Theory of Production Processes

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Lecture – 39
Sheet Metal Operation

Welcome to the lecture on sheet metal operations. So, we have discussed mostly so far about the bulk deformation processes. Now, we will discuss about the sheet metal operations you know which is one of the important forming processes because whenever we have to have flat products, you have to have products or very small thickness I mean CDs some certainly it has very small thickness. So, when we do the forming operation on that, so there are certain considerations which are to be involved and basically the considerations which are to be considered are like the buckling property you know I mean they may buckle under certain type of forces or so. So, sheet metal operations, we will discuss in this lecture.

Now, what are the sheet metal operations and what is the sheet metal forming process. So, in sheet metal forming, the shape is produced from a flat blank by stretching and shrinking the dimensions of all its volume elements in three mutually perpendicular principle directions, so that is the definition of the sheet metal forming process. So, in this, you can classify these processes may be based on the type of stresses which are induced. And then based on that you have a specific operations which are involved. Suppose, you can have the type of stresses like shearing, you may have type of stress which is involve is tension, you may have compression or we may have tension plus compression.

So, based on that you have different types of you know processes which are based on that types of processes suppose for example, if you take the example of the process known as shearing or blanking, piercing, trimming all these are basically the processes or the specific operation which are based on the shearing stress which is involved primarily. Similarly, if you take the example of stretch forming where you have a form block and then you try to pull from both the sides by applying the tensile forces, so you have based on the tensile stresses, this is stretch forming process is completed. Similarly, you have the processes of coining, sizing, ironing all these operations where in the case of coining,

or sizing or ironing, the compressive type of stresses are involved. So, based on that you have this definition of I mean definement of these processes.

Similarly, you have both tension and compression type of stresses are involved in certain processes like you have drawing. So, in the case of drawing or deep drawing where you apply, so because of the tension and compression both at the appropriate positions, you have the plastic deformation and you have the formation of the flat product into flats sheet into different shapes. So that drawing is the example where this tension and compression both type of stresses are involved. You have bending is there, you have then you have embossing is there, so or a spinning is there. So, these are the processes which are involving these different types of stresses like you have it involves tension and as well as compression.

So, you can classify based on the type of stresses. Similarly, the classification may be based on the shape of parts produced. So, what type of shape of parts you can produce like you may have a singly curved part so the one. Then you may have the contoured type of flange parts, so that maybe you know you may have shrink flanges or you may have the stretch flanges. So, this way you may have that kind of shape.

Similarly, you may have the curved sections that can also be you know produced using the sheet metal forming. Further, you may have the deep recessed parts. So, in that you may have the sloping walls or you may have the vertical and sloping walls. And you may have also the shallow recessed parts. So, like you have disc shape and then you have emboss and corrugated parts. So, this way depending upon the different varieties of shapes you can produce you may have the classification of the sheet metal forming.

Then further the another classification will be based on the severity of forming operation how much severely you can deform. So, there is a limit up to which so you have a forming limit up to which you can deform. So, after that there may be chances of having you know the defects or so, so how much with how much severity you can do the deformation. So, all these are the different you know classification you know parameters by which you can define these different kinds of sheet metal forming operations. Now, coming to the forming methods; now, before that we must understand that why this sheet metal is somewhat different than the bulk deforming processes.

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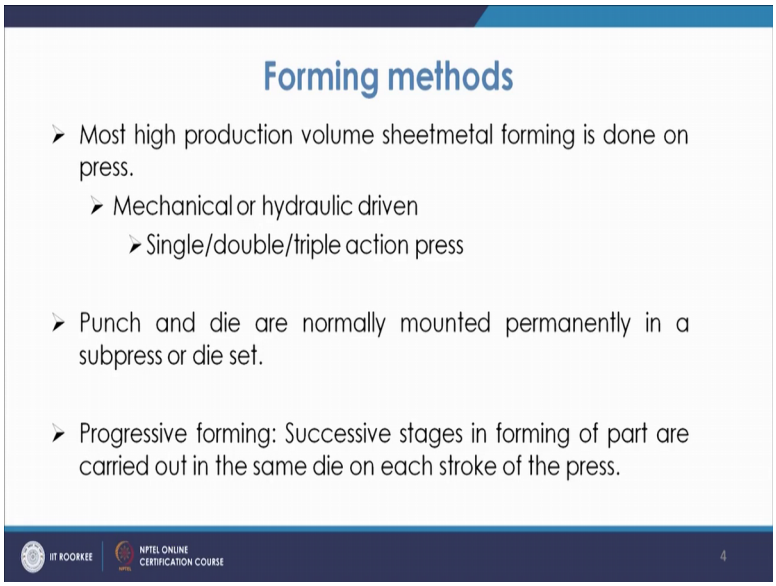

Now, the thing is that normally the sheet metal deformation it is carried out in the plane of the sheet by using the tensile forces; you do not use the compressive forces in the plane of the sheet. So, this is to you know avoid any kind of buckling, so that is one of the you know limitation or one of the characteristic of the sheet metal operations. Now, normally what we do is in the case of bulk deformation processes, our intention is to change the thickness, so we try to decrease the thickness, but here in the case of sheet metal operations, that is not our intentions, our intention is to change the shape. So, we do not want to primarily to change the thickness because that may again lead to that kind of defects like you know buckling or so, so that is the another difference.

And then another characteristic which is very important for to differentiate the bulk deformation processes. And the sheet metal deforming process is that you have quite high surface area to thickness ratio, in this case of sheet metal forming as compared to the bulk deformation processes. So, these are the differences between the bulk deformation process and the sheet metal deformation processes.

Now, we will discuss about the different kinds of forming methods which are utilized for the sheet metal. So, the different kinds of sheet metal deforming processes. Now, most of the high production volume sheet metal forming, we do it on the mechanical or hydraulic driven presses. So, we use either mechanical or hydraulic press. And then that presses

basically it may be single acting trace or double acting press or triple acting press. So, these are the tools basically which are used for the press work.

Then you have basically the attached tools that is you have punch and the die. So, they are used, so you punch will be from the top portion it will we attach that it will be coming and then it will be pressing against. So, it will come and so punch and die these are basically used for this sheet forming operations. And normally they are mounted permanently in a sub press or die set. So, so as to every time you have to fix the punch or we will have to assemble the die or so, normally that is mounted permanently in a sub press die set.

Now, there is a technique of a forming that is known as progressive forming. So, progressive forming means you have successive stages in forming of part which are carried out in the same die on each stroke of the press. So, what happens that in the successive stages how you do the forming, so that the product is being a final product is being basically prepared. So, if you take the example of this progressive forming, you can see that you have a punch here.

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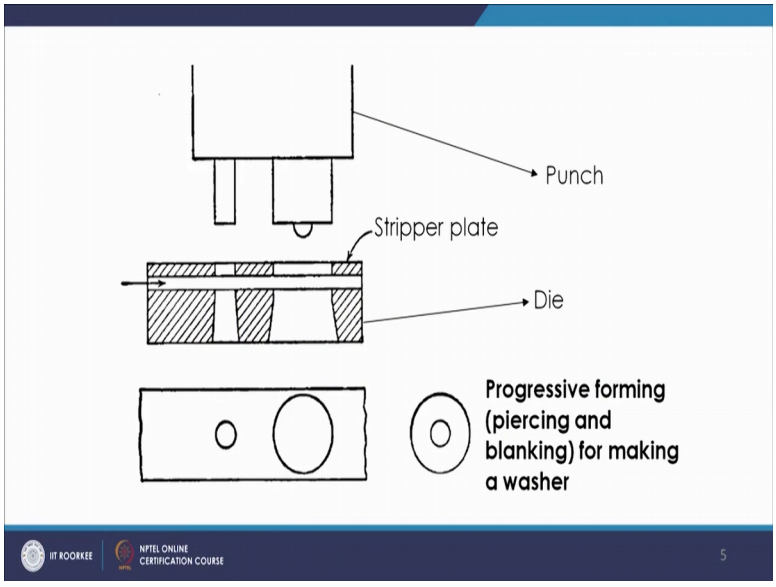

So, here you have a punch this is the punch and then you have the blank here. And this blank will be moved. You see that in the first stage this will be cut, so you will have this is the piercing operation done. And then the blanking operation will be carried out here, so that you ultimately get a washer. So, this is how in the progressive forming operation,

your this piercing and blanking operation in succession that gives you the product of this washer, so that can be seen in the case of these progressive forming methods.

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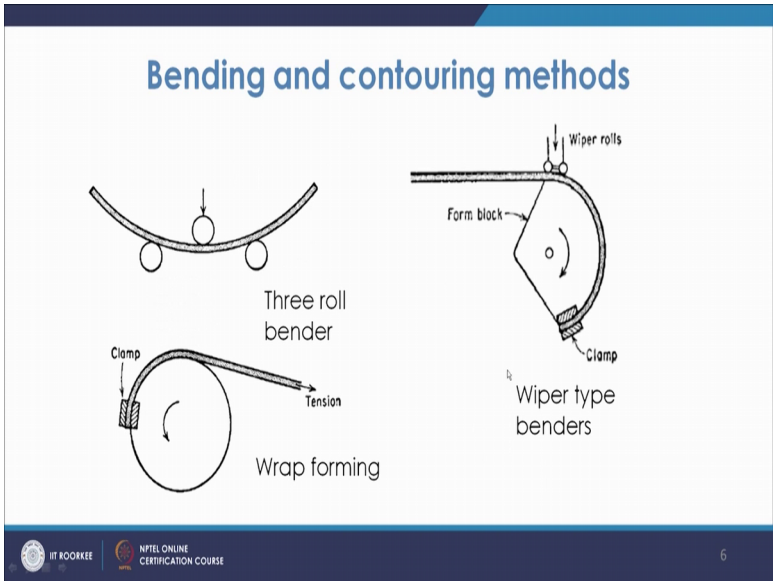

Now, other than that you have the bending and contouring methods. If you look at here you have these methods as known as bending and contouring methods. So, they do the bending operation or they make the contours of the you know shape you want. Now, in the case of bending and contouring methods, you have normally three types of these methods are available.

Now, in this case, you have the three-roll bender. So, we have you use the three rolls, two rolls at the bottom and one roll on the top. And then they do the bending operation, but then certainly some limitation here. There is chance of having the buckling you know in this stage depending upon the roller distances or depending upon the amount of forces applied, so that is the problem with this three-roll bender. Because in the case of three roll bender the maximum bending moment will be you know experienced here in this position. And if the gage of the sheet is very thin then there may be the chance of buckling.

So, then you have two other types of benders, one of the bender is known as the wiper type of benders which give you more uniform deformation along the length of the part. So, as compared to the three-roll bender, this wiper type benders provide you more uniform type of more uniform bending along the length of the bender. So, what happens

in this case in that basically you have the successive use, so this is the wiper rolls. So, this is as you can see that it is pressed here, and then you have this is the form block here. So, this is the form block. And then you have the contoured progressively formed in this case. So, by pressing against the form block and then that way your bending takes place.

Now, in the case of the another example is you know wrap forming method. So, as you see that you have a clamp here. So, in the case of wrap forming, so the sheet is compressed against form block, so that you see that you have this is the form block. So, the sheet will be compressed and clamping is there. So, it is compressed and then the tension force is applied in this case.

So, here you are the pressing is done in the rolls using the wiper rolls, so that way by pressing the against that form block you try to make the safe as per the form block shape. And in the this case, this is clamped and then and then you are giving the tension force in this direction and that way. So, since this just like it is wrapped around that form block. So, this way this type of method is known as wrap forming. So, these are the different you know bending and contouring methods, we will discuss about more about these bending methods as we move further.

Then coming to the shearing, and blanking, and punching methods. So, basically you have operations like shearing, blanking, punching and piercing these are the operations that basically are used to cut the sheet metal. So, if you look at these shearing operations, we can have a look at the shearing you know pictures. So, here what happens you have a sheet or a blank and then the blades are from both the sides. So, you have from the top side as well as from the bottom side and then there will be some clearance in between them. So, because of the shearing force, you can have basically the shearing action taking place, so that is possible by that.

Then blanking and punching basically here what we do is you have the blank. Now, in that on that flat sheet you are removing the central portion and then depending upon the use you have the words do you have this definition known as either blanking or punching. So, when in one case you can use the resist part or the part which is you know made hollow at many places; and then in another case we may use the you know part which is taken out. So, depending upon that you have blanking and punching defined.

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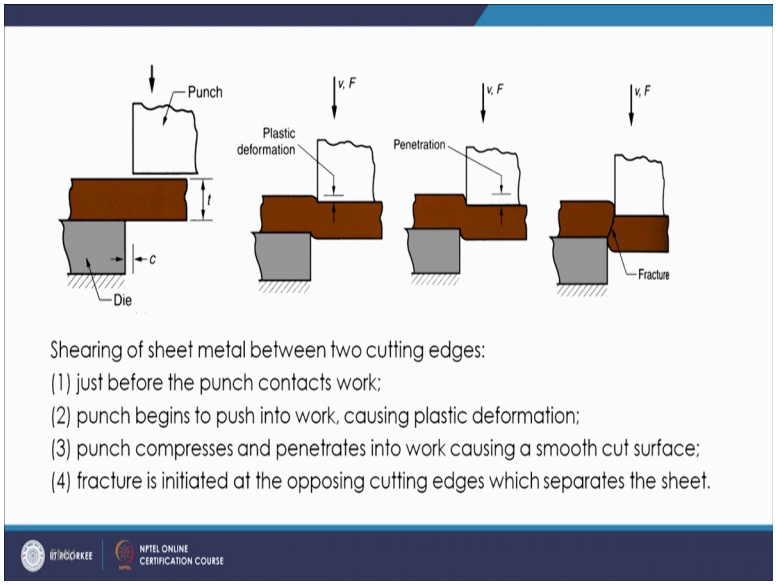

So, that can be seen by looking at the picture. So, coming to the process of shearing, if you look at now this is the case of shearing where we see how the searing process is advanced. So, you look at these stages. In the first stage, you have this is the punch, and this is the die. And as you see this distance c is known as the clearance between the die and the punch. So, punch will be the dies anyway fixed at the bottom, and the punch will descend from the top. And this is the thickness of the sheet which is to be sheared. Now, what happens that this punch will descend with the force and it is so just the before the punch is contacting the work this is that stage.

Now, what will happen that this punch will begin to push into the work causing the plastic deformation as you see it is pushing here and this is pushing here, so this way you have this is the plastic deformation you see from here, so this much is the plastic deformation in this case. So, then further punch will be compressing and penetrating the work causing a smooth cut surface in this case. And then the fracture is initiated and the opposite cutting edges which separates the sheets. So that because of this you know as these starts doing the plastic deformation, the fracture will start at this point and then the fracture will be initiated at the opposite cutting is and that way you see that this way the fracture is you know ultimately started. So, this way after that the two sheets will be removed. So, this way the shearing action is taking place.

Now, in the case of this shearing, you know you need to have the punch force. And if you look at that the punch force has been given, and it can be computed, and the maximum points force that will be you know you can have that for that you need to know the ultimate tensile strength, then you need to know the thickness of the sheet. And also you need to know the total length of the shear edge. So, once you know that you can have the maximum punch force. So, maximum punch force will be 0.7 times you can have the so 0.7 times sigma u that is your ultimate tensile strength and then the thickness of the sheet and then the total length of the sheared edge.

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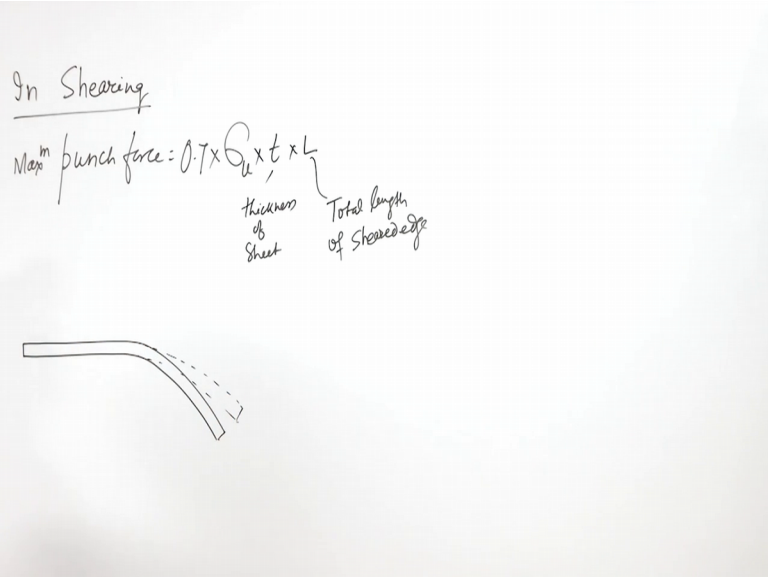

So, you can write in shearing maximum punch force so it is basically defined as 0.6 times sigma u that is your ultimate tensile strength then you have thickness. So, this is thickness of the sheet. So, once you have one you know that you have 0.7 times sigma u times the thickness, and then you need to know the total length of the sheared edge, so that is L, so that will be total length of sheared edge. So, you have the sheared edge suppose you are shearing along any length. So, you have this sheared edge length and then you have the thickness so that will be giving you the idea basically and then you are doing the ultimate tensile strength of the material which is basically of the sheet and then you multiply with that. So, this is basically said to be the maximum punch force are in that case.

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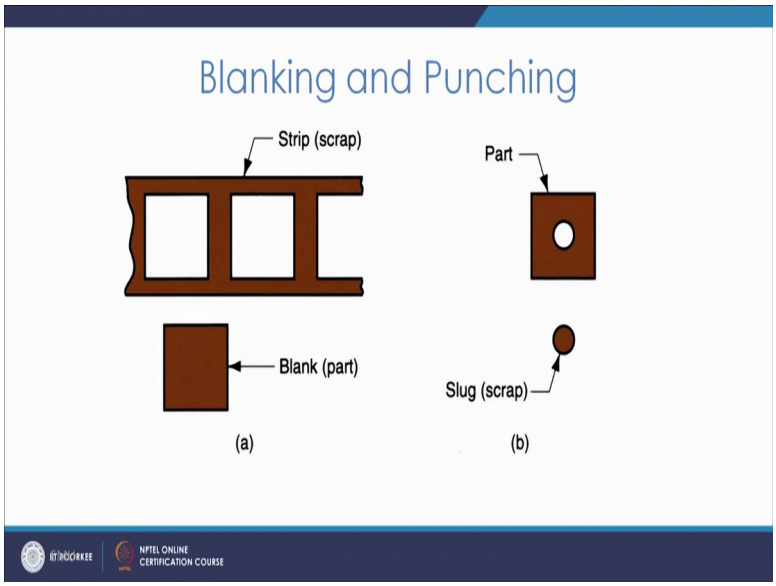

Now, if you look at the next operation what you see is that you have the blank and blanking and the punching. Now, what happens it is just the use of the product based on that this blanking and punching is defined. So, you know when the metal inside the contour is the desired part, so when this is the desired part then it is known as blanking. So, once we have done the shearing, and once we have taken this portion out, and if you want to use this, then it is known as the blanking portion. In that case, this is the scrap. And similarly in the case of punch, you need to have this sheet punched. So, now this is of use to you and this becomes a scrap for you. So, basically that becomes and that this slug is the scrap, so depending upon that you define either the blanking or the piercing or the punching.

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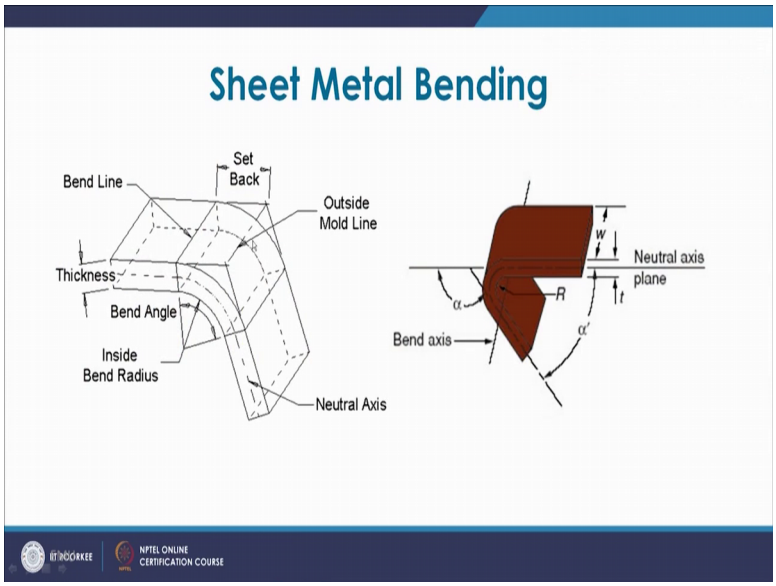

So, next we are going to discuss about the bending. Now, what we see is that in the case of bending, what we see that you have this surface which is bend. This surface is bend. So, you have the in inner surface also bend, you have the outer surface also bend. And then in between you have a surface that basically that is known as the neutral axis. So, if you look at the bending, so the part which is under the tension, the inner part will be under the compression, so in between you will have one line which is neither either under tension or nor under compression. So, in that case that is basically known as the neutral axis.

If you do the bending, there are certain terminologies which are basically required to be known. And one is the bend radius. When you bend then you will have the formation of a radius so that radius, so this is known as the bend radius. So, this will be the radius, inside bend radius will be this much. So, then you have the other terminologies in the bending is basically about the spring back. So, when we do the bending because of the elastic property, whatever is the bending you have got the bend radius, now after that that will change so because of the elastic property. So, that way the bend radius basically changes, and you do not get the proper you know shape to which it you have bent it. So, that is how that is because of the spring back effect because of the elastic property of the material. So, that is there in the case of bending.

Now in the bending, you have the parameters like you have the R that is bend radius. You have the bend angle that is alpha, so that is that you know that you have the bend angle which is alpha. And similarly you also give the bend allowance, because you have to as you know that allowance is to be given, so that you get the appropriate shape of the bend component. So, also we need to know some other aspects in bending operation, you know how much you can bend maximum. So, there is a limit on that. And for that the there is a minimum bend radius which is basically expressed in the you know in terms of its thickness, so that is the minimum bend radius up to which you can goes as you are bending the bend radius goes on reducing.

So, what happens when you bend, you cannot bend more than that depending upon the type of metal which you are bending or its thickness or so. So, suppose something like it 3 t minimum bend radius is 3 t means three times the thickness of the sheet, so that will be 3 t. So, if you do you cannot go beyond that 3 t, three times the thickness of the bend radius, so that way the minimum bend radius is basically specified in many cases.

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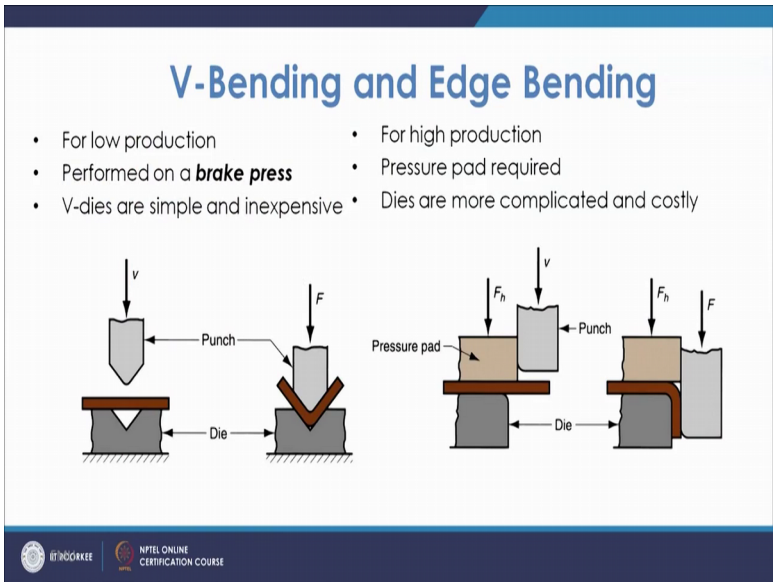

Now, if you take the bending process if you try to see the how the bending is done. So, you have the v bending, and you have the edge type of bending as you see. So, you have the v dies. So, based on the type of dies that is v dies you get the v type of bending. So, they are simple and inexpensive. You apply with velocity v and you apply the force f, so that basically gives you the v kind of bending.

And then if you go for the edge bending. So, in the edge bending, you are applying that on the edge. So, you have the high production, you have pressure pad which is required here because when you go for bending. Here in the case of V bending from the both side when you apply the pressure then both side are in touch with that the punch itself. So, you need not worry about its interference, but in this case if you do not put this pressure pad then this may go and fall and form the shape along the punch, so that is not desired, so that is why you are putting a pressure pad. And then once you punch you apply this you have ready force here and this is descended then the this takes this shape. So, dies are more complicated and costly, but required for high production.

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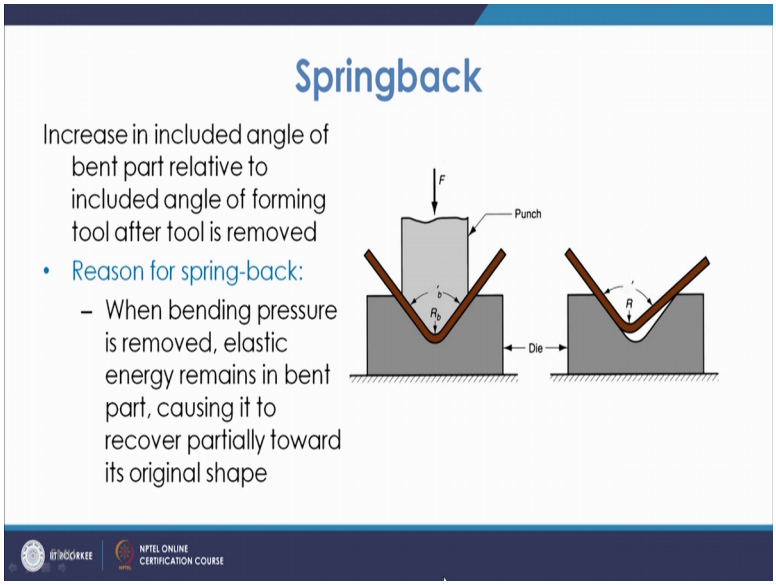

So, now if you look at as we discussed that we needed to know what is the spring back, what happens that the spring back is nothing but the increase in the included angle of the bent part relative to included angle of forming tool, after the tool is removed. So, what happens if you have the bending, so after the bend the final radius bent radius will be somewhat more. So, just like you bent up to certain way like suppose you have bent in this shape, and then because of the spring back it will move to like this. So, this is because of the spring back. So, in this case, the bend radius was smaller and because of the elastic property, the radius became a little more, so that is because of the spring back effects.

Now, this is basically depends upon many kinds of parameters and depending upon the type of materials or so. So, reason for spring back as we discussed that when the bending process is removed elastic energy remains in bent part causing it to recover partially towards its original shape, so that is what the reason for this spring back is.

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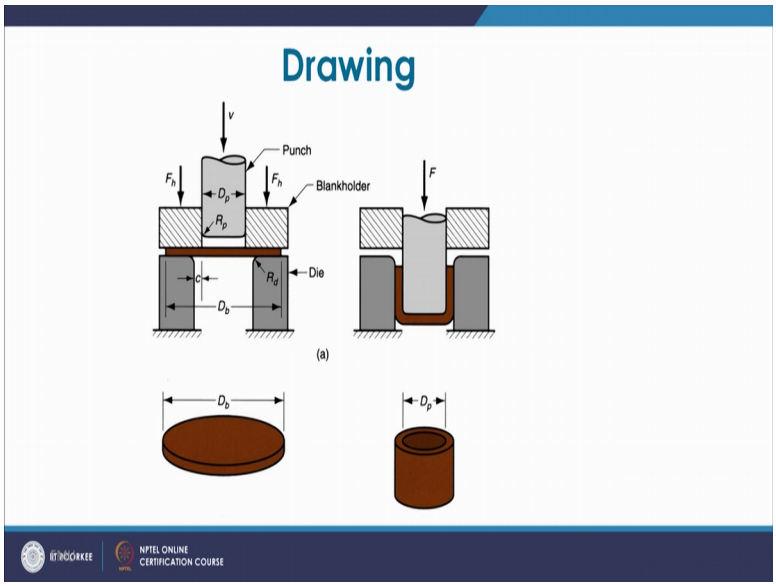

Now, other important sheet metal operations are basically the drawing and the deep drawing. So, in drawing, what happens you have the punch. And this punch will be you know going in the downward direction. And then you have the die and there will be clearance in between. So, when the punch descends and the thickness will be basically taking in this clearance part. So, this way you know this kind of component is formed and that is known as drawing.

Now, there is another process that is known as deep drawing. So, in the case of deep drawing, the length is basically the height is larger. So, you have certain correlation between the height and the diameter. So, this is larger. And in that case, you have the provision of something which is basically ensuring that it does not interfere with the punching operation. So, you have that way a sheet which is kept here which ensures that it does not interfere with the punching because once it so that time since the it goes to larger thickness, so you have a larger length of the sheet, so that way once it goes it can come and inter it can interfere with this punch. So, that time you have the condition of deep drawing.

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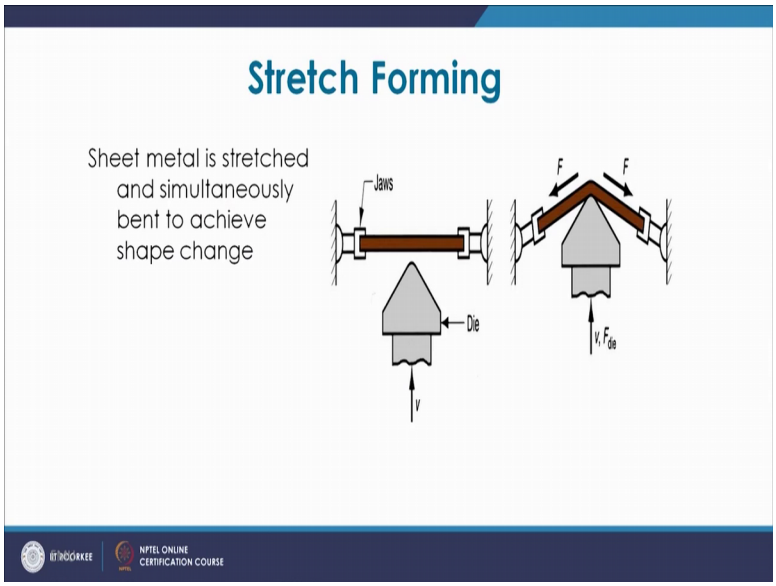

Apart from that you have other processes like you have stress forming. So, in the case of stretch forming again as we discussed you have the application of tensile stresses. So, you have a form block, this form block is here. And then this form block is pressed against this. So, it will be under the tensile forces. So, once it goes, it will be taking this shape ultimately, so that is known as the stretch forming methods.

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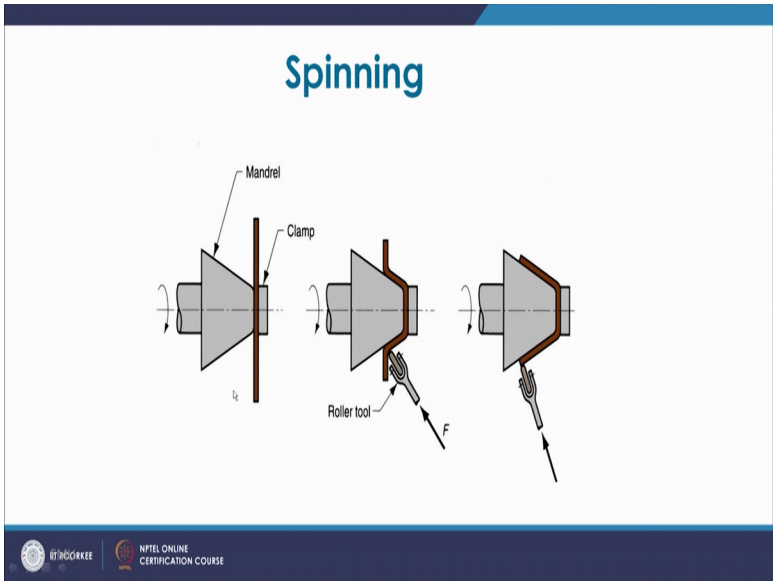

And then you have the spinning methods these are the known as the spinning methods as you see. You have different kinds of spinning method. So, where that is rotating and then

you are applying the force here. So, depending upon the tool which you use, you can see that you have the different kinds of and so basically it is used for the axisymmetric type of parts where you apply the force and you get the axisymmetric type of the product. So, normally you have and you use the lathe also, so that there itself you use that you know on the lathe you have a form block attached and then there you apply the pressure. So, this way since it is rotating, so that way your axis symmetric such kind of part will be produced in the case of spinning methods.

Apart from that you have other methods like you have ironing is there where basically many times you need to decrease the diameter of the cylindrical specimen. So, that way it is passed through and then in every successive operation the thickness of that cylinder will be reduced. So, basically reducing the thickness of cylinder in every stage that is done by the process known as ironing.

Now, you have other sheet metal operations like you must have gone through that in your earlier courses like you have embossing is there, coining is there. So, depending upon the flow of the metal in the case of embossing and coining you know in the case of embossing, you have the relief on the other side where in the coining the flow of metal takes place in those cavities. So, you have the flow of metal in the even small (Refer Time: 34:23) it goes, so that way the coining operation is carried out by this use of again the punch or so. So, this way you have different kinds of sheet metal operations. And you can read about these different kinds of sheet mental operations and know basically now here in this case we need to know the forming limit basically up to what it can be formed, what degree it can be formed because after that you are likely to have the defects. So, this is about the sheet metal operations in forming.

Thank you very much.