Fundamentals of Manufacturing Processes
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Lecture - 37
Material Removal Processes: Chip Formation

Hello, I welcome you all in this presentation related with the subject fundamentals of the manufacturing processes. And we are talking about the machining processes. And in the machining processes in the last presentation I have talked about the mechanism of the chip formation or mechanism of the material removal.

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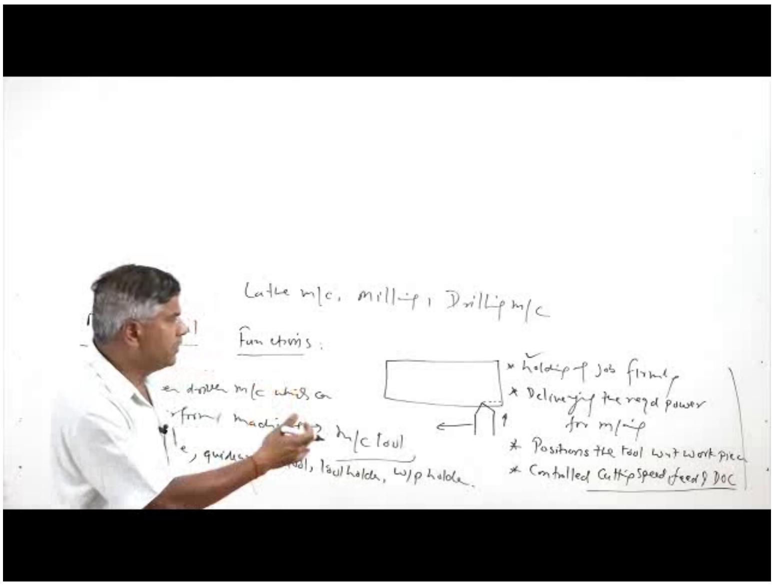

But for the machining purpose, we need to use a machine tool. Machine tool may be in form of like lathe machine or a milling machine or a drilling machine. So, these are the various kind of machines, which are used for the machining purpose conventional machining purpose.

But they play a very specific role in the machining and that the functions or the role which is performed by any machine tool includes like the job will be held in a particular position. So, the first one is holding of the job or the work piece firmly. This is the one main important role which is played by the machine tool another so that it is secured and is able to with his stand under the cutting forces during the machining without getting disturbed from it is position. Another one it will be delivering to delivering the required power, actually this is needed for ensuring that machining takes place. If the required power is not available to make sure that machining happens, then there will not be any metal removal or the metal cutting.

Another thing is that it positions the tool with respect to work piece and that position is maintained in such a way that like say for the turning process the position of the tool will be maintained at a particular position and we will removed in linearly. So, if the position of the tool is not stable, it then we will not be getting the geometry of the surface of geometry of the work piece as desired or similarly the roughness and the dimensional accuracy will be badly compromised, there will be very much compromised.

So, the position of the tool must be maintained and it should removed along a particular line a particular direction a particular line only. And for that it should have in to the machine tool should be able to deliver the controlled cutting speed feed and depth of cut. So, these will be able to these will help in removing the material in very controlled way from the a stock material, in order to get the desired size and shape. So, any machine which is able to perform these functions can be termed as the machine tool and in more general generic terms.

Any power driven machine which can perform, must which can perform machining or the metal cutting can be termed as machine tool. So, it the it has a number of systems. Means machine tool will have the number of systems like the power drive and the guide ways for tools movement, tool holder work piece holder, and likewise number of other attachments are normally provided in the machine tools so that these 4 functions can be effectively performed by a machine tool like holding of the job.

Or the work piece firmly so, that it can withstand the machining forces delivering of the required power during the machining so that the metal cutting can take place. And positioning of the tool with respect to the work piece appropriately so that required size shape and finish can be achieved. And controlled the machine tool should also be able to give us the required cutting speed feed and depth of cut. So, the controlled conditions of the metal cutting can be realized. Now apart from the metal cutting today in this presentation we will also try to talk about the classification of metal cutting processes based on the process, based on the tool geometry and the way by which it interacts with the work piece.

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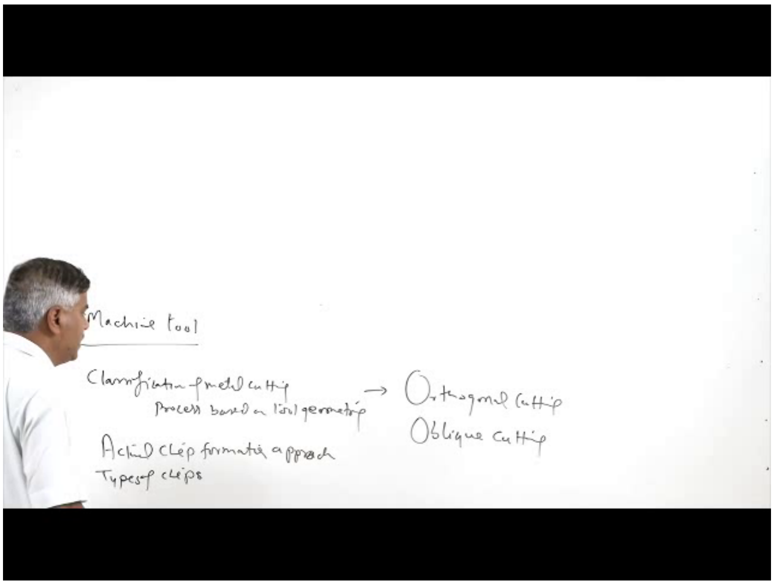

So, this one is like orthogonal cutting is one, and oblique cutting is another. And the another aspect which we will be talking in this presentation, will be about the actual chip formation approach or the mechanism which slightly differs from the ideal approach which we have talked in the last presentation. And then the different types of the chips which are produced during the metal cutting. So, type of the chips which are produced during the machining, about that also we will be talking about. So, the after the machine tool the classification of the metal cutting based on the orthogonal, based on the tool geometry or geometry of the tool which interacts with the work piece can be classified as orthogonal cutting or the oblique cutting.

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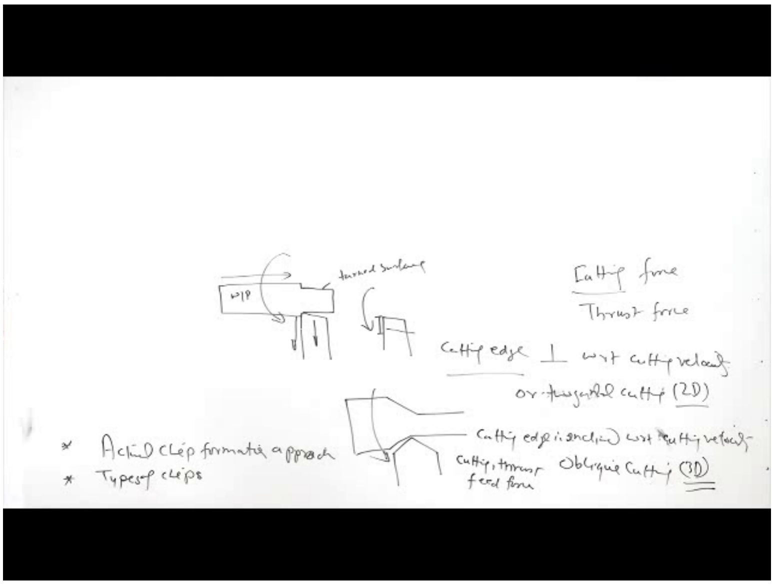

So, say we are using a tool of this kind for the turning purpose like this. So, this is the turned surface and this is the work piece, and the region which is react to be turned. So, if we see here the interaction between the cutting edge, and the work piece is like this. Here cutting edge interacts with respect to the cutting a speed or cutting motion this interaction is at 90 degree. So, the cutting edge when the cutting edge is oriented at perpendicular with respect to the cutting velocity or the cutting direction.

Then it is termed as ortho, ortho, gonal, gonal cutting. While in another case when the cutting edge is inclined at a certain angle like this with respect to the cutting velocity. So, cutting edge is inclined here will be then example of the oblique cutting. So, in this case the cutting edge is basically inclined with respect to the cutting velocity direction so that will be termed as oblique cutting. Basically orthogonal cutting is also termed as 2 dimensional cutting.

Because the of mainly the 2 kinds of the forces acts one is the cutting force, the force is acting the 2 directions one is the cutting force and another is the thrust force. So, thrust force will be acting in this direction and the cutting force will be acting in the downward direction. While in case of the oblique cutting, the which is termed as the 3 a dimensional cutting means the 3 the forces during the cutting will be acting in the 3 directions, one is the cutting force, another is the thrust force, and third is the feed force.

So, under the identical conditions, if we see compare the orthogonal cutting and the oblique cutting. Then we will find the for same depth of cut same feed rate and the same cutting a speed. The interaction area between the work piece and the tool is more in case of the oblique cutting than in case of the orthogonal cutting.

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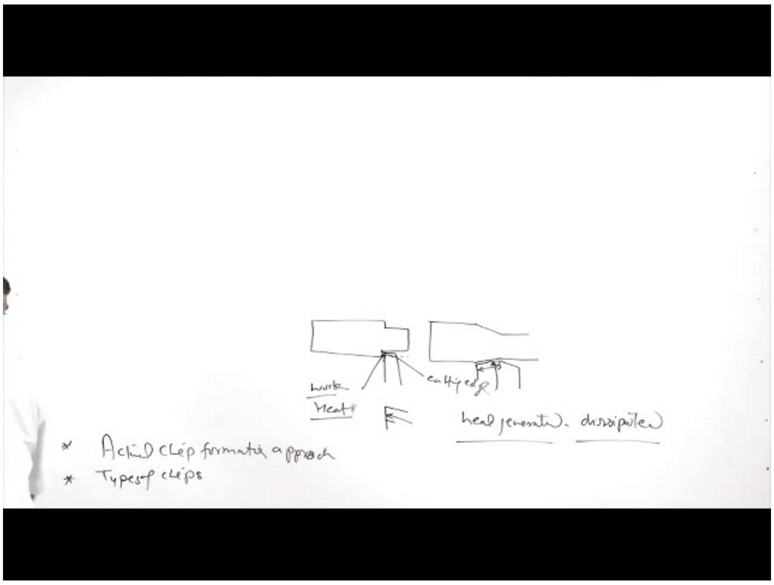

Say this is an example of the orthogonal cutting like this. So, for the same depth of cut interaction for the same depth of cut the interaction between the tool and work piece will be taking place along this cutting edge. And for the same depth of cut if we draw it like this for the oblique cutting, and what we will notice that for the same depth of cut the interaction between the cutting edge and the work piece will be over the much longer area. So, this is the cutting edge which is interacting with the work piece.

So, in this case for same feed same depth of cut and same cutting speed what we will notice that the interaction in this case is ma over a much larger area larger length of the cutting edge as compared to the orthogonal cutting. And because of this under the identical conditions of the speed feed and the cutting speed, the cutting forces the force is acting on the cutting edge, will be distributed over a greater length in case of the oblique cutting. So, the stress in on acting on the cutting edge in case of the oblique cutting is less than the orthogonal cutting. So, from this explanation it is clear that the orthogonal cutting will be experience in the higher stresses.

At the cutting edge than the oblique cutting under the identical conditions. Therefore, the cutting edge the cutting life will be means the tool life will be less for the orthogonal cutting as compared to that of the oblique cutting. One more thing here whatever heat is generated is localized to worry over a very small length in case of the orthogonal cutting, because under the identical conditions some work will be done that will be converting into the heat, and heat will be localized over a much smaller area in case of the orthogonal cutting as compared to the oblique cutting.

So, more while in case of oblique cutting, the heat generated will be dissipated through the larger contact length between the work piece and the cutting edge. So, the this dissipation of the heat or heat transfer from the cutting edge cutting zone to that tool will be much faster in case of the oblique cutting as compared to the orthogonal cutting. So, the cutting edge will be at the lower temperature as compared to that of the oblique cutting. This is what we can see here.

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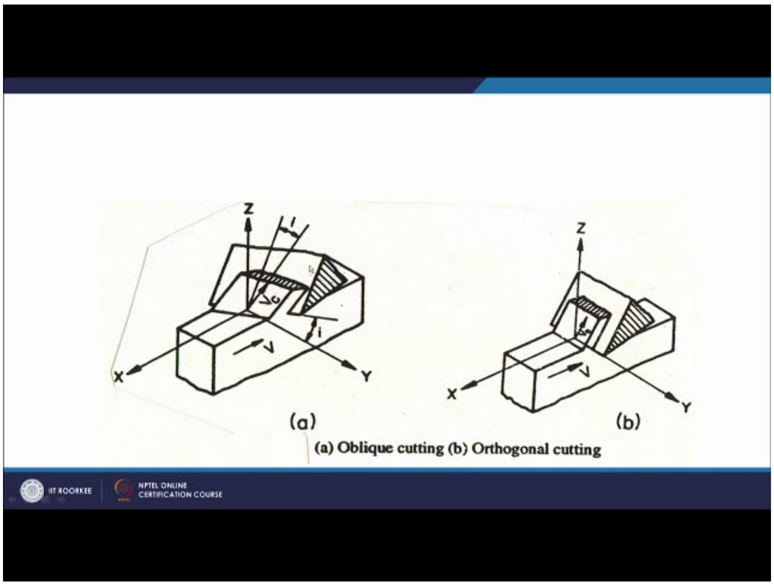

This is the same the figure here where this is the tool and this is the cutting edge cutting edge is inclined, with respect to the velocity direction. So, this is the case of the oblique cutting wherein the forces will be acting in the 3 direction, that these are the x direction y direction and the z direction.

While in case of the oblique cutting sorry in a orthogonal cutting. The direction velo or cutting velocity direction is this. And the cutting edge is perpendicular to the direction of the cutting. So, this is an example of the orthogonal cutting.

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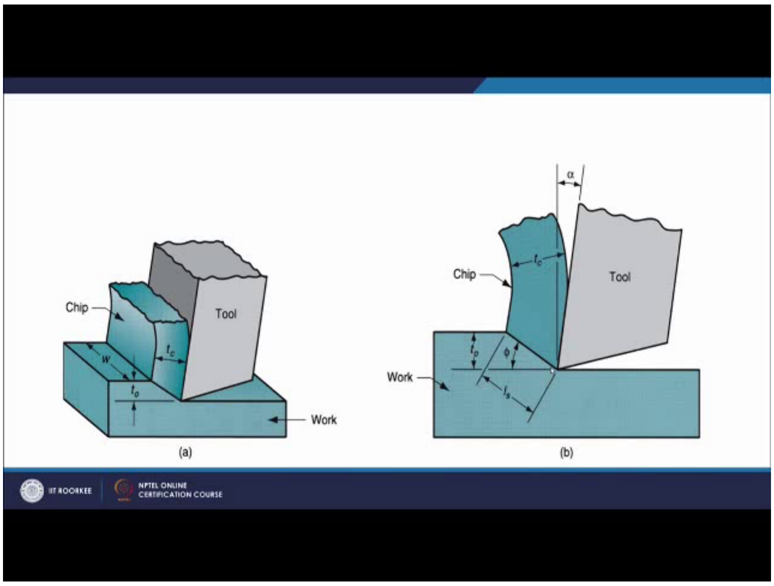

So, in orthogonal cutting if we see the same thing the same example, but in the 3 dimensional image here, we see this is that this is the cutting edge that the cutting edge is running all along this width and this is the clearance this is there will be the rake and the this is the plane along which shearing will be taking place, this is the uncut depth, uncut chip thickness and this is the width of the cutting edge as well as the width along which the material will be removed during the machining.

So, in the 2 dimensional diagrams, same thing can be represented using this diagram. So, here angle phi is the shear plane angle that t naught is the uncut chip thickness, and t c is the cut chip thickness. Alpha is the rake angle and this is how we can see. So, here the width is important to see in the 3 dimensional view. Because this otherwise we do not get in case of the 2 dimensional figure. So, this width needs to be considered while calculating the shear area. So, means this shear plane length multiplied by the width will be giving us the shear area. So, in that case what we need to do the shear plane length is L s this needs to be multiplied with the width. So that L s into w will give us the shear area. And this shear area if multiplied by the shear strength of the material then we will get the force required for facilitating the shearing process.

So, this is how we can understand the things about the shearing which will be occurring actually in case of the real tools with the help of 3 this three dimensional diagram.

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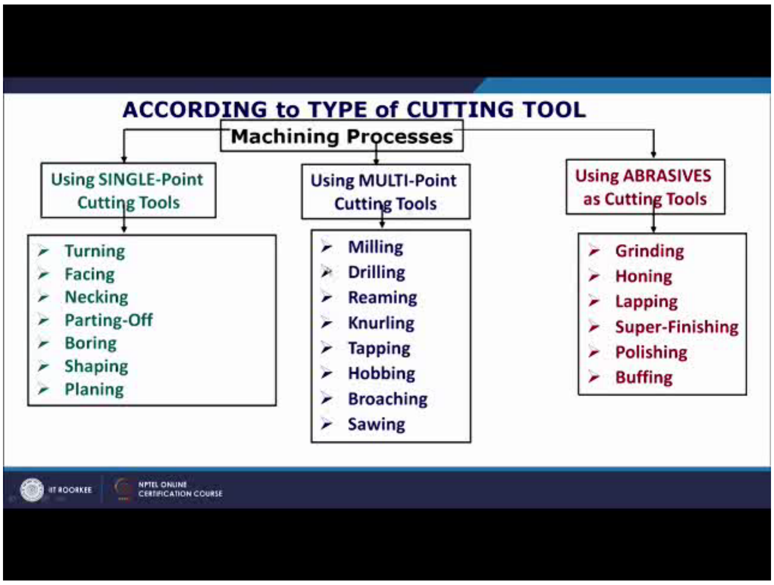

These are the processes based on which you see this classification is based on the like that normal kind of the tool, which is being used a single point tool and multi point tool or abrasives. So, these are the processes which are which will be using the single point tool the other processes, which will be using the multi point tool and the abrasive based processes. So, turning facing necking boring shaping planing etcetera, use the single point cutting tool while the multi point cutting tool is used by the milling, drilling, reaming, knurling, hobbing, broaching, shine etcetera and Abrasives are used as a cutting tool in the grinding, honing, lapping, polishing, buffing and other super finishing processes.

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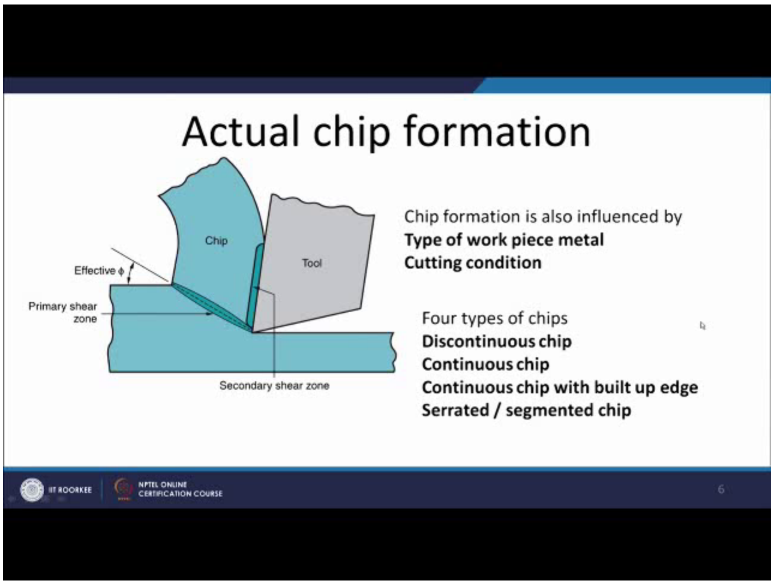

Now, if we see the last time what I have explained that if this is the work piece material which is to be re machined.

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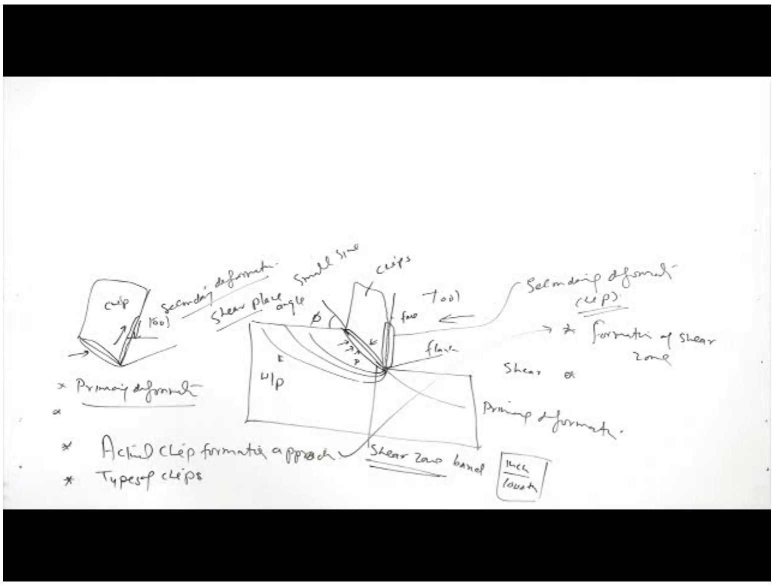

This is the plane along which shearing is taking place this is the tool and this is the flank. So, this is the face of the tool this is the flank and this is the machined surface of the work piece. So, the shearing will be taking place along this particular plane and after shearing of the chips will be coming off the surface like this. So, these are the chips which are being formed. And but at a material you see due to the relative motion between the tool and work piece.

So, basically this is tool and this is work piece due to the relative motion between the tool and work piece the material head of the cutting edge is compressed are stressed like this. So, the zone which is very close to the cutting edge will be subjected to the plastic deformation. And another zones which are away from the cutting edge there will be under the elastic deformation in a deformation initially, but as soon as the tool approaches towards the regions away from the cutting edge.

There will also be under the plastic deformation. So, as soon as the stresses in the material or exceed the shear strength of the material along a particular plane which is called a shear plane The material gets sheared off and the chips starts forming in. So, this is the ideal case, but according to this one the shear deformation will be taking place along this line only, but actually the shear deformation occurs does not occur instantly, but it occurs over a zone or of a certain size. So, may be the shear deformation is starts at this is zone and then at the along this boundary and the it ends here. So, basically shear a actually the shear zone is a kind of band of a certain thickness of the micrometers this is very small in size. But is still the shear deformation is starts is starts over a certain boundary line and then it ends after certain line. So, this z1 over which the shear deformation occurs is called the shear zone and this is not actually one plane, but it comprises one band.

Since the this is of very small in size. So, for all analysis purpose it is considered as one plane and which gives us a quite accurately good results for analysis of the metal cutting purpose. And this angle along which the shearing takes place is a designated as a phi and is known as shear plane angle, shear plane angle. So, actual deformation actually actual shear formation basically involves the formation or the shearing along a particular zone or the band not necessarily at just one plane. So, formation of the shear zone means the shearing occurs over a zone of the certain size, and then after getting removed when the chips will be flowing.

So, this is the one shear which is facilitating the removal of the material in form of the chip from the work piece, while the chip material after getting removed under pressure it passes through the face of the tool like this. So, since the frictional where during the movement of the chips over the face of the tool under pressure some kind of the deformation also observed along this zone. So, this is called secondary deformation. So, deformation in the at the chip tool interface the deformation occurring at the tool chip interface especially, at the especially in the narrow region of the chips is called a shear deformation.

So, the there are 2 deformation zones during the metal cutting which are formed, one is the primary deformation zone along which shearing takes place and the chip is formed. And so, this one is basically the primary deformation zone. And another shear deformation takes place at the tool chip interface which is termed as the secondary deformation. In order to and in this case basically the deformation of the chip which is in contact with the tool rake face sliding under the pressure gets deformed.

So, basically there are 2 zones this is one zone where the shearing will be taking place will be termed as a primary deformation zone, and this is another zone which is the secondary deformation zone. And there is a third aspect related with the actual chip formation and which is that the chip formation is also affected by the work material.

So, because theoretically in the orthogonal model of the chip formation what we have assumed that the shearing takes place along the one plane, and there is no other form of shearing, but actually the shearing takes place over a particular zone. And then there is a secondary shear also apart from that the chip formation is also affected by the work piece material. Whether it is hard brittle or it is ductile. So, this is one aspect. And the second is the cutting conditions also effects the chip formation cutting conditions. So, this includes like the cutting speed feed and depth of cut.

Both these factors all also affect the chip formation actually during the metal cutting. So now, I will summarize this presentation here. In this presentation I have talked about the machine tools and the actual chip formation approach. We have seen that the actual chip formation approach is found different from the ideal chip formation because here in actual chip formation approach. The shearing takes place over certain zone and the shearing also takes place between the tool rake face and the chip. So, these 2 will be leading to the additional deformation which will be needing the additional power requirement during the machining.

In addition to that chip formation is also affected by the cutting conditions and the work piece material.

Thank you for your attention.