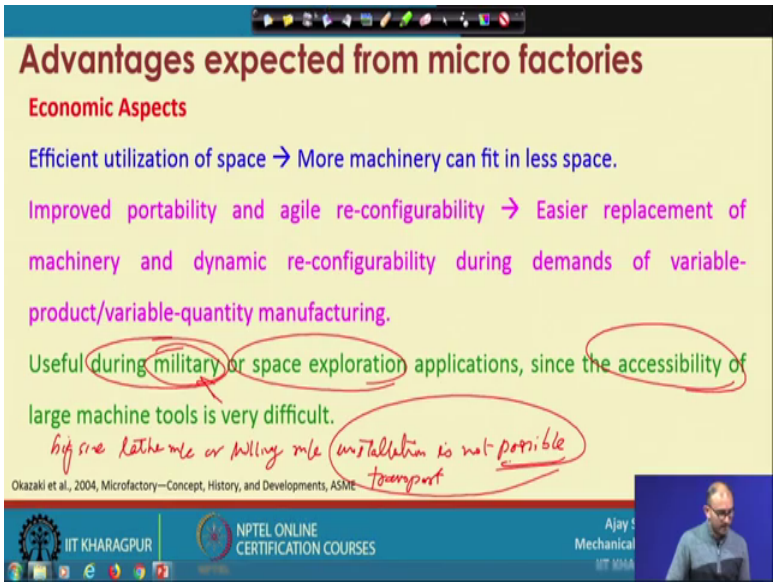

So, useful during the military or the space exploration applications since, the accessibility of the large machine tool is very very difficult. Now, these example very very important here because we know that this are the two locations where the size matter size and the what is the volume. So, here a suppose there is a some type of military operation going on at that time there are some machine or weapon or which are damage because of the some type of attack.

So, now you want to replace some small bolt or some you want to do some type of tube fabrication or something at a very very small scale, but you cannot move this lath machine and milling machine lathe machine or milling machine big scale big size machine installation is installation or transport is not possible right. So, these are the applications where it is very difficult to move this particular lath machine or any machine not related to this particular two machines only.

So, you it will take lot of time also to transport those machine and then it will create lot of problem at the later stage. So, if you has this type of palm top machine or some type of suit case size of machine, then what happened that you can easily transport that machine to that location only and right in the field of the that location, you can directly fabricate those components which are damaged or which are not in the operating condition.

So, here advantage is very very high ; that means, you can transport the machine very easily you fabricate the component there itself and directly assemble there so, without any problem. So, here there is a accessibility is the problem with the big machine and other than this two; there are different type of application other locations also where you can actually get the things done very easily by this small machines right.

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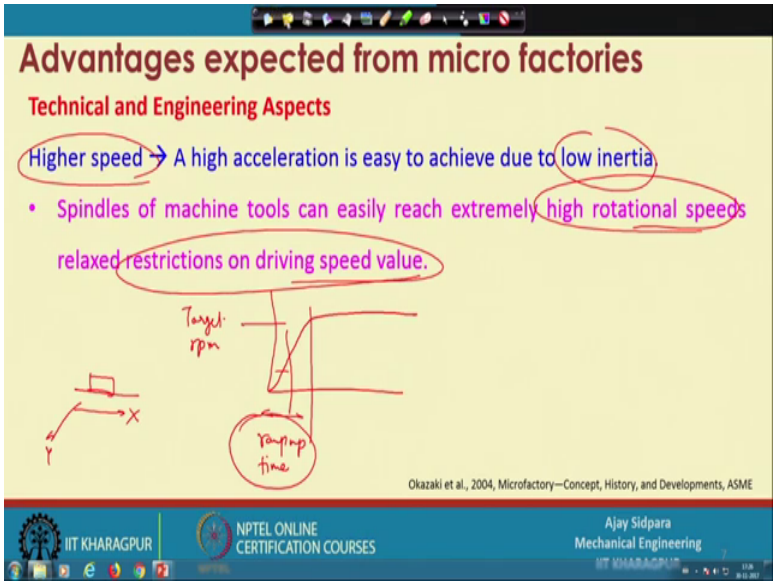

So, now what are the technical and engineering aspects till now we have seen that how it can save the money and the time only so, but now we have to look at the technical aspect also first thing is the higher speed.

Now, we know that size is very very small of this machine that is the advantage because now you can go with a very very high acceleration without any problem because we know the low inertia will create a high acceleration, you can easily reach to the required r p m without any problem.

So, spindles of machine tools can easily reach extremely high rotational speed relaxed restrictions on the driving speed value and we have seen that in micro machining our speed should be very very high and to fulfill that requirement; what we need that we need a very very high rotational speed and we have also seen that if the size is very very big, then what you have to do that you have to give some type of rap up time because it is not reaching directly to that requirement part.

So, we have seen that initially it is increasing rpm and then it will actually reaching to the target value target rpm right. So, you have to spend this much amount of time let it be in few seconds only.

So, this is the ramp up time right. So, this much this time will be less if you have a low inertia and you can quickly reach to this location and then you can start the operation. So, and other than that you are not restricting the driving speed value this is not only highest speed related to the rpm only, but you can quickly move on to component because our objective is to move this component in the x direction and the y direction also.

So, if you have a small travel stroke; that means, you can easily or quickly move this component. So, total time requirement for the machining of this component is also very very less because you are quickly moving in x, y and z direction and your rpm of the spindle is also very very high right productivity can be increased by dense and highly parallel allocation of the machinery that.

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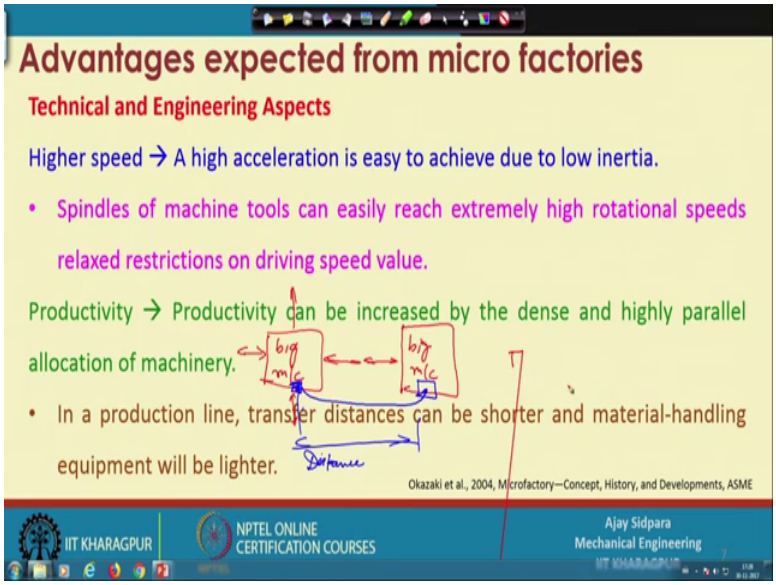

We have seen in that earlier example that in a same area, you can put many machines similar type of the different type also, suppose, you are using a very big milling machine for micro machining, but you put this type of small five milling machine within the same area and then you can do the operation. So, it is very very dense structure so; that means, the number of machines, you are putting at the same areas are very very large here and

you can put the highly parallel allocation of the machinery. So, you put many machines in a line.

So, you can actually utilize the all the machines for a different different operations and without creating any problem at the later stage. So, this are the advantages of the going with the micro factories in a production land transferred distances can be sorter in the material handling equipment will be very very lighter.

So, this is another advantage because we know that suppose we have one big machine here then you have to maintain some space here right. So, this is the space requirement here on all the side to make sure that this machine is accessible to from all the side for different different regions. So, now, this is the thing and then you have to mount the another machine which also require some space between these two.

So, this is the another machine big machine big machine. Now you are fabricating one component out of it. So, this is one component which you have fabricated and you want to transfer this component from here to here. So, now, you are thing is that you have to move this much amount of distance and then you can actually start doing operation at the next machine.

So, your production land will be very very large because now if you consider this is the two machine and there is a third machine again then the size which is occupied by this particular machines then it is also large transferred distance is large because now the you have to kept some keep some machine special between these two and that will be also large and material handling equipment should be also large in this particular because now you have to move it away from this location; this location as some times the component is also very large.

So, if that is the case in the bigger machine. So, if you see the smaller machine here now this is the small machine.

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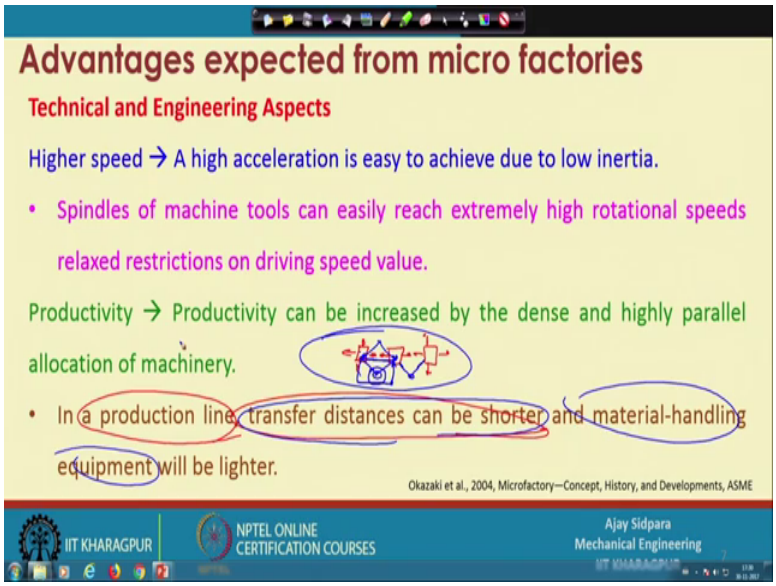

This is the small machines now the space requirement from this side also it is you require some space from a, but this space will be very very small in this case. So, what is important thing here is the production line you can put many machines here, transport distance are shorter because now your component will be moved from here to here some times, what happens you do not required some type of movement comp moving compound.

So, something like a robot or something you need one station here which has one I am meet, I am will pick up this part and then it will move directly ; that means, you do not require any robotic or this station or something which will pick up this part and then it physically moves to this location and then it will plot this thing.

So, sometimes what happen that sometime transfer are more something important or sometime something like that material handling equipment which you can directly feed this thing somewhere permanently and then it will do all the movement from here to here without any type of physical movement of that equipment; it is just moving the component only from one location to another location.

So, here what happens that you are not only saving the space and the money in terms of the machine, but you are actually saving money in terms of the auxiliary operation. So, this transfer of the component from one location another location is considered auxiliary operation because many times you do not require this thing everything you are doing in

the seem single machine, but many times you are using some type of operations which are in sequence and that should be performed by the different different machine. So, at that time you need this type of material handling and the transport distance for the different different regions. So, these are the advantages of going with this part.

So, we will continue this lecture further in the next class. So, let me stop it here and we will see that what other things are there in to the next part.

Thank you very much.