Fundamentals of Manufacturing Processes
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Lecture - 32
Metal working processes: Sheet Metal Operations II

Hello. I welcome you all in this presentation related with the subject Fundamentals of Manufacturing Process and we are talking about the sheet Metal Operations.

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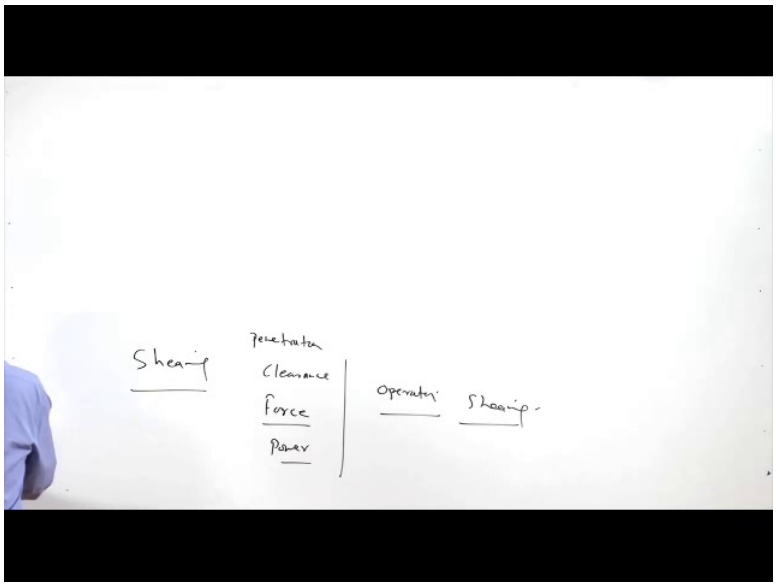

In the previous presentation I have talked about the mechanism of the shearing which is used for metal cutting in the sheet metals here we I have I have talked about the role of the penetration and the clearance. So, apart from this we also need look into the force and the Shear force which is required and the power consumption in the shearing and there after we will see some of the operations related with the shearing like shearing based operations the punching, blanking, nibbling, notching, shaving, etcetera. So, those things will be seen.

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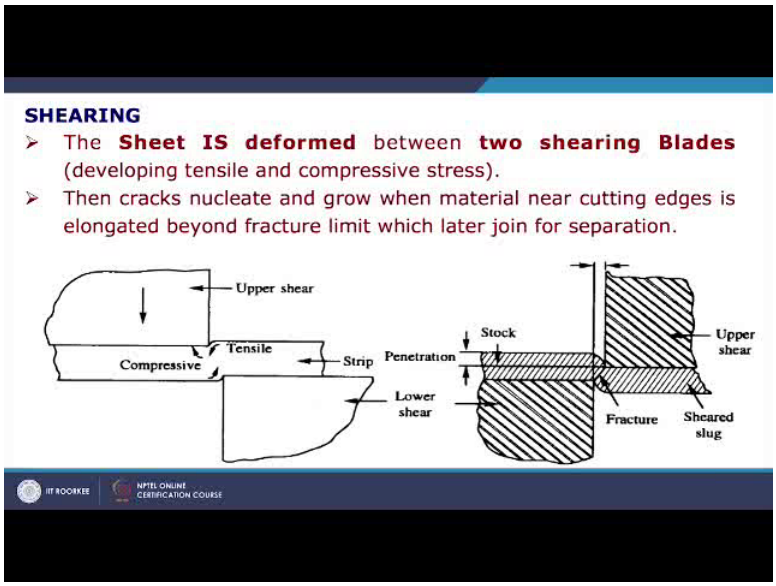

So, we will go through the slide some of the slides first regarding the effect of the clearance. So, this is what I have already said that in the shearing; we used one die and punch; there is a upper blade and the lower blade when the punch move is down the strain is generated into the sheet metal and when it crosses the cracks nucleate; both the sides here and then their propagation leads to the shearing and the separation of the material.

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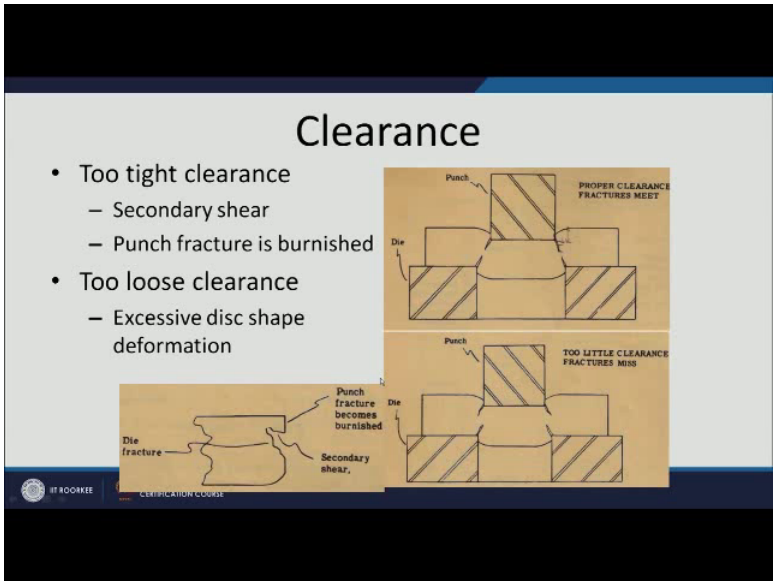

So, here when the clearance is the optimum, then what we get and when the clearance is improper then what we get.

So, this is the case when the clearance is optimum then all around the circumference the cracks will be propagating from both those edges from the lowers side of the punch and the upper side of the die and here into the sheet metal and this; they will be meeting at the center when the clearance is optimum when the clearance is tight, then it will be leading to the secondary shear where the cracks will be growing from the both the sides, but they will not be meeting at the center. So, this leads to the very rough and rugged surfaces when the clearance is too loose means the gap is too wide it is not than optimum one, then it will be leading to the more disc shaped deformation and so that will also not be the required one.

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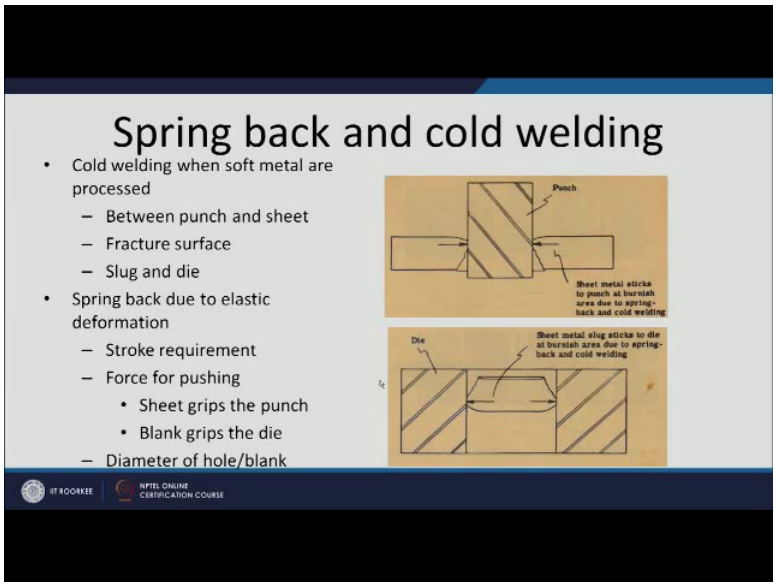

So, this is the kind of the secondary shear edge which will you produced and will be more refer as compare to what will you; what roughness we will be produced when the clearance is optimum.

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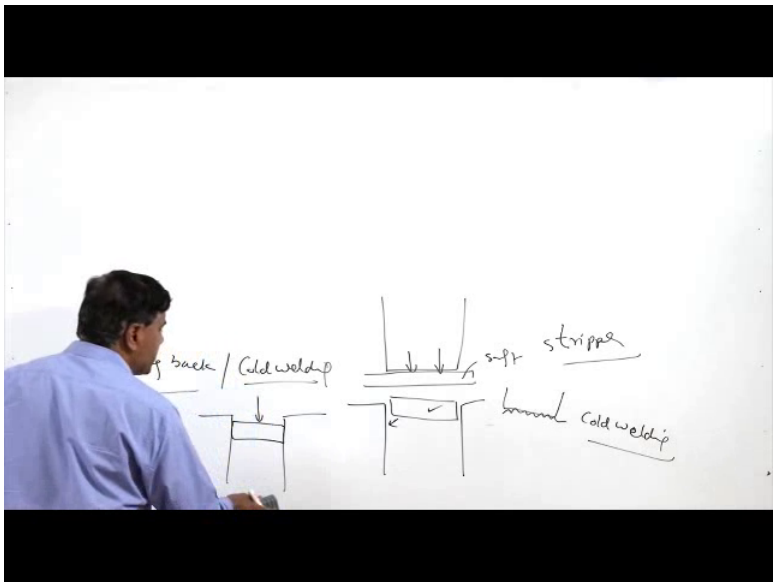

Spring back is another a phenomena where in spring back and the cold welding these are the 2 another important things like in case of the spring back and the cold welding spring back and cold welding; these are the 2 different phenomenas like this is the punch when it comes in contact with the sheet metal. So, if the sheet metal is soft punch puts in lot of the compressive stresses compressive force on to the sheet metal and because of this sometimes the sheet metal gets embedded with the surface of the punch and even under the low temperature conditions. So, this is what is called cold welding and because of this cold welding the even after the shearing the slug may remain attached with the punch or the after removal the die may get or the slug may get attached with the slug also.

So, these are the 2 issues. So, because of this there will be the problem of the disposing of the slug material which is will be which is being removed. So, we need to work extra like say this is the die. So, because of the cold welding the slug may remain get attached with the die itself. So, we need to push it down we need to work extra in order to dispose it of properly similarly to separate this; the slug from the punch surface also; we need to put in the strippers. So, it can separate the slug from the die. So, these are the 2 issues related with the cold welding where in the slug which is being formed scrubbed informed remain attached with the punch or the slug is getting attached with the die itself. So, its disposing of becomes difficult. So, the strip wise used for the separation of the punch from the slug or the sheet metal.

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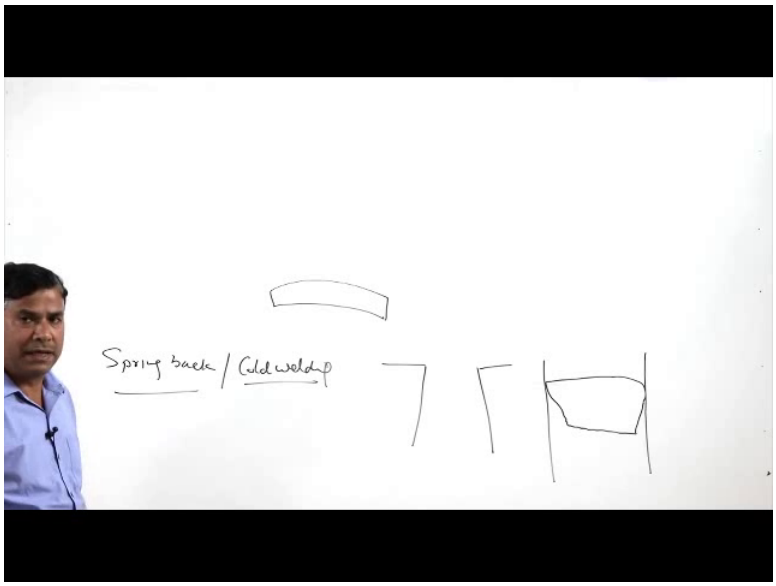

S back is another effect; it is basically related with the say this is the die. So, whatever the slug is formed; we have seen; it has a particular geometry at the ends like this. So, this is the kind of geometry and this portion will be passing through the die. So, because of the spring back effect whatever is the bending effect is there on the slug that the slug gets straightened as it gets a space into the die especially in the lower portion of the die. So, it may get remain attached with that.

Another thing is that it affects the size of the blank as well as the size of the whole which is being produced.

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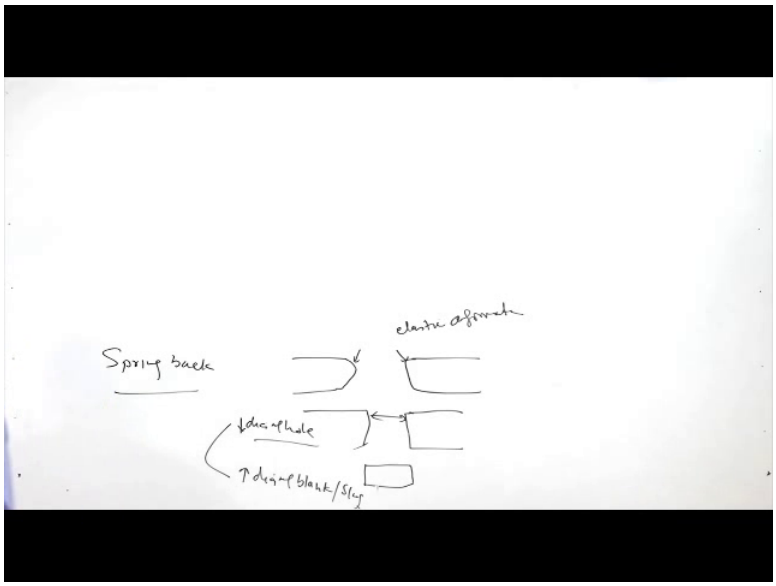

So, if we see the geometry of the whole it this is the kind of the whole edge which is produced. So, this portion actually remains under the elastic deformation in course of the shearing. So, when the punch goes off this portion gets straightened like this and because of this kind of the straightening the whole diameter gets reduced. Similarly in case of the slug straightening leads to the increase in diameter of the slug.

So, spring back effect has the 2 effects one is the reduction in the dia of the whole and increase in the dia of the blank or the slug which is being produced slug or scrap which is being produced. So, these are the 2 things which we can see here the cold welding when the soft metals are processed. So, it cold welding leads to the joining between the punch and the sheet or the welding of the fracture surfaces and the slug and die. So, this is the slug and die they can also get re the cold welding or the punch can get welded with the slug itself, spring back effects due to the elastic deformation.

So, due to the spring back effect, the slug may remain attached with the die itself. So, it needs more stroke for clearing it or a proper disposing of similarly force for pushing is needed and it also effects the die and the whole diameter.

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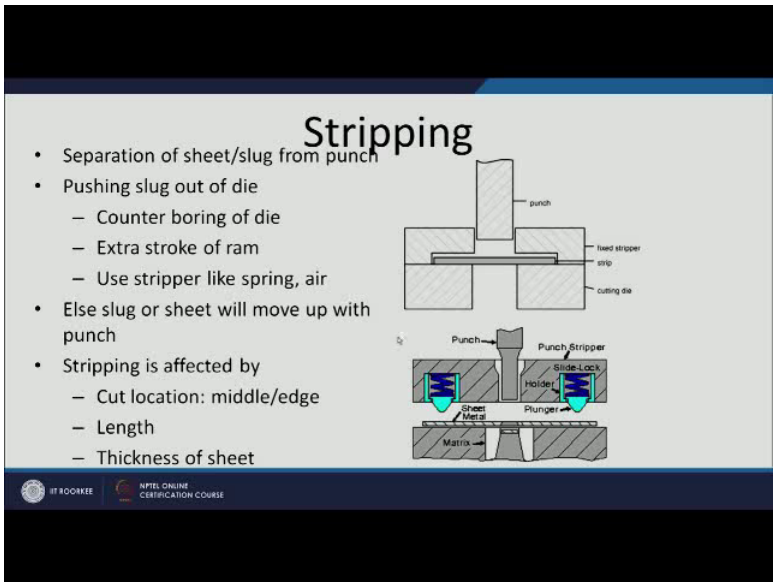

So, the whole diameter due to the spring back effect gets reduced while the diameter of the blank is increased Stripping is needed primarily for the separation of the punch from the die. So, that it can easily be cleared.

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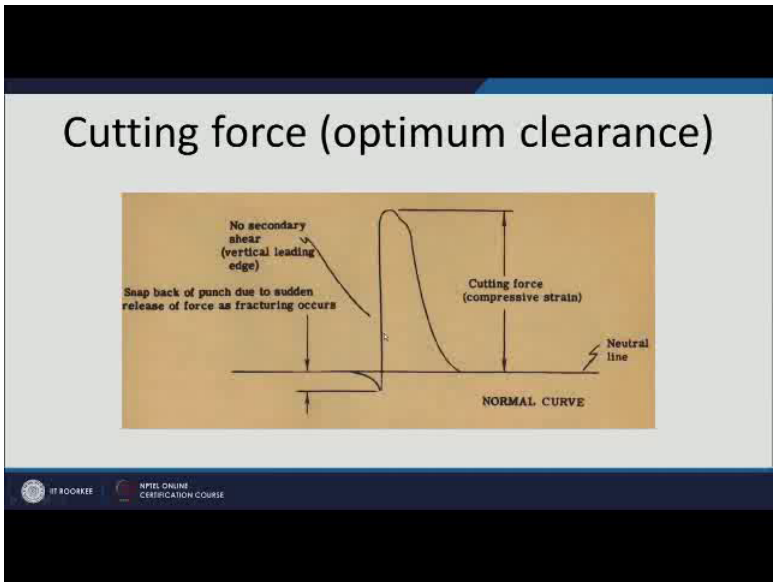

This is the diagram which shows the kind of the cutting force variation in course of the shearing when the clearance is optimum then what we can see these increase in force is very clear and it is vertical and then there is no. This is the case, when there is no secondary shear. So, this is how the force varies in case of the shearing when the

clearance is optimum; this is the kind of compressive force or the strain which is generated.

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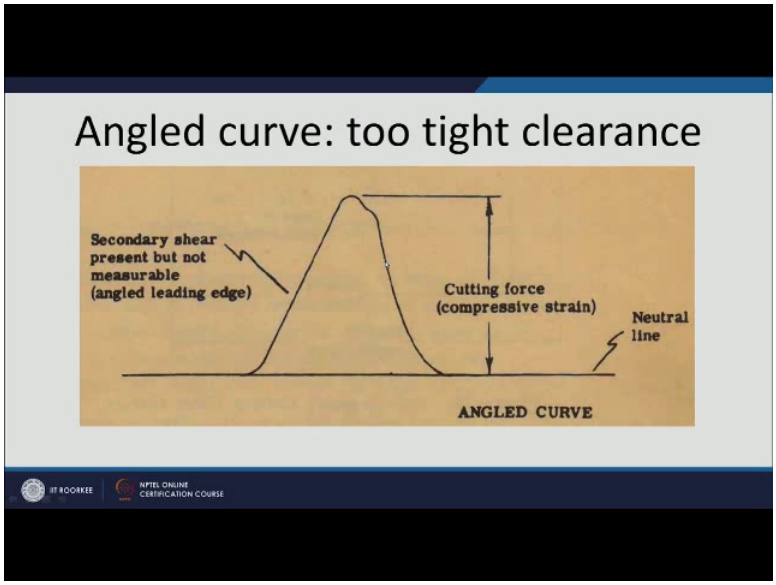

The hump curve is obtained when the clearance is low and in this case secondary shear takes place.

So, the variation in the force is like say we will have the slope and it some kind of deviation also v in the curve suggesting the occurrence of the secondary shear and when the curve is angled indicating the too tight clearance this is also case. Secondly, shear is present, but it is not measurable in this case the variation; in the force is continuous as a function of time and then it starts decreasing for calculation of the Shear force which is required for the shearing purpose, we need to consider certain things which will help to determine the magnitude of the Shear force and the work required for the same.

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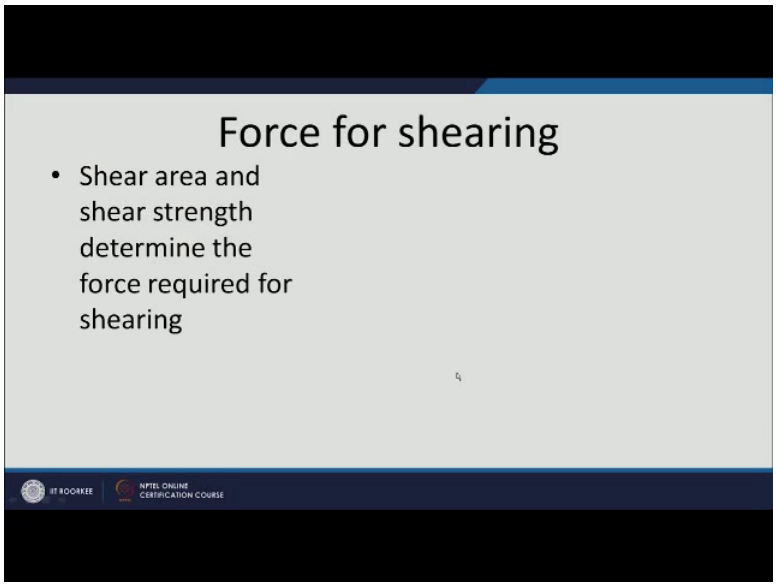

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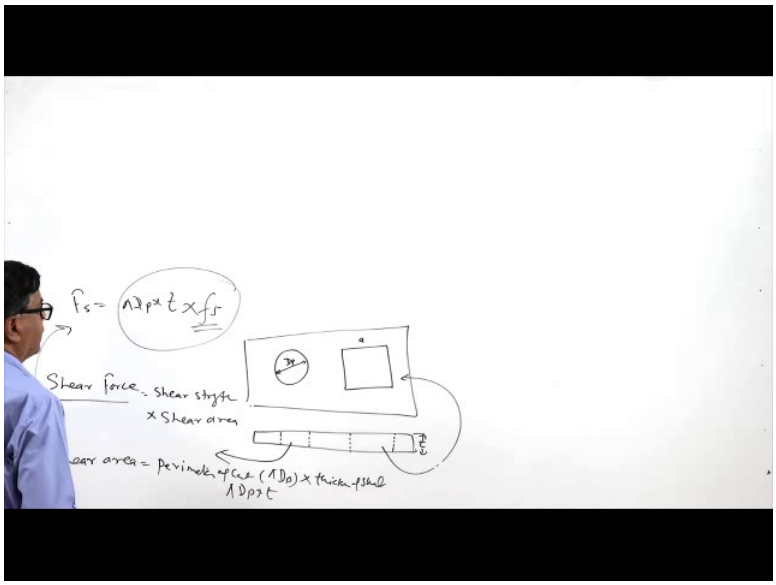

So, like this is the strip in the top view; in the front view, we will see the strip in this form and if we use the punch of this diameter and say this is the punch of a particular diameter D p. So, the whole of this size is created and if we see the punch is of the square size, then size like a then. So, these are the 2 cases. So, in this case the punch is of the circular section, then it will be producing a hole the corresponding hole like this in the strip and in case of the square punch section it will be also producing the square hole.

So, if you have to calculate the force required for shearing for these 2 cases, then what we need to determine what we need to do is Shear force for making these holes, we will can be obtained through the shear strength of the material multiplied by the shear area what is the shear area shear area; shear area is obtained from the perimeter of the cut perimeter of the cut.

So, which in this case is the pi D p; this is the diameter of the punch or diameter of the hole which is being produced into the thickness of the sheet thickness of the sheet; so here the pi D p multiplied by t if the t is the sheet thickness while in this case. So, this is how the shear area can be determined for the Shear force, we need to just Fs Shear force. So, perimeter of the cut pi D p multiplied by t is the sheet thickness into Fs is the shear strength of the material. So, if we use these we can calculate the Shear force which will be acting while neglecting the frictional effects if they are there.

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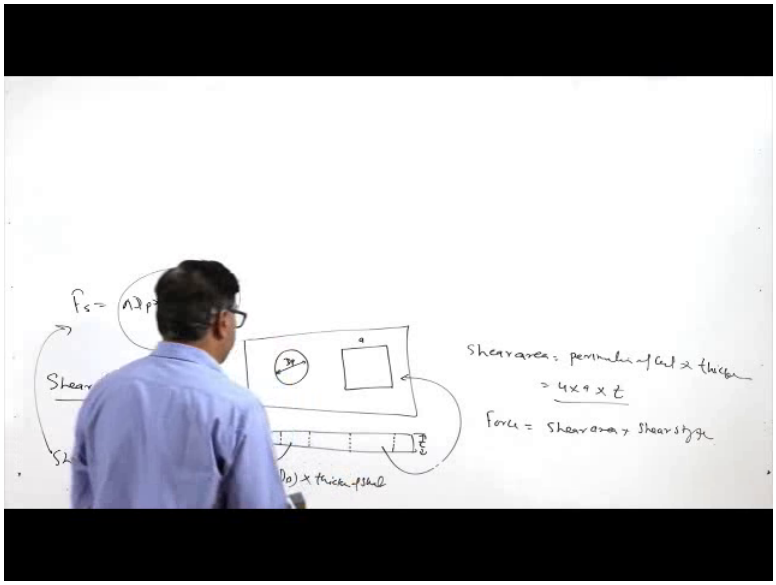

In this case, the shear area is; shear area can be obtained through the perimeter of the cut into the thickness of the sheet. So, perimeter of the cut is actually; this is the square section. So, 4 into a and the thickness of the sheet is t. So, this will be the shear area and to calculate the force; Shear force we need to multiply the shear area with the shear strength of the material or shear strength of the material. So, that we can get the Shear force we do not use the tensile strength of the material for the shearing purpose.

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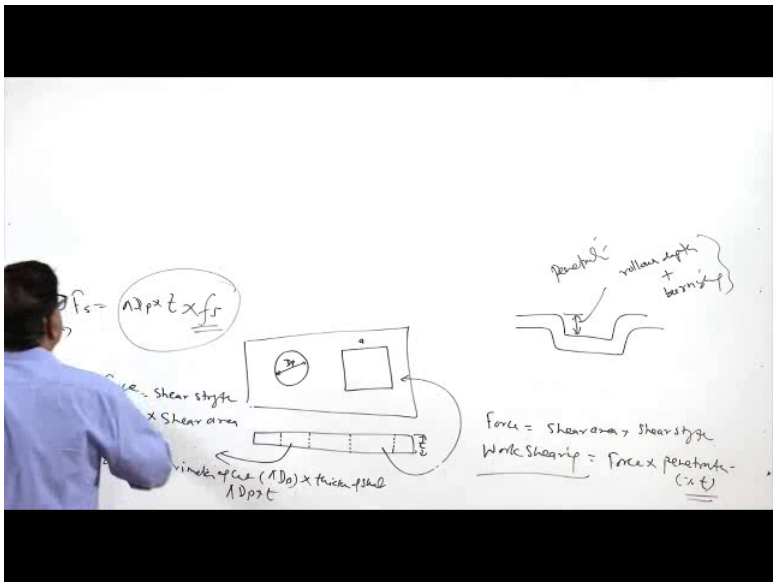

Now, if we have got the Shear force then using this we can determine the work to be done for the shearing work for shearing, then force multiplied by the distance through which the force is to be applied for the shearing and that the distance for which the force is to be applied for the shearing becomes equal to the depth of the penetration. So, say this is the depth of the penetration which is basically the sum of the roll over depth or the deformation depth plus the burnishing depth. So, sum of these 2 is used as a penetration. So, penetration depth is to be mu.

So, here we will be using the penetration which is to be used it is expressed as a percentage of the six sheet thickness. So, if we use the Shear force and multiplied by the penetration then we will get the work required for the shearing.

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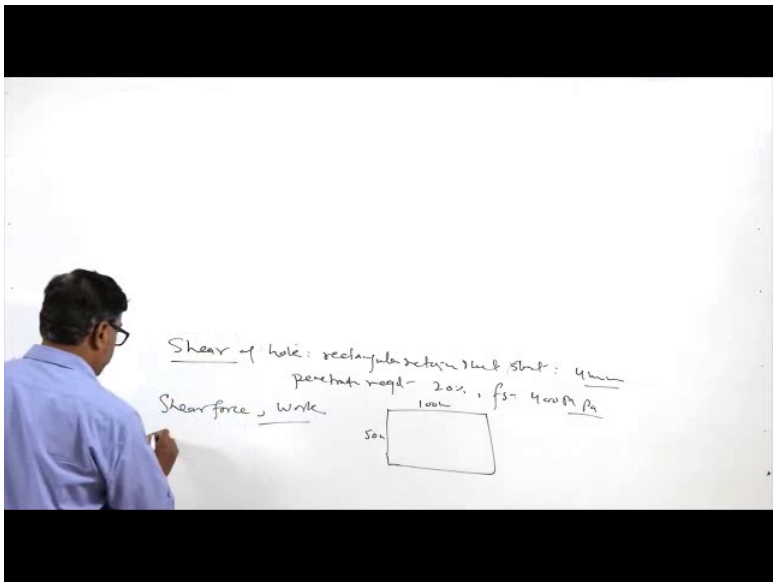

So, here we will consider one e example now. So, say one square hole is to be sheared; shearing of the hole of the rectangular section rectangular section in steel plate or steel sheet is to be done steel shear is say of the 4 mm and the penetration required is for this penetration required is or say 20 percent then and the shear strength of the material is say 400 MPA, then how to calculate the though Shear force and the work required for the shearing.

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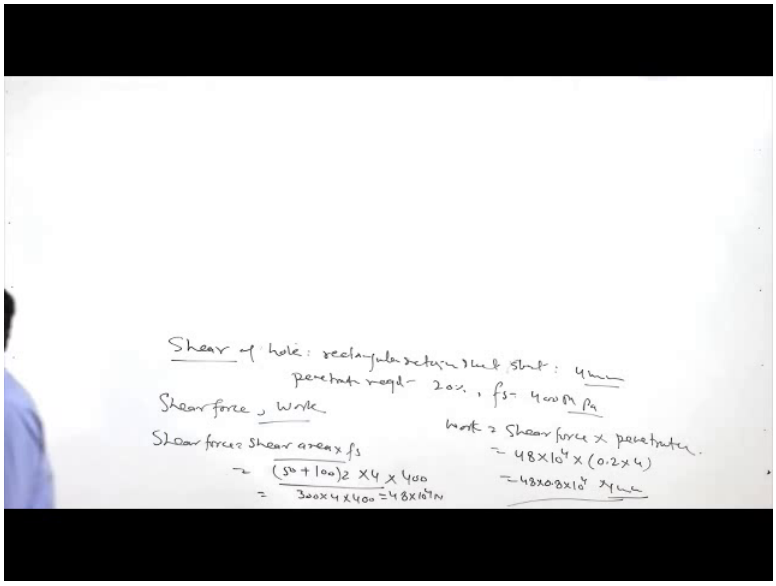

So, in this case the rectangle hole; say like this is to be obtained of dimension say 50 into the 100 mm. So, the length or the parameter of the cuts for the Shear force what we have to do Shear force is equal to the shear area multiplied by the shear strength. So, shear area for these cases like 50 plus 100 into the 2 multip. So, this is the perimeter of the cut and then thickness of the sheet we have to multiply. So, or this will give us the shear area, this is the perimeter of the cut and this is the sheet thickness multiplied by shear strength which is say 400 MPA. So, what it will give us; so 150 into 2 into 4. So, 300 multiplied by 4 multiplied by 400. So, this will give us 48 raise to the power 4 Newton. So, the work required for the shearing is like Shear force multiplied by the penetration.

So, now 48 multiplied by 10 to the power 4 into the penetration is 0.2 multiplied by 4 is the sheet metal thickness. So, on solving this, we can get the work required in Newton mm. So, this is what we can solve further 48 multiplied by 0.8 into 10 to the power 4; this will be the answer for the work to be done for the shearing purpose. So, here now we will see this is what has been shown with the help of the diagrams.

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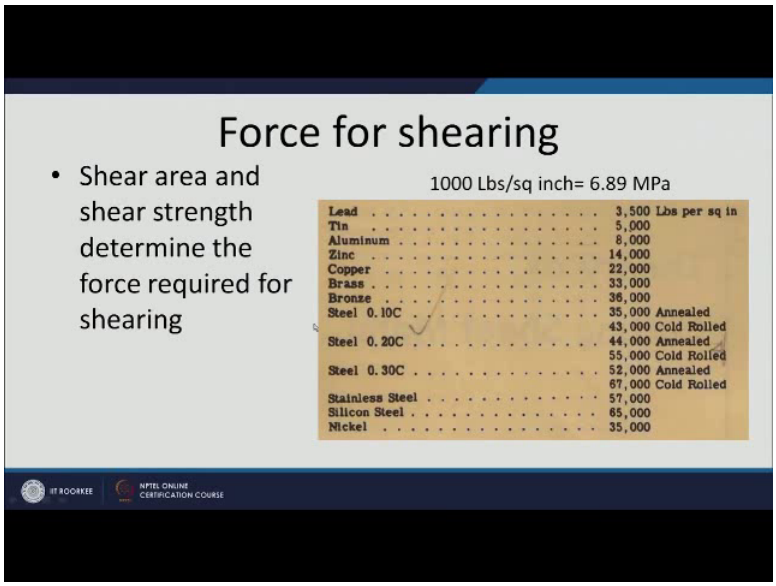

We know that the shear strength of the different metals is well established. So, this is what we can see shear strength 2 different metals like for lead it is in 3500 Lbs per square inch of for aluminum it is eight thousand lbs per square inch and this can be converted in the MPa. And so likewise for the different metals the different shear strength are there and which can be used for calculating the Shear force.

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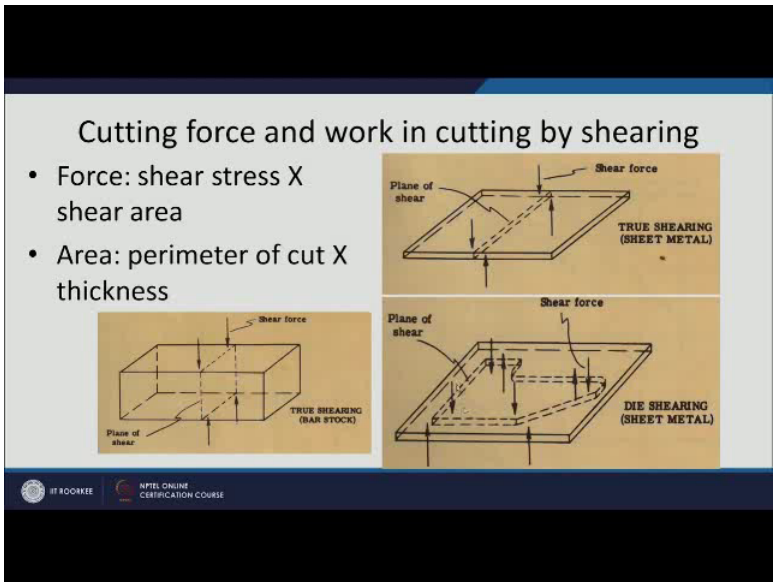

So, Shear force is obtained through the shear area and the shear strength shear again shear strengths are used to determine the force required for shearing basically, it uses the shear area is obtained through this; this is the plane of the shear and which is obtained through Shear force is Shear force multiplied by the shear area; shear area is basically parameter of the cut in to the sheet metal thickness. So, this is the parameter of the cut multiplied by the sheet thickness.

So, in this case, this is say simple sheet length of the this is the parameters of the cut multiplied by the sheet thickness a parameter of the cut in this case will be sum of all these sites multiplied by the sheet thickness.

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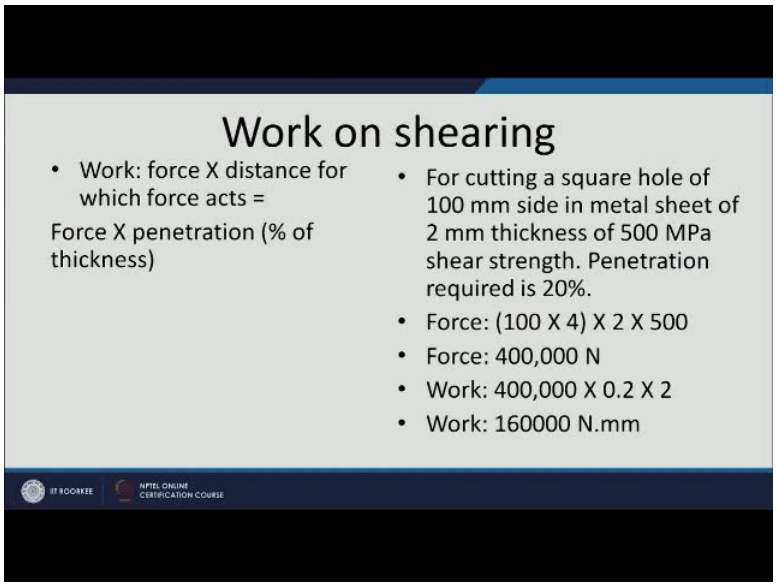

So, work for the shearing can be obtained like this one; other example work for the shearing is the force multiplied by the distance through which force must act for the shearing purpose. So, force multiplied by the penetration which is expressed as a percentage of the sheet thickness. So, for cutting square hole of the 100 mm side in the sheet metal of 2 mm thickness having the shear strength of the 500 MPa well the penetration requirement is 20 percent. So, Shear force can be obtained through the square hole multi means the side is a.

So, what we will be doing side multiplied by 4, this will give us the parameter of the cut multiplied by the sheet metal thickness will give; thus give us the shear area and multiplied by the shear strength of the material. So, we will get the Shear force which is coming out say 400,000 Newton. So, if it is multiplied with the penetration required. So, penetration is 0.2 multiplied by the sheet metal thickness. So, this will give us the work required; it is 160,000 Newton and then this is how we can calculate the force required for the sorry; work required for the shearing purpose.

Now, now what are the different operations which are used through the shearing mechanism so that some useful shapes geometries can be generated. So, that is what will be seen through some of the shearing operations. So, shearing operations are like blanking is one which involves the shearing punching is another nibbling is third notching and shaving. So, these are some common shearing based sheet metal

operations. So, what we do in case of the blanking like say this is the die and here is our punch and between the die and punch sheet metal is placed. So, when the punch acts on to the die what we get basically the sheet metal with the sheet metal with the hole of this kind and one small piece of the metal is removed. So, this is the like say the left out metal and this is the blank which is produced.

So, in the blanking basically purpose is to produce to produce a small piece of the metal sheet of required size and shape. So, that it can be further processed for making any usable good on the other hand, punching is also the same thing, but here objective is not to produce this blank objective is to make the hole in the sheet metal. So, like if we have one big strip and we have to make a cut of this kind and this if; this one is used for processing further this is our product, then it will termed as a blanking and if after making the cut if the hole of this particular shape is produced then it is called punching.

So, only the difference in the punching and blanking is in terms of is in the terms of the output. So, in case of the punching goal is to make the hole while in case of the blanking goal is to cut the small piece of the metal which can be produced process further for making some usable goods. So, this is; what is the difference in the punching and the blanking.

So, if we see here for the blanking purpose process of obtaining a small piece of the metal from their strip from the sheet metal by cutting or shearing from the stock with the help of punch and the removed strip is called blank which can be used for further processing to make a usual goods while in case of the punching; punching is similar to the blanking objective is to make the hole and the removed strip here whatever metal comes out as a result of the punching that is just a scrap.

So, for the purpose of the since the punching and blanking both can be performed through both are performed using the shearing, but the there is the difference in the size of the si like which factor will be governing the size of the blank and which one will be governing by the; which will be governing which factor will be affecting the size of the hole. So, if objective is to have the hole through the punching then it is the punch diameter which is controlled and then clearance is given additionally over and above.

So, basically the punch diameter plus 2 C is given with the help of formed for making the hole by punching while in case of the blanking the. So, basically punch governs the

inner cut size while in case of the blanking the die diameter for the blanking basically die diameter is controlled and then the pun clearance is made negative from the die diameter. So, basically clearer if the die is made of the larger diameter for the blanking while the suitable clearance is given to the punch.

So, if we see here the for the blanking for the blanking the blanking punch diameter is this is a blanking die diameter is the db for the blanking purpose and the punch diameter is just means it is reduced by the 2 C value for giving the clearance. So, the blanking die diameter is db and the punch diameter for the blanking purpose is of is made of the smaller size by that 2 C value; C is the clearance while for making the punch for punching purpose for making the hole like say the punch diameter corresponds to the diameter of the punch means the punch diameter governs the diameter of the hole and the hole die diameter. So, the diameter of the die for punching purpose is obtained through the diameter of the punch plus the twice of the C.

So, here the clearance is given and over and ever to the die and here the in case of the blanking the punch is made smaller and by the 2 C value as compare to the blanking die diameter and in case of the punching the die is made larger by the 2 C value with respect to the punch diameter, which one is given clearance that will be governed by the kind of operation which is to be performed. This is what we can see that when there is sheet metal is not gripped properly in that case we get very rough edge having the they deformed zone burnish to zone fracture zone and the burr, but due to the little movement of the sheet metal in course of the punching, but when the punch when the sheet metal is properly gripped during the shearing then we get very clean square edge and all these zones are of the very small size. So, very clean and smooth edges produced when thus punching or the blanking is carried out with the proper gripping of the sheet metal.

So, they are these are the some of the operations are related with the shearing trimming is a primarily used for removing the extra material spread out near the parting line or drop forging or the die casting. So, like say when we go for the forging then the upper and lower half may be leading to the remove formation of the some additional flash at the parting line or in case of the casting also cop and drag case when the 2 parts are used some extra material gets deposited in case of the casting near the parting line. So, all these extra materials need to be removed and for this purpose, it will be placed over the

die and then punch will be applied. So, that all these extra material is removed this one is called trimming.

So, trimming is basically removal of the extra material which has been deposited in the component made by the forging or by the casting. So, removal of the flash or removal of the extra material deposited the parting line through the; with the use of the punch and die is called trimming it also involves the shearing process.

Another one is nibbling in case of the nibbling particular profiles are generated into the sheet metal. So, here this is say sheet metal in the top view. So, what we do we apply we need to make the cut in a particular profile like this. So, what we will be doing sequentially punch and die will be used for making the successive cuts like this. So, this is basically the shearing, but successive live shearing is carried out along a particular line so, that the particular strip in a desired profile can be produced. So, this kind of operation is called nibbling primarily used for cutting the sheet of specific profile.

In case of the notching noting is about removal of the material from the sites and this is primarily used to facilitate the folding of the folding and bending of the sheet metal. So, if particular the strip is to be folded then what we do we make a very small cut at the side like this. So, the cuts are made at the edges of the sheets to facilitate the bending drawing and folding of the sheets. So, if the purpose is to make to make to make small cut at the edges and the sides with the help of the die and punch. So, that it can be bend and it can be drawn and it can be folded then for that it is termed. So, such kind of operation is termed as nibbling.

So, these are the operations which have been shown in these diagrams like the shaving is another one where the rough cut surfaces in the normal sheared surfaces have the rough edge like this. So, in order to make the edges very clean the; shaving is carried out. So, shaving is basically s h a v i n g- shaving is a shearing one where very close control close clearance is used. So, that such kind of the rough edge can be removed. So, basically making the clean and clear cut edge is called the shaving these are the operations which have been shown here the gap between the punch and the die is very close. So, the rough cut edge of the sheet metal is removed and very clean clear square cut edge is produced in case of the shaving.

This is the trimming which has been shown schematically this is the job having the extra material deposited either as a result of the flash formed during the forging or extra material deposited at the parting line during the casting. So, this is removed with the help of punch and die punch move is down. So, this portion is sheared off and any extra material which is deposited the parting line in form of the flash that is removed and nibbling as I have said or the sequentially the number of cuts are made in a particular profile.

So, that the sheet of the suitable profile is produced in case of the nibbling this is also cutting means cutting performed using the shearing principle, but along a particular profile, this is the notching where in the cut is made at the sides of the plate and the edges. So, that it can help in proper folding bending and the drawing of the sheet metal.

Now I will summarize this presentation. In this presentation, I have talked about how to calculate the Shear force; how to calculate the work done in the shearing and what are the common shearing operations like punching, blanking, nibbling, notching, trimming, etcetera.

Thank you for your attention.