Fundamentals of Manufacturing Processes
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Lecture – 33
Metal working processes: Sheet Metal Operations III

Hello, I welcome you all in this presentation related with the subject fundamentals of the manufacturing processes. And we are talking about the sheet metal working processes, where in we have talked about the sheet metal operations based on the shearing.

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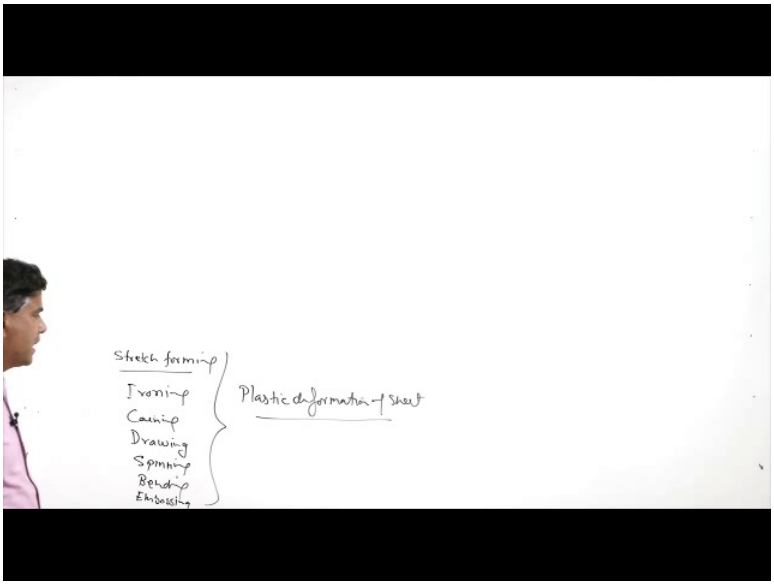

Where in we have talked about the processes like punching, blanking, notching, nibbling, etcetera, which are which basically involves the cutting of the metal by the shearing principle. Today we will be talking about the other processes a like a stretch forming, ironing, then here is coining, drawing, then a spinning, bending and one more process like embossing.

So, these are the processes about which I will be talking about, and these are used for the different purposes. Under the different types of the stresses are developed to achieve the desired size and shape and mostly all these processes involve plastic deformation, plastic deformation of sheet metal. So, the different types of the stresses are induce in order to get the desired shape to the sheet metal for sheet metal operation so that desired product of the desired shape and size can be achieved.

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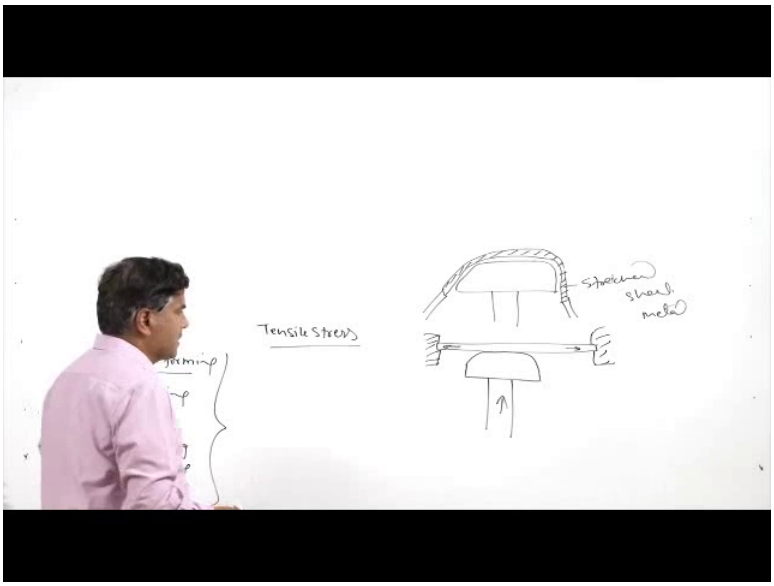

So, a stretch forming basically involves the tensile stresses. Wherein one strip like this is taken, and it is held at the ends firmly like this. And then suitable form block is used in this way this is the form block. And this form block is pushed through the sheet metal. So, the sheet metal is stretched. So, basically when the sheet metal is stretched it follows the shape of the form blocks. Say this is the form block and after the stretching the sheet metal takes the shape of the form block in this manner.

So, the shape of the form block decides the shape which will be achieved by the sheet. So, when it is pushed through the sheet metal the sheet metal is stretched. So, basically the stretched sheet metal this is stretched sheet metal which will be experiencing the tensile stresses. So, this is the case which is used in this operation the suitable contour in the sheet metal is produced through the development of the tensile stresses this is the typical figure, which shows that this is the form block. Or we can say the die against which and this die is pushed against this the blank or the sheet metal. This the sheet metal is held at the ends using this the flexible arrangement, where like say hydraulic cylinders are used to allow it is little bit movement.

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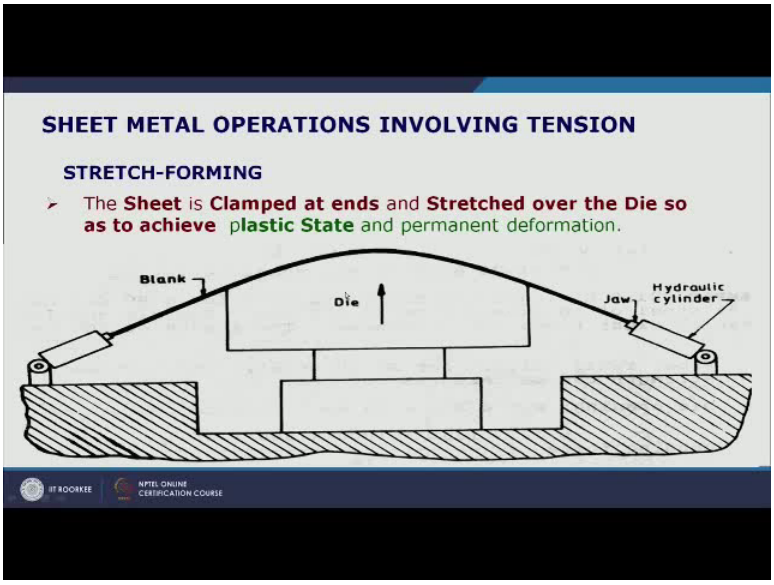

And when the die is pushed through the sheet metal, it develops the tensile stresses. And which intern leads to the that the situation where the sheet metal takes the shape of the die. So, sheet metal in this case is clammed at the ends and the sheet metal is stretched over the die so as to achieve the plastic state and permanent deformation to the sheet metal.

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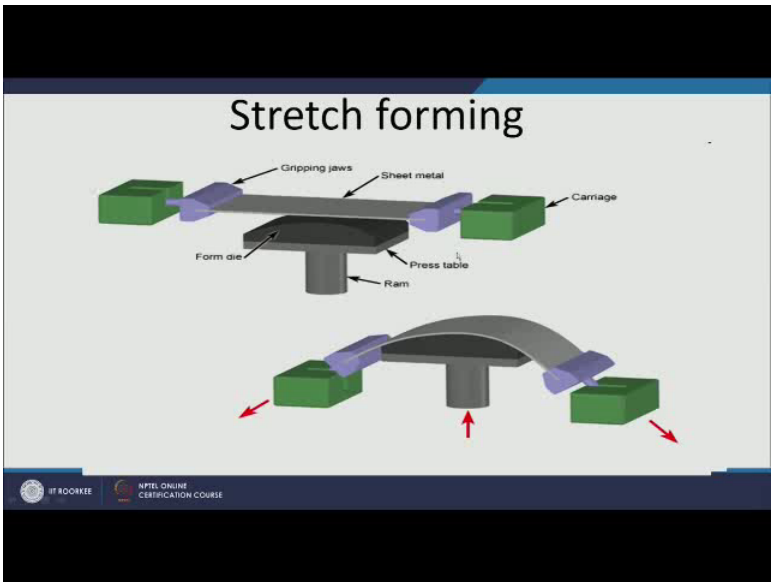

The same thing has been shown in the these 2 diagrams, wherein these are the gripping ends of the sheet metal, this is the sheet metal and this is the die, which is pushed through the sheet metal and finally, the sheet metal when it is stretched, with the help of

through this push force of the die, the it takes the sheet metal takes the shape of the die and the suitable shape is achieved in the die.

So, this is what uses the in this case the tensile, stresses are used to give the shape to the sheet metal according to the a shape of the die.

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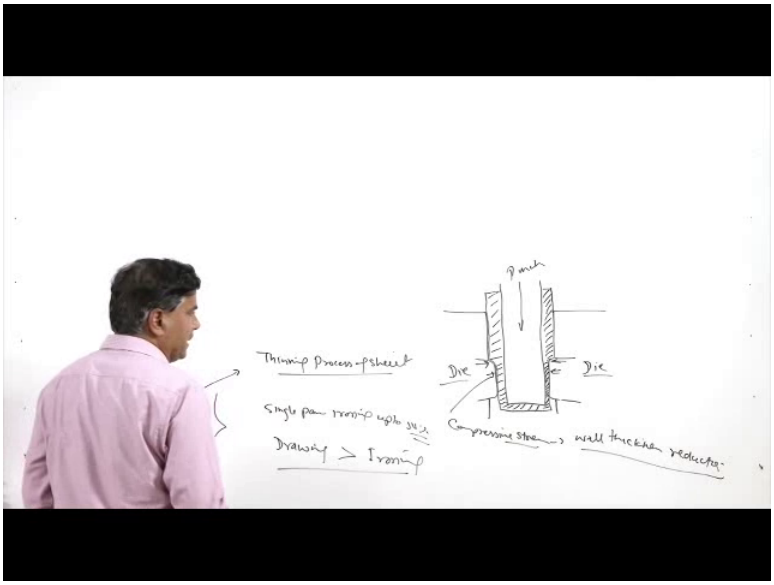

Another process die or the form block another process is ironing. Basically ironing is a thinning process; a thinning process of the sheet metal, wherein the thickness of the wall of the sheet metal is brought down through the ironing process. So, what it uses it also uses one die like this. Yeah, and here a punch goes in this is the punch. And this is where the strip or the sheet.

So, this is the sheet metal this is the sheet metal thickness before the ironing. And this is how the thickness is being reduced after the ironing. So, this is the sheet metal thickness variation before and after the ironing. So, ironing is facilitated in this zone when the punch is will be pushing the a sheet metal through the die basically this is the area where die will be working. So, when the punch and when punch will pushes the sheet metal through the die, here the clearance is narrow the clearance in this case is narrower than that is used in case of the drawing operation. So, because of the narrow clearance in this zone the sheet meal experiences the compressive stresses, and because of which wall thickness is reduced.

So, this reduction in wall thickness is facilitated due to the flow of the metal in this ironing zone, which will be facilitating the reduction in thickness. So, in a single pass ironing up to 50 percent reduction can be realized. The clearance if we compare with the drawing process. So, clearance for the drawing is used more than that is used for the ironing purpose. So, ironing basically helping to reduce the thickness wall thickness of the sheet metal with the help of the compressive stresses, which will be generated when the metal is forced to a pass through the gap between the die and the punch.

So, the same thing will be explain using this diagram, wherein the sheet metal involving the compressive stresses called ironing.

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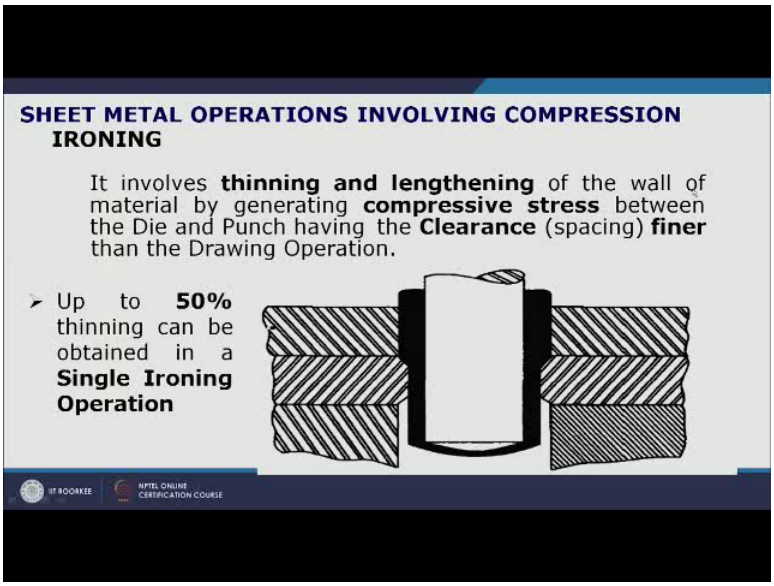

It involves basically the thinning and the lengthening of the wall of the material by generating the compressive stresses between the die and punch. And so, the clearance in this case is used in such a way that it is finer then that is used for the drawing operation, and up to the 50 percent thinning can be achieved in single drawing operation.

So, here we see the wall thickness of the sheet metal is bigger before ironing and when the punch pushes the metal through the die in this zone it will be compressed, and the flow of the metal will be leading to the increase in length, and reduction in wall thickness which will be facilitating the process of ironing. So, this is what is the ironing process.

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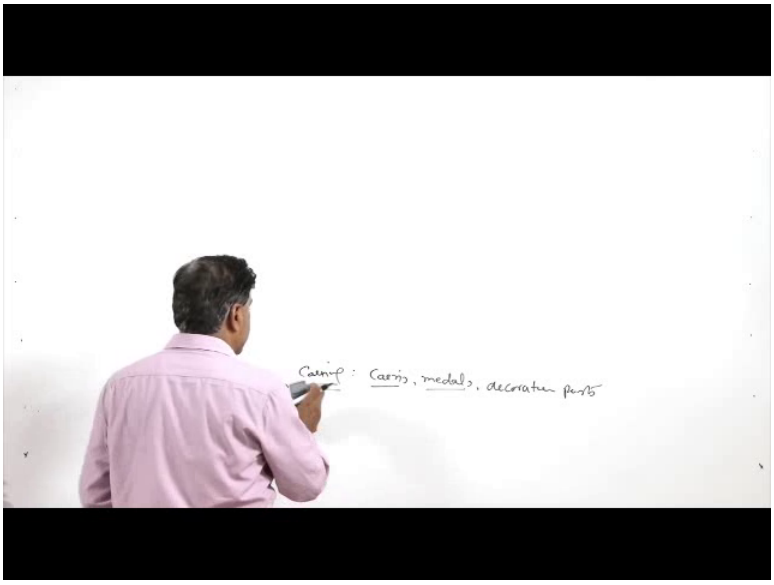

And the coining, coining process is used for develop for making the coins, medals and other decorative parts or the components. So, in this case both die and punch is used. So, if you have to see the is one punch which will be having the suitable impressions like this.

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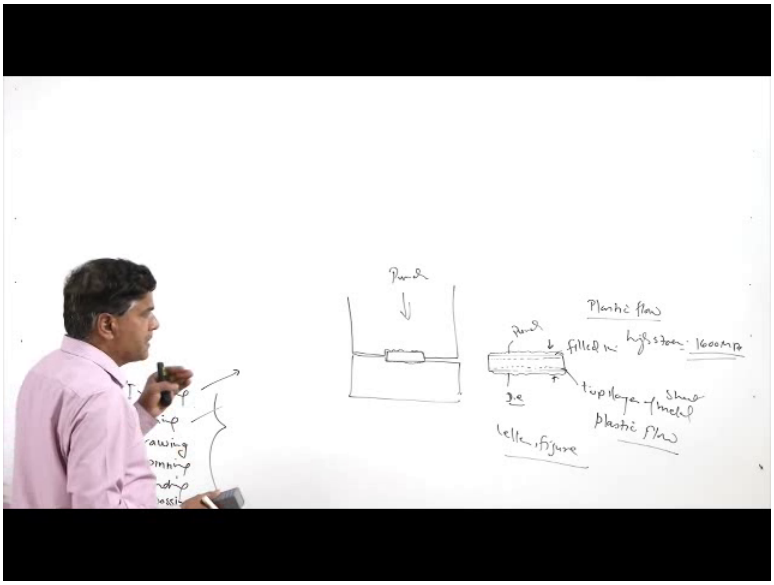

And the die will also have the corresponding impressions desired, like this and the metal is placed between the die and punch.

And when the force is applied when the die is closed the when the punch is move down the force is applied on to the sheet metal. So, basically the sheet metal initially is like

this. So, when the force is applied heavy application of the heavy force results in the movement of the material at the top layers or at the external layers like this. And which will be moving and flowing into the finer details of the die and punch like this. So, the finer details in the die and which are present in the punch as well as in the die side they will be filled in by the flow of the molt flow of the metal at the top layers.

So, basically the top layer of the sheet metal is subjected to the significant plastic flow. So, which will be filling in the finer details present both in the die as well as in the punch side. So, which will result in the development of like the letters, the figures, which are required to be produced in the coin but for ensuring that the flow of the metal into these fine details in form of the a fine letters and the figures is complete, and all the fine details are produced very high presser is used for a ensuring that the flow of the metal at the top layers into the cavities both in the punch as well as in the die side facilitate the development of the desired impressers in the coin.

And for this purpose very high the plastic flow is facilitated using the high stresses, which may be as high as 1600 MPa. So, because all these things happen under the compression conditions the metal is forced to flow into the finer details present in the die as well as in the punch so that the desired impressions in form of the letters and the figures are produced in the coin. Whenever there is the plastic flow of the metal at the top layers So obviously, because of the work hardening that zone will be strengthened and the harden hardened by the strain hardening process. So, this is this is what we can see here in case of the coining there is a punch and die which will be having the desired details in form of the letters and figures engraved in the die as well as punch And then using the very high pressure.

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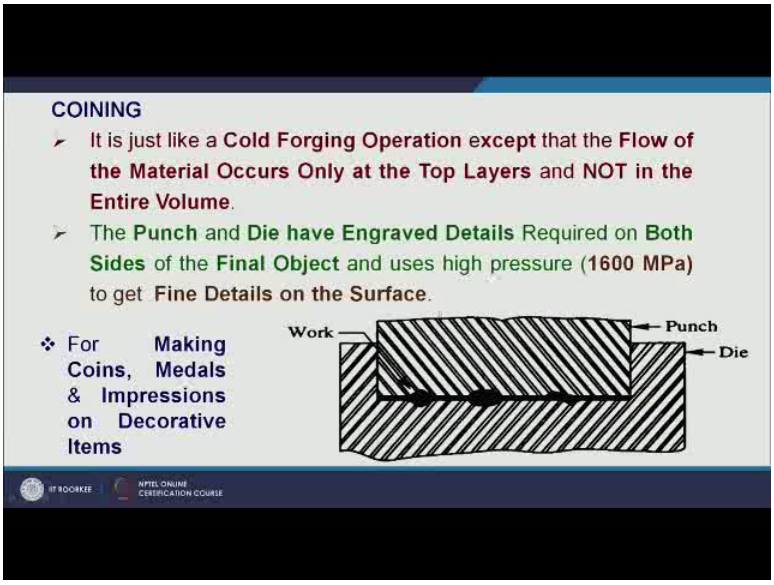

The high pressure application on to the sheet metal will be leading to the plastic flow at the top layers and that intern will be producing and the desired finer details on to the surface. It is basically used for making the coins medals and impressions of the decorative items.

Now, coming to the another sheet metal processing, process which is called the drawing.

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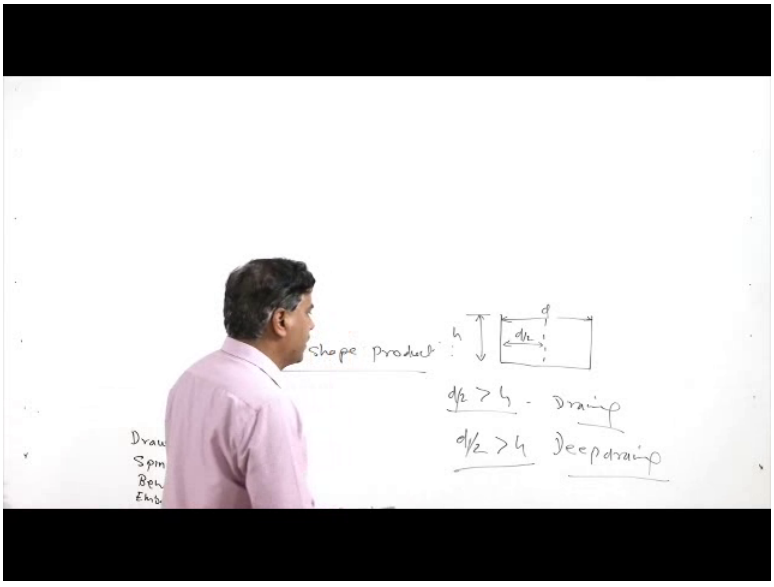

Drawing is basically used for making the cup shape products. So, and especially the like the cup shape products are of this kind wherein the height of the cup h and the diameter of the cup. This ratio particular ratio is like this wherein the height of the cup is smaller

than the diameter of the cup a half of the diameter of the cup. So, this is the d is the diameter. So, half of the diameter is this much. So, the d by 2. So, the if the d by 2 is greater than the h, then it is called the drawing process. And in case when the d by 2 d by 2 means the diameter half of the diameter or the radius of the cup is greater than the height of the cup then it is called the deep drawing process.

So, we need to take a special precautions for the deep drawing process as compared to the simple a drawing process.

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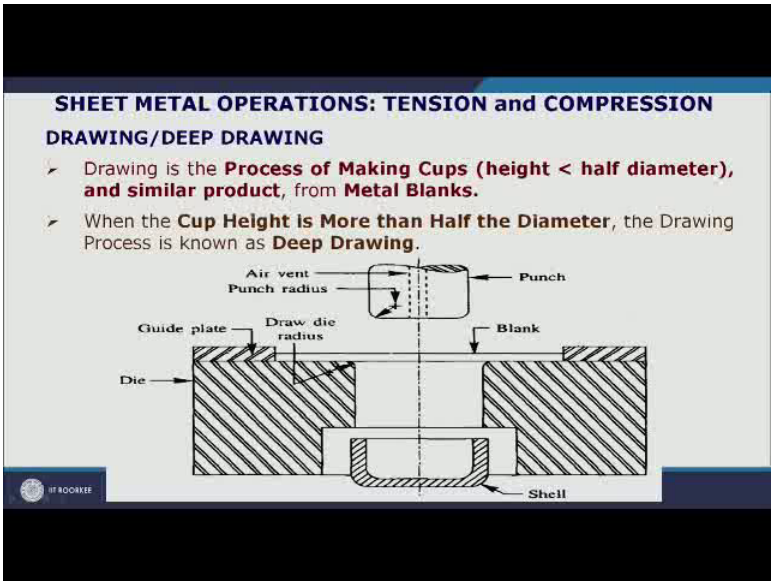

So, for this purpose for the drawing purpose basically one die is used like this. And then one guide plate to ensure that the strip is placed at a particular location and here like say a strip is placed in this manner over the die. So, this is the sheet metal, this is die, and this is guide plate. So, these are placed both the sides. And the punch is we will be applying the force from the top.

So, this is punch. So, when the punch is moved down, it will be deforming the it will be deforming these strip and when it is deformed it takes a particular shape like this. So, this cup shape product which is produced as a result of the drawing means the punch is we moved. So, the sheet metal is forced to move down through the gap between the punch as well as the die. So, it takes basically the shape of the cup. And this cup shape products the processing of or manufacturing of the cup shape product using the punch and die you

this using with the help of this kind of process is called the drawing wherein the height of the cup is smaller than the radius of the cup.

If you have to see the finer details of the process, maybe we can we can see the next slide wherein this is the sheet metal operation. So, basically this process involves the tension as well as the compression. So, there are 2 variants depending upon the height of the cup to the diameter half of the diameter of the cup, there it can be the deep drawing or the simple drawing process. Drawing process drawing is a process of making cup shape products or the similar products using the sheet metal, wherein the height of the cup is less than the half of the diameter of the cup or radius of the cup. When the cup height is more than the half the diameter then it is called the deep drawing process.

So, basically it uses one a punch which will have the higher fillet radius higher radius at the edges in order to avoid any kind of the shearing phenomena and the So, this which you can say the punch radius. And then this is a guide plate this is the die, and when and over the die the sheet metal is placed. And when punch is moved down through the die and when punch applies force onto the sheet metal. And so, the sheet metal is forced to pass through the die and in this process it will be subjected the sheet metal is subjected to the tension as well as compression and that will finally; take the shape of the cup.

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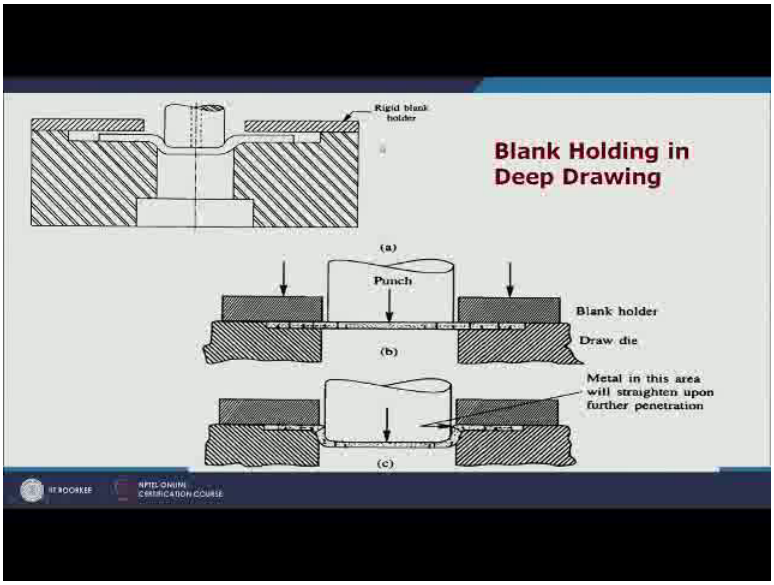

So, for performing sequentially if we see how the flow of the metal takes place in case of the deep drawing process. So, for this purpose basically under the control conditions the

sheet metal is allowed to move during the drawing process. So, when initially in the in the case when the punch just touches to the sheet metal, this is a blank holder, this is the die. And blank holder will be holding the sheet metal not very firmly so that it relative movement can occur between the punch holder and the sheet metal when the force is applied through the punch.

So, when the force is applied through the punch the sheet metal starts moving down. So, this is the region where there in the metal in this area is subjected to the bending and there after straightening. So, as the punch will keep on moving down the material will be straightened, and it will be subjected to the and the bending maybe little bit thinning also can takes place. Under these conditions, but the thinning is not a significant in case of the drawing process.

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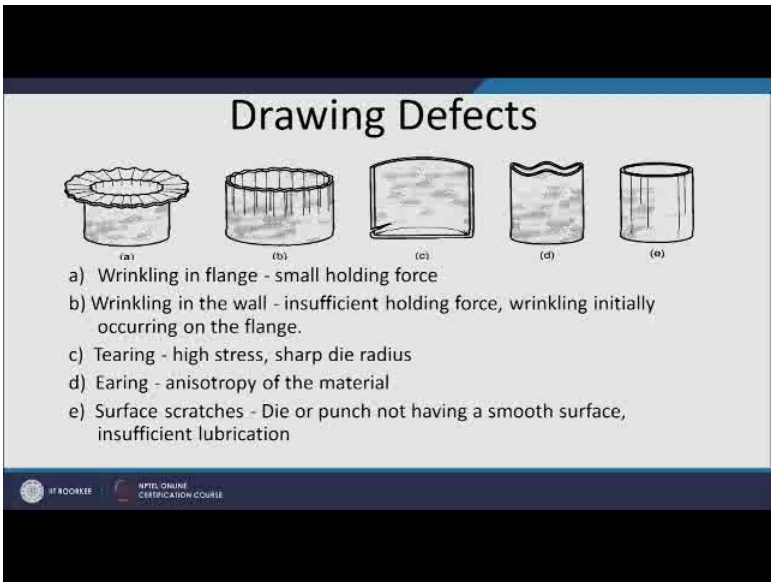

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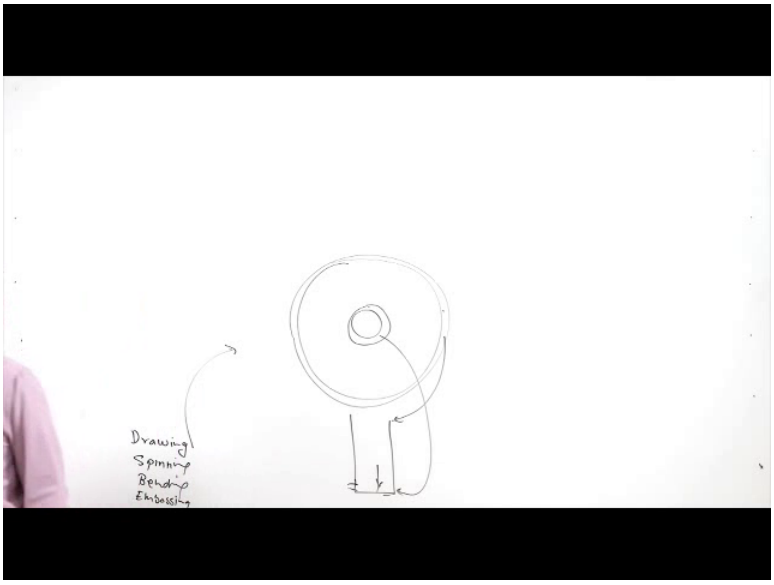

See so, the if we see the drawing process normally the sheet metal in the larger diameter is used, and here we apply our punch. And finally, it takes the shape like this. So, if we see right from the bottom of the cup to the top here the diameter is same. And it is the cylindrical, but actually the material which is involved is less at the bottom and more at the top. So, this will be the region corresponding to the top, and this will be region corresponding to the bottom.

Since at the top lot of material is involved. So, it leads to the wrinkling effect. So, these wrinkles sometimes disturb the shape of the cup shape products. At the same time if the too much of the force is applied and the sheet metal is thin then the tearing can also occur at the end. So, some of the defects which are observed in the components of the products which are produced with the help of the drawing process, it can lead to have the wrinkles in the flange portion like this, or these the wrinkles in the walls also can be observed if the insufficient holding force is there. So, in that that is a situation where the wrinkles in the vertical walls the this vertical surface can also be observed.

If the material sheet is weak and it is very thin then because of the force being applied by the punch onto the sheet metal, it can lead to the tearing especially under these 2 conditions when the metal is weak or the stress is being applied or high or the punch radius is very low. So, if the sharp die radius or punch die radius low punch radius can lead to the tearing kind of the defect.

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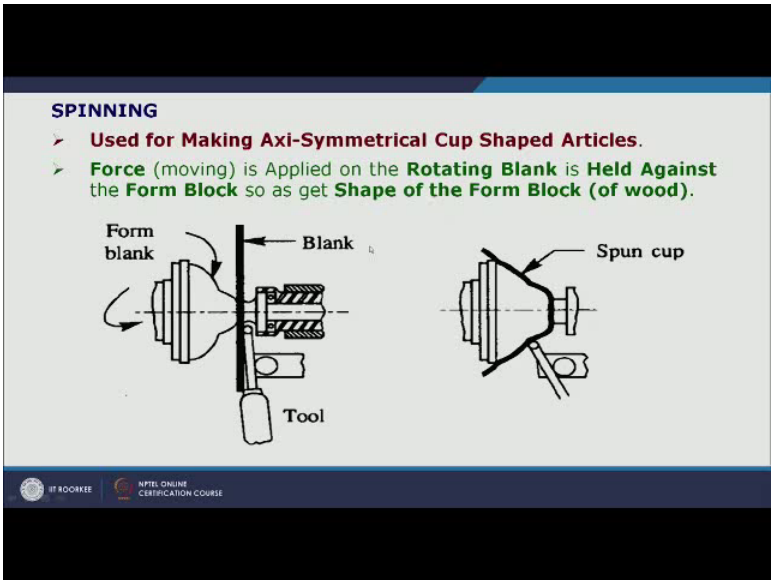

Now, coming to the another sheet metal operation, which is called the spinning process. The spinning is basically used for making the Axi-symmetric products.

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So, about the axes of the product the configuration is uniform. So, for this purpose basically one and the form block is used, generally this form block is of the so obviously, over the form block will have the shape like this.

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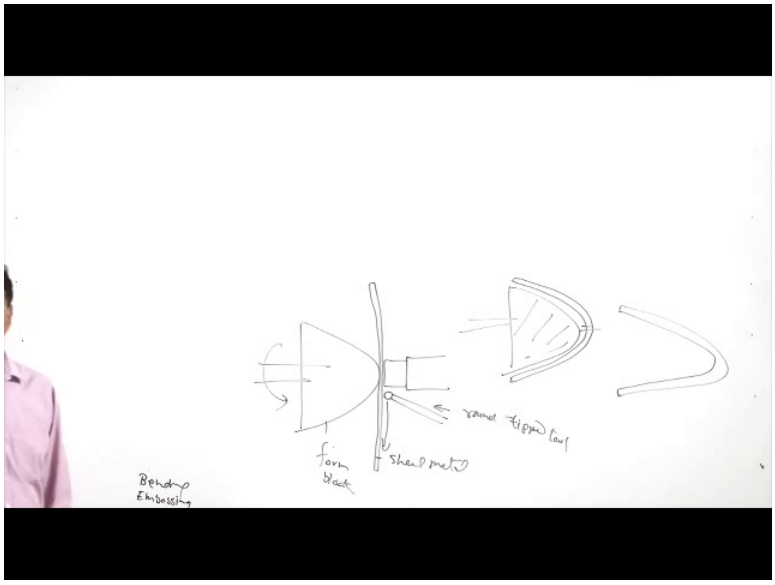

This form block is rotated maybe like on the headstock of the lathe machine. And then one sheet metal which is to be used for spinning process is kept like this in contact with the form block, and it is held firmly with the help of a another holding pressure this may be like say the pressure being applied through the tailstock side.

So, in order to keep the sheet metal and this is form block. So, the sheet metal is held firmly against the form block and form block is rotated. So, the strip or the sheet metal will also be rotated. Now with the help of a rounded tipped tool like this, the sheet metal is pressed. So, basically round tipped tool is pressed against the sheet metal. So, it follows the shape of the form block. So, basically as soon as the pressure is applied all along the this radial direction the outward direction, the form block shape takes the sheet metal takes the shape of the form block.

So, eventually what we have the situation where the sheet metal takes the shape of the form block. There can be different geometries for the form block as for the requirement, but in this case eventually we will be getting the sheet metal of this shape. There can be different Axi-symmetric a configurations and geometries which can be produced by the spinning process.

So, basically the round tipped form block helps to take helps to deform the sheet metal according to the shape of the form block so that the desired shape is achieved. So, this is what has been used a has been shown using the schematic diagram.

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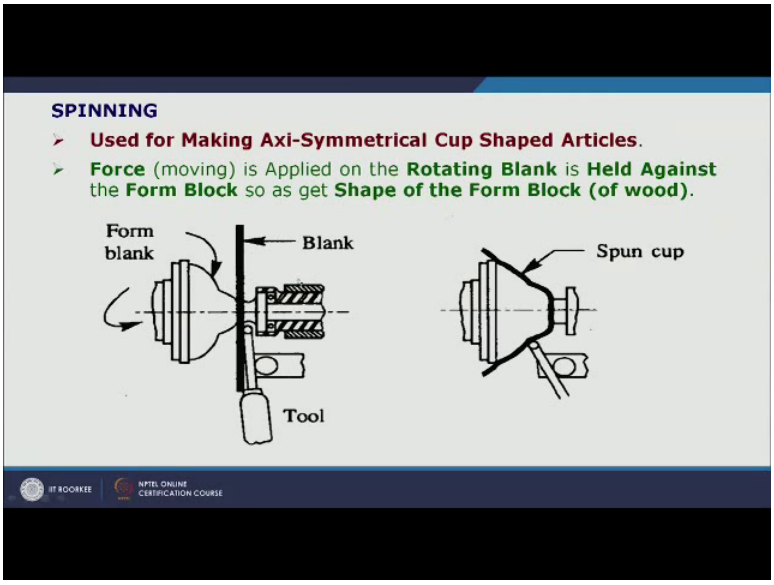

Is spinning used for making the axi symmetric cup shape products and force? In this case like this is the form block and the sheet metal is held between the form block and another support system which will be pushing this face the sheet metal against the a form block and then form block is basically rotated. And this is the round table tool which will be pressed on to the a sheet metal.

So, the sheet metal deforms and that takes the shape of the form block, after and so, during the rotation when the force is applied the sheet metal takes the shape of the form block like this. So, the force is applied on to the rotating blank is held against the form block. So, this hand tool a hand tool will be used to apply the force on to the sheet metal when the sheet metal is rotating because form block is rotated so, with the sheet. So, with the form block sheet metal a sheet metal is also rotated and against the rotating sheet metal this form block is applied so that it takes the shape according to the shape of the form block. Form lock is normally made of the wood.

Now the another a sheet metal operation is the bending. We know under the normal conditions when the sheet metal or any plate is subjected to the bending about the neutral axis the different zones are subjected to the different kinds of the stresses.

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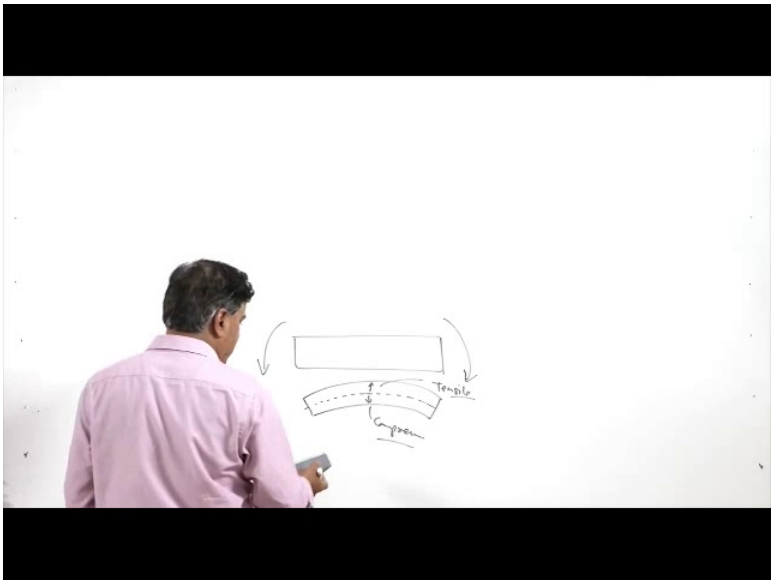

For example the simple plates when subjected to the bending like this. So, in this case due to the bending moment the sheet may bend in this manner, but in this case about the neutral axis on the above the neutral axis we will see that the tensile stresses will be acting and below the neutral axis, the compressive stresses will be acting and; obviously, at the neutral axis no stresses will be there under the bending condition.

So, the bending of the sheet metal is used in number of ways to give the desired shape to the sheet metals.

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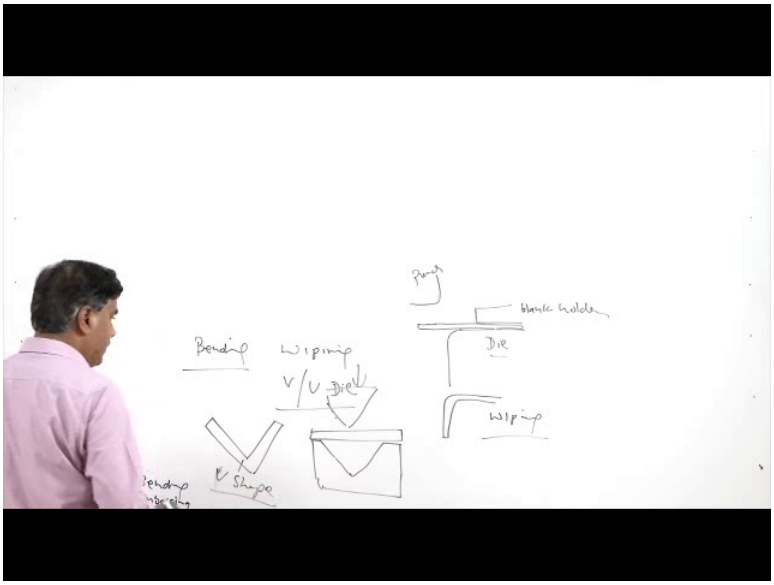

So, like for bending the typical operations are like wiping. V and u shape productions using the dies. So, what wiping involves basically like this is the die and here we have the sheet metal. The sheet metal is held with the help of the suitable block like this. So, we can say blank holder. This is die and here we have punch when the punch is moved down. So, this portion will be bending in this way through the 90 degree and a suitable a radius will be given according to the shape of the die.

So, this kind of process is called wiping. For the v and u shape productions a suitable shape of the die and punch is used like say this is the punch, and the suitable shape of the die is here like this. And a strip is deformed by the combination of the die and punch. In this manner so obviously, in this case the first the sheet metal will be placed over the v shape die in this manner. And when the punch of the suitable shape comes down it takes the shape of the it takes the v shape.

So, when the punch will be moving down. So, we will be getting the sheet metal deformed in this shape. So, this is called realizing the v shape products using the v die process. And similarly the u shape u shape die like this it is used and over this sheet metal is placed in this manner, and then the die sorry punch will come under the punch, when the punch acts on to the sheet metal through the die.

So, the sheet metal takes this u shape in this manner. So, basically the vu or other the bending the sheet metal through 90 degree with the help of the die and punch to realize through the wiping can be achieved through these the bending processes. These are the processes which are very commonly used for achieving the different kind of the shapes and geometries of the sheet metal for manufacturing variety of the products.

So, this is what we can see in this diagram. Here the different bending methods where different types of the approaches are used like wiping.

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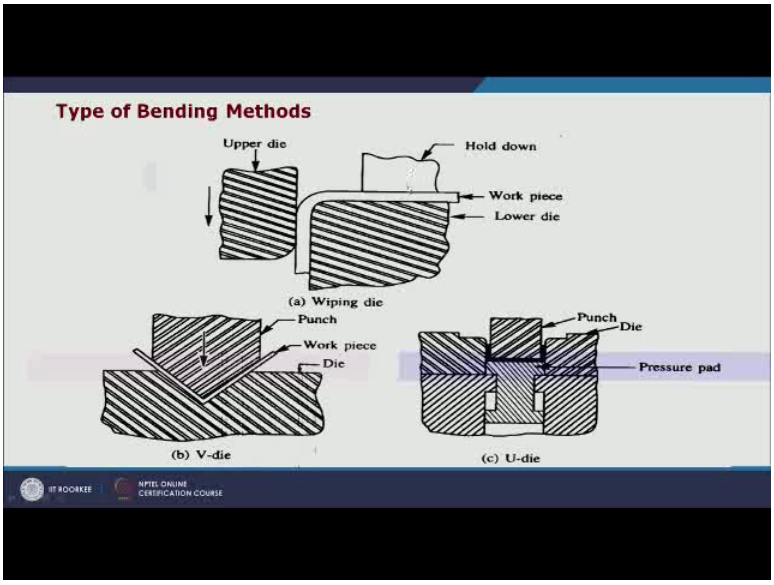

die in this case he sheet metal is held using suitable blank holder, and this lower die this upper die your punch we can say when the upper die move is down the sheet metal is deformed, according to the shape of this lower die. And then for the v die the sheet metal is placed on to the lower die or the die and the punch of the v shape comes into. And then it deforms the sheet metal according to the shape of the v. And the similarly here we can see this is the die and this is the punch and between these 2 when the punch applies the force onto the sheet metal switch it takes the shape of u shape of the die.

Other bending operations which involves like the flanging is the another operation, wherein flanging directly through the 90 degree that is a straight flanging, then stretch flanging and a shrink flanging. So, straight flanging stretch Flanging and a shrink flanking.

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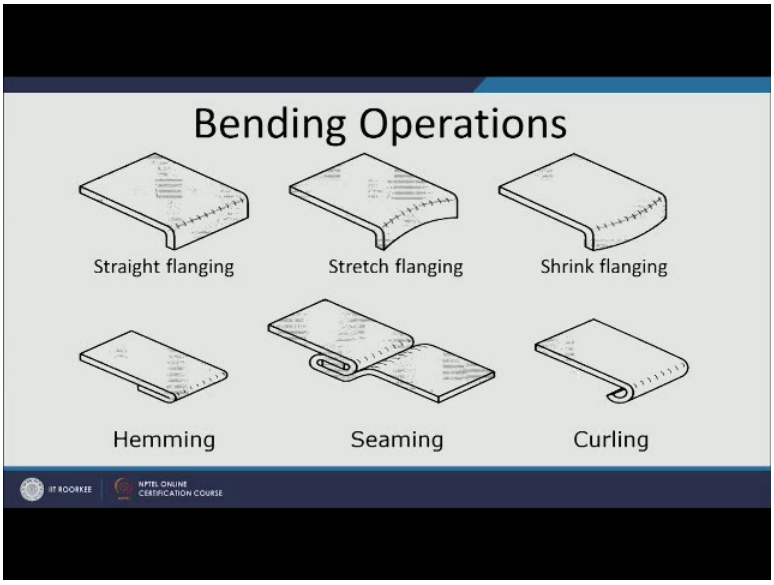

These will be basically a little bit rounding off to the edges like sheet metal is like this. So, the sheet metal is bend at the end. So, in order to avoid any sharp edges and the corners basically it helps to the stiffening of the a sheet metal it is strengthens and hardens the a sheet metal.

So, apart from giving the better shape to the edges, so the different ways of the flanging can be used for stiffening purpose. And then hemming seaming and the curling in case of the curling or it is bend through like this, and for the hamming purpose like it is bend completely through the larger length. So, this is the larger difference. And a seaming is the process where the joint is produced by providing the hamming in the 2 sides of the components and then they are joined together.

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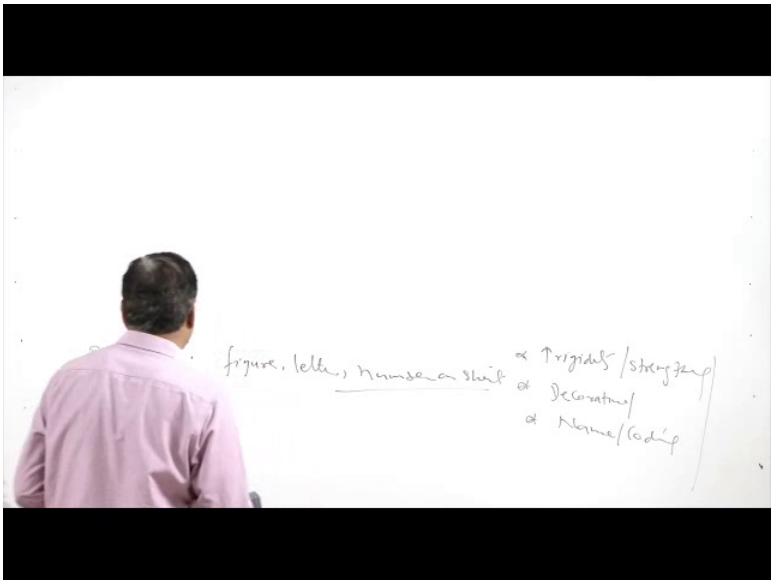

Then another one is the embossing. Embossing is basically a process of producing the a figures letters onto the sheet metal, embossing is used for producing the figures, letters, numbers on to the sheet metal. Basically it is used for the 2 purposes. One is for increasing the rigidity and strengthening of the sheet metal, and another is for the deco rative purposes or for naming or coding purposes. So but how it is achieved? That is what we will see here. Basically the punching a punch and dies are used for this purpose.

So, an embossing involves the application of the drawing and the bending kind of the stress a process combinations, wherein the suitable the shape suitable impressions are produced into the die and punch, so that the product can be made.

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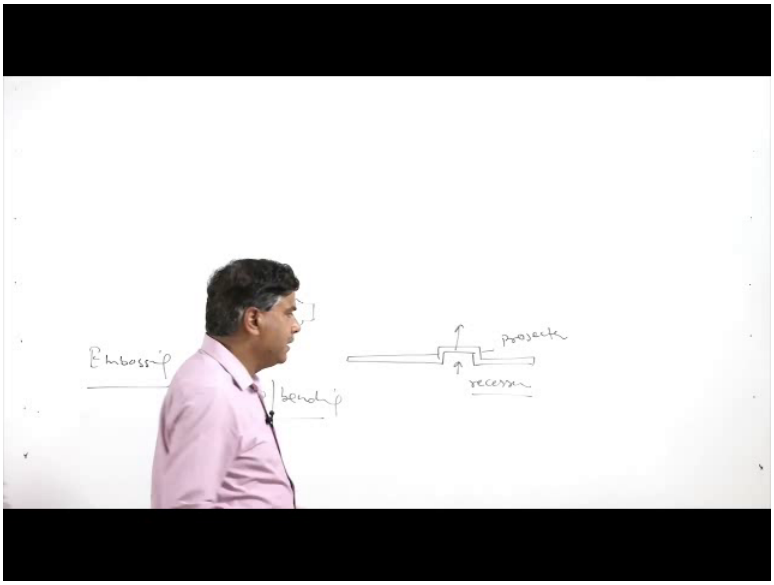

For example if the shape like this is to be generated onto the sheet metal, like this is one like say feature to be produced. So, here if we see this region is having projection in one side and corresponding recession in other side. So, this is the recession side and projection in another side.

So, wherever you will see the projection in one side, then the corresponding recession will be there in another side. While in case of so, this is the difference as compared to the coining in case of the coining we just had a projections of numbers and figures both the sides. While in this case wherever there is a projection in one side there will be corresponding recession on the recession or relief on the other side.

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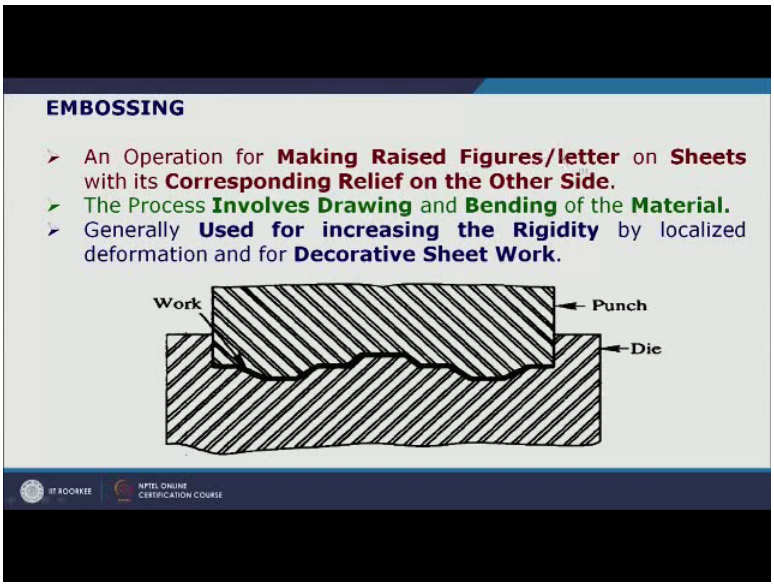

So, in this case like so for this particular say situation we will be making the this kind of feature into the punch, and the corresponding kind of feature will you made in the die. So, this is the die and this is the punch. So, when the punch acts on to the sheet metal, it takes the shape of the of this typical feature which is present in the die and punch. So, basically this kind of a movement involves the drawing as well as the bending of the metal during the embossing process.

So, this is what has been explained using this diagram, like a embossing is used for making the raised figures and letters on to the sheet metal, with the corresponding relief or a recession on the other side. So, if we see here there is a if there is a projection in this side then there is a corresponding recession on the other side. This process involves the

drawing as well as bending of the material and is generally used for increasing the rigidity or for a producing the suitable features for the decorative purposes.

So now here I will summarize this presentation. In this presentation I have talked about the different processes which use like compression, the bending, a tension and compression or the drawing and the bending kind of the combinations for producing the variety of shapes. So, the operations which included like operations which were presented like a coining the stress forming, drawing, embossing, and then there was a ironing. So, these are the different operations which are related with the sheet metal processing.

Thank you for your attention.