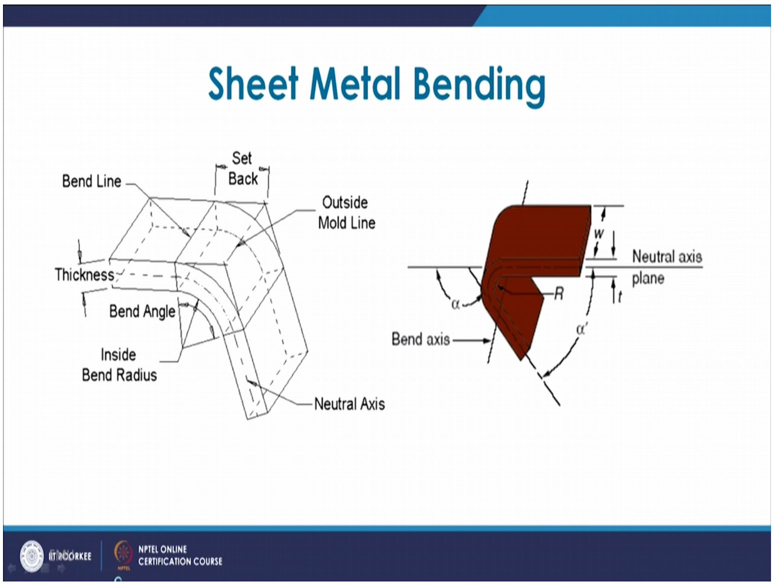
Principles of Metal Forming Technology

Dr. Pradeep K. Jha
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 38
Sheet metal operations - II

Welcome to the lecture on Sheet Metal Operations, that is part II. So, in this lecture we are going to discuss about the sheet metal operations like bending, drawing or deep drawing, and other miscellaneous kind of sheet metal operations like stress forming or others. So, coming to the sheet metal bending; so, as we know that bending is very important process which is normally applied on the sheet metal. And when we talk about these bending; so what do you mean by bending?

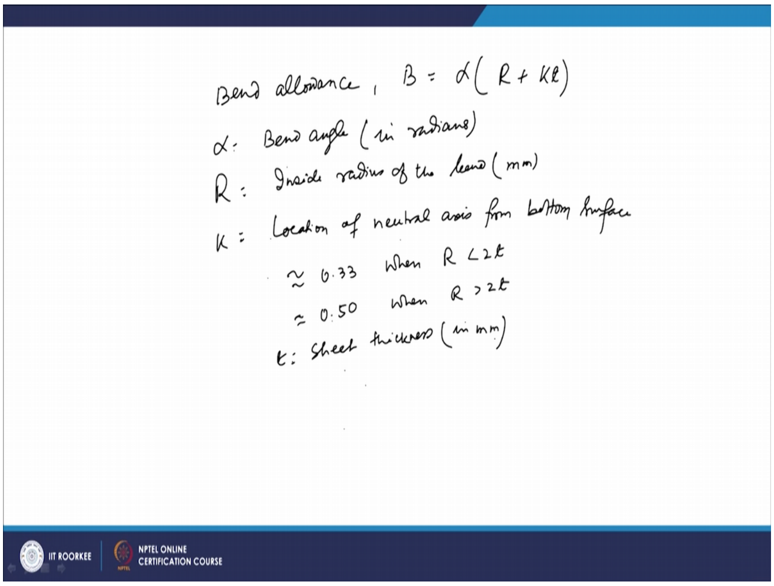
(Refer Slide Time: 01:07)



Basically we are a flat sheet is there. So, we are deforming this flat sheet around a straight axis so, you have a neutral playing basically. Now what happens that if you look at the sheet which is bend; now, this basically has 2 surfaces. The top surface is in the attention and while the bottom surface is in the compression. So, they there will be even a access which will be neither on the (Refer Time: 01:44) or in the compression. So, that basically is known as the neutral axis. Now the thing is that you have a certain, you know, a terminologies, you know, in that bending process. And basically among them the important one is the bend angle. So, bend angle is basically defined with certain angle that is alpha so, that is this is your bend angle alpha.

Now, the thing is that you have a the bend line, now be this bend line indicates that basically there is no effect of bending on the structures or so, you know, after this reason. So, so this is the reason of the bend line, and you have this is also this reason is known as the bend allowance. So, based on that you need to know these, you know, bend allowance in the case of bending, and when we talk about finding the bend allowance then this bend allowance is basically.

(Refer Slide Time: 03:02)



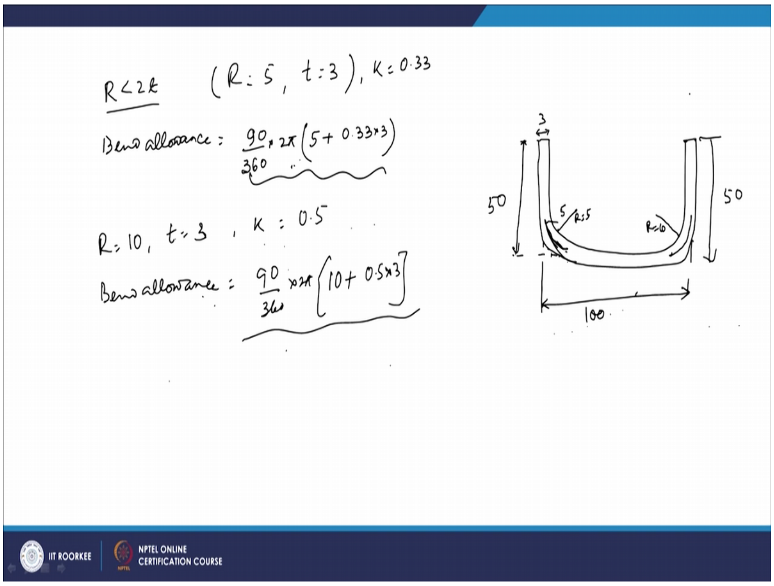
So, bend allowance that is normally represented by B and it is equal to alpha into R plus k t. So, bend allowance that once that is known to you, then, you know, that that is the reason where the deformation is occurring because after that the material is not, you know, in between that bend lines you have the bend allowance, that is along the neutral axis that length is known as bend allowance. And after that the material is not affected. So, in that alpha is known as the bend angle. Then that is in terms of radians.

Similarly, you have R so, R is basically the inside diameter of the bend. So, this is known as inside then not diameter inside radius that is in the units of millimeter. And you have k so, k is basically is it is the location of the neutral axis from bottom surface so, this is location of.

So, it is value normally is taken as 0.33 when, you know, it depends upon the thickness of the seat. So, when R is less than 2 t then we take this as 0.33 and we take it as 0.50, when the R is more than 2 t; where t is the sheet thickness that is in m.

So, in incase of bending that is what is normally required to be known. So, you may have certain kind of problems; where you have the, you know, sheets given, and in that case you have to calculate that bend allowance. And accordingly you will have to find the total length suppose, you have you are given one example that you have to length of the sheet you have to find.

(Refer Slide Time: 05:40)



If you have certain kind of, you know, sheet is sheet is to be bend in certain, you know, a types you have to bend. So, what should be the total length, because you have to have the bend allowance. Now suppose these dimension is given as 3, and this dimension is given as 50. And you have this dimension is given as 100. And similarly you have radius here. So, this radius suppose is given as 5.

So, this is R equal to 5, and similarly here you have given as R as 10; and this is also the height which is given as 50. Now you maybe, you know, given the such kind of bend, you know, a structure you have to make and what should be the total length because you have to ultimately bend it is so, what should be the total length of the sheet required for making such component where the R is provided; so in those cases as we discussed that as we see that here the thickness is t and this R is 5.

Now, if you take the 2 times thickness in such case. So, here what we will see that we see that R is less than 2 t. In this reason where, you know, R is 5 and, you know, t is 3. So, certainly t 2 times t is 6 so, R is less than 2 t so, that is why we will take k as 0 0.33. That is why for this reason you will take the bend allowance. And bend allowance as we know that it will be alpha times R plus k t. So, it will be alpha. So, alpha is certainly that is 90 degree. So, 90 by 360 and into 2 pi so, that will be your radian. And then you have a formula as R plus k t. So, R is 5 and k is 0 0.33 and t is your 3.

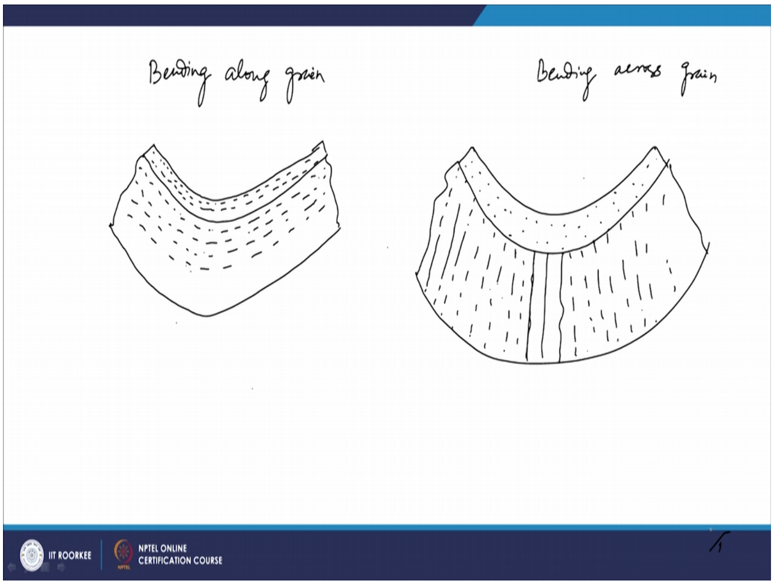
So, ultimately this will be the value which is which you have to find, and that way you are getting that that value. So, bend allowance will be on this reason you will have this value, similarly, if you take to this side this side you have R as 10 and since t is 3. So, in this case R is more than 2 t so, in this case you will have k as 0.5. So, in this case you will have the bend allowance, and bend allowance will be again that will be 90 by 360 into 2 pi and in that case you will have this 10 plus in that case 0.5 into 3.

So, that way you will have the calculation of these bend allowances, and that will be taken out so accordingly you will have to take for this part for this part where you have to find these bend this (Refer Time: 09:18) this bend allowance here. And here you have to take that and then ultimately you have to add these values to find the total length. So, that is how we work for the finding the bend allowance.

Now, you know, bend radius also is specified minimum value and normal it is 0.5 t for the soft materials and t for the other materials, and it will be 3 t for the spring materials. That is also provided in the literature as far as the, you know, bending is considered. Now there is also, you know, spring back effect in the bending, and it is to be compensated when we talk about the bending and for that you are certain data which is available in the literature.

Now, you have also different types of bending and we can also see that there will be, you know, bending which will be sometimes the bending you can do along the grains.

(Refer Slide Time: 10:35)



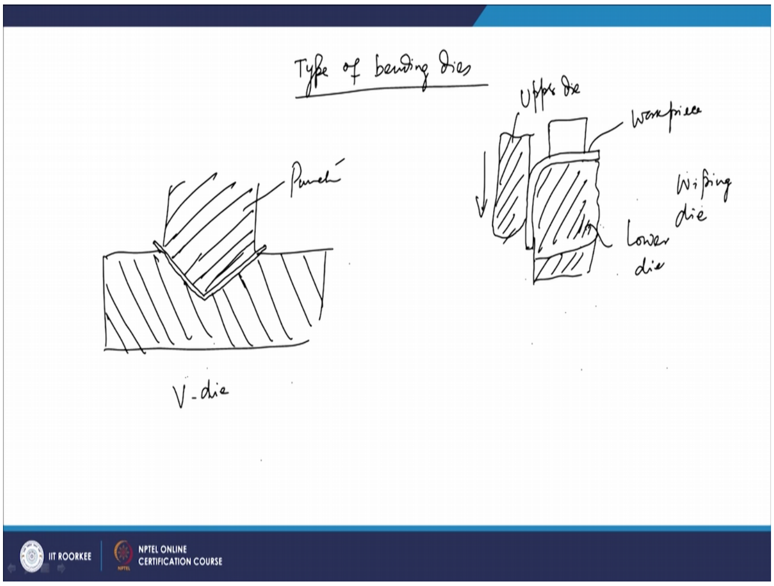
And you can also do the bending across the grains. So, there may be bending along grain and bending maybe across the grain. Now the, you know, when we talk about the bending along the grains. So, basically if you have a certain kind of bend you have produced. So, you have such kind of bending, and you can have the bending like this.

So, what happens that when your lines are like this? It is a example of bending along the line from the fiber lines basically. So, this is bending along the grains. So, so this is the example of bending along grains. So, this is the example of bending along grains, where as you may have a grain structure which may be a; you know, so, the grain structure may be like this it is not having a line in that way and grains structure is basically in this case, if you look at.

So, in this case the grain structure may be like this. So, it may so happen that if you are doing the bending. Now in such cases you have bending from here and your bending comes like this. So, this is bending that is a cross the grain. So, this is the example of bending across the grain. And as far as the possible the bending is to be done in a direction perpendicular to the grain directions. So, that is normally preferred and along the length of the access basically. So, that is normally preferred in such cases.

Then you have also depending upon the type of bending which you have do you have the bending dies. So, you may have the wiping type of die or you may have the V die or you may have the U die. So, that will basically we doing the type of bending operations you have type of bending dies.

(Refer Slide Time: 13:36)



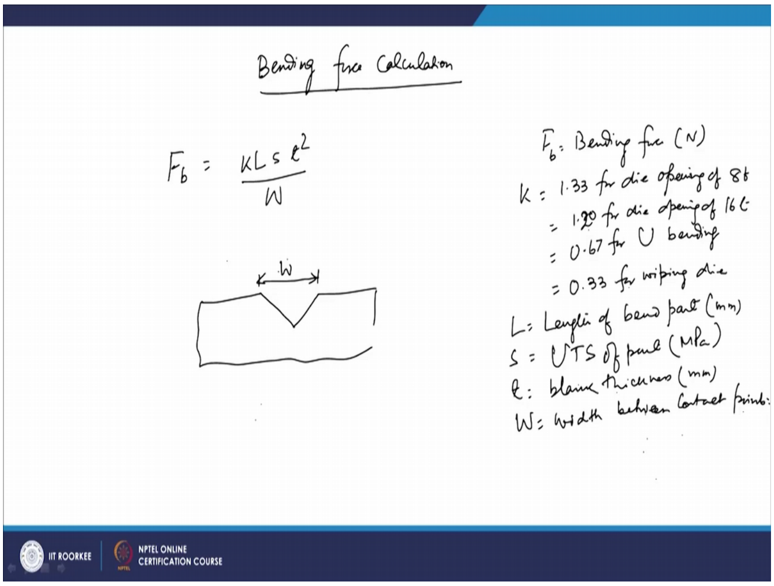
And you have if you have to make such kind of bend. So, if going you have to make such kind of bend, in that case you have wiping type of die. So, you will have an upper die, it will be coming like, you know, this so, this will be your upper die. And similarly you have another lower die so, lower die will be here. And so, this will be your lower die.

So, this is your upper die, and this is your lower die and this is your work piece. Now in this case what we do if we have to hold it (Refer Time: 14:35). So, that is normally known as so, this is basically for holding down. And then once it is hold down and then this a wiping action will be done by this upper die, and they will be moving over this job, and it will be taking this path going in the bottom direction. And that will be bending the sheet; so, that is an example of this wiping type of die. Then if you have to make some angular, you know, type of conclude or you have to make in angle V angle is there.

So, in those cases you have the V die and you can have so, suppose you have to make such kind of bend. Now in this case you have the punch, basically punch will be of this shape only so, this will be your punch. So, this is normally your punch and bottom you will have a die. So, so it is from here you will have a die. So, so this will be another die, this is a bottom die and the top you have the punch. So, this is known as a V die, this is known as your wiping die.

Similarly, you may have the U type of die. So, you have for U kind of, you know, shapes which are formed that is known as the U die. So, that way you have different types of dies which are available; now, when we talk about the bending forces, when we have to calculate the bending force for bending force; if we talk about the bending force calculation.

(Refer Slide Time: 16:35)



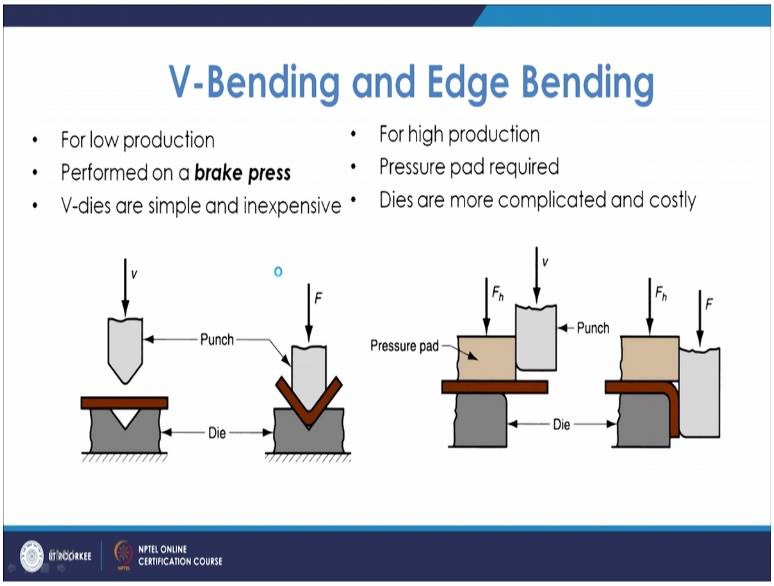
Now, bending force is calculated using certain empirical correlations, and that is KL s into t square divided by W. Now in this case bending force is this is F b and it is measured in terms of Newton. Then k is a constant, and this is constant is a function of t. So, so it will be one 0.33 for die opening of 80.

Similarly, it will be a 1.20 for die opening of 16 t, similarly it is 0.67 for U bending, and 0 0.33 for wiping die. So, that is your k, then l is the length of the bend part. Similarly, s is the ultimate tensile strength of the material. So, it is U t s, that is, you know, of the part, and it is in the unit of mega Pascal.

Similarly, you have t, l is basically in m m, and then t is basically thickness of the blanks, so, this is your blank thickness. And it is measured in terms of m, m and w is the width between the contact points. So, once, you know, all these values, then you can have the calculation of the bending force. So, suppose width may not be clear. So now, what happens that when you have such kind of, you know, bend which is to be carried out, then in that give this is your width, this is how so, this is basically that is your die opening basically which is this is known as; and then you have the R n R r 1 and R 2 which is there already you have the, you know, provided that may be also provided for the, you know, wiping die.

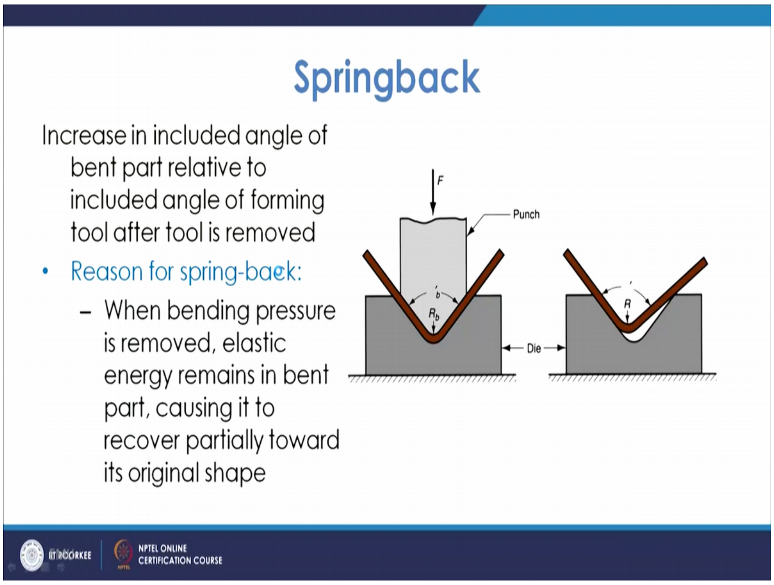
So, in the case of wiping die you have the 0.33 has to be taken. So, when we have such wiping dies given, as we know that in that case you will be given the radius also to the dies and accordingly; you have to find the bend allowance or bend length for solving the problems based on the bending. Now coming to so, that is what we have seen about these bending operations.

(Refer Slide Time: 19:51)



Then coming to the V bending and the edge banding as we see here, this is your V bending and this is your edge bending we have already discussed that how the bending process is basically done this is; how you are holding that and then the punch will be descending and doing that bending operation, here we (Refer Time: 20:11) by on a V type of dies. And this is your wiping die. So, that is how the bending process is going on.

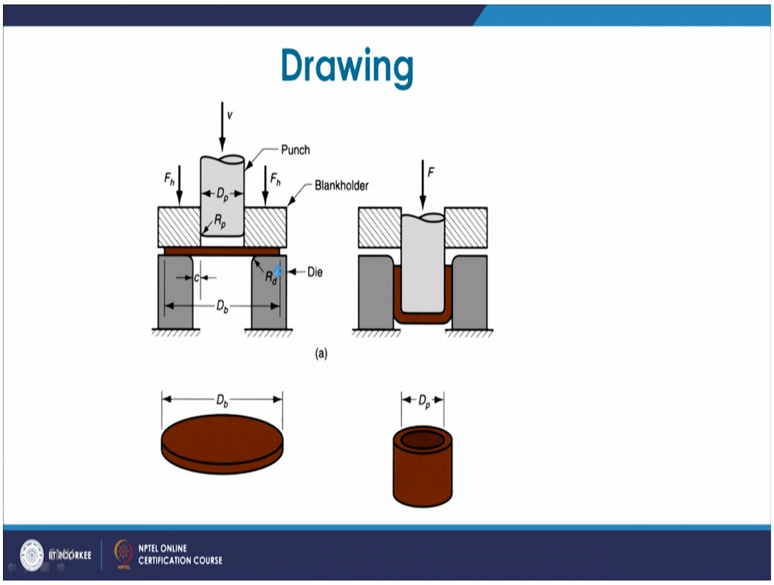
(Refer Slide Time: 20:20)



Now, there is a, you know, spring back effect. So, because of that spring back effect what will happens is that you can see if you have a spring back it will be coming like this. So, you have increasing the included angle of bend part, relative to included angle of forming tool after the tool is removed; so certainly that because of the elastic nature. So, once the tool is removed you have the increased a value in the included angle of the bend part. So, it is basically when you are holding that tool, to this job in that case these included angle and the also the angle of the forming tool they are same. Whereas, when we go to and once the tool is removed in that case that part increased. So, that is how the spring back effect comes into picture.

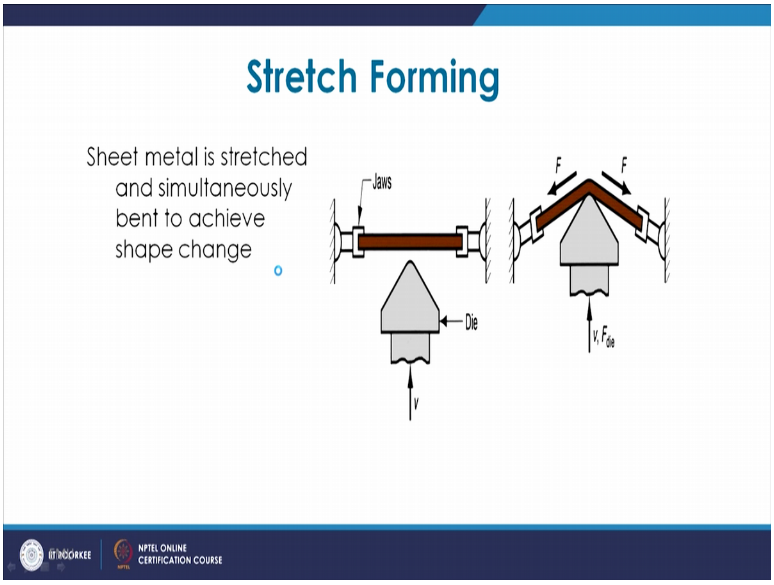
So, what is the reason of this spring back, basically when the bending pressure is removed elastic energy remains in bend part, causing it to recover partially, you know, towards it is original shape. So, that is what because of that part this is basically, you know, coming back to it is, you know, shape.

(Refer Slide Time: 21:34)



Now, we have another process that is your drawing. Now in the case of drawing as we see, you have we have already discussed that we have a blank holder, and you draw, and then this sheet basically you have a clearance provided. And then once you have the in the die you have the radius provided and you have the holding. So, holding force is there and you apply with certain velocity and force and then this basically does the job of the drawing operation.

(Refer Slide Time: 22:12)

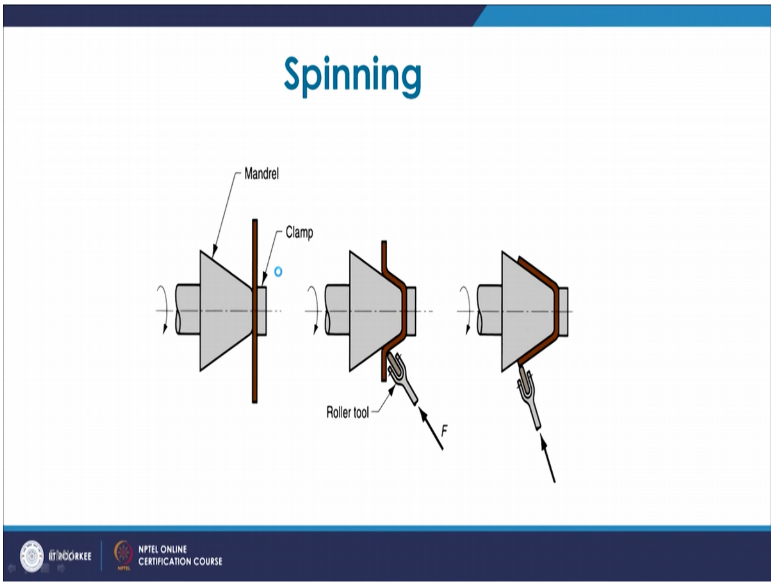


So, then in the case of basically drawing you have another, you know, operation that is deep drawing. So, in that give deep drawing basically (Refer Time: 33:18), you know, for that this blank holder is there so, basically one statue goes. So, here the length is basically this length is larger. So, you have the chances of interfering with the punch motion so you have for that also you have to have the mechanism so, that we will see. Before that we have another process that is stress forming.

So, in this case of stress forming, what is done is that the metal will be stress and simultaneously bend to achieve that shape change. So, basically have a form block, and using this form block when you are applying the force then the material is coming and taking the shape of this form block or die, so that the example of these stress forming operations.

Then apart from that you have certain operations like you have spinning.

(Refer Slide Time: 23:27)

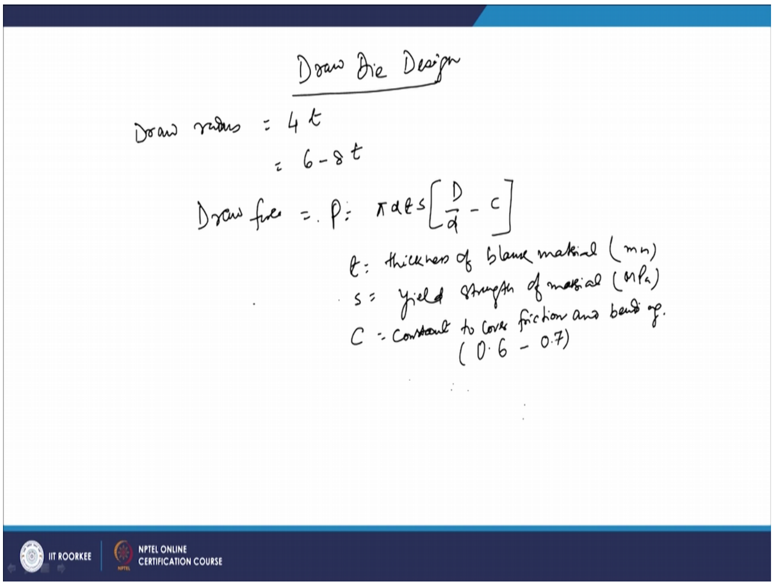


So, in the spinning you have a tool which is basically being applied with certain force, and then it is like the, you know, stock of the, you know, lath. So, you have a application of the, you know, this tool and once it rotates and then apply the forces, in that case it is taking that particular shape so, this is the a spinning tool. Apart from that you have processes like embossing and coining. So, as we know that in the case of embossing you have you have might have seen many sheets where you have a relief is there on the outer side. So, you might have seen the examples of.

So, here we are using the all the compression forces and in those cases your relief is basically produced on the other side that is embossing. Similarly, in coining basically so, in that case the flow is in one side of the die, whereas in if you look at the coining; so in the coining basically is a type of the cold forging operation. So, here only at the top layer the flow of the metal will take place and all the final details will be achieved in the case of these coining operation. And, normally the embossing is used to provide the dimples on the sheets. And they are used in the panels in the religious structures or religious places so, that is they are in the case of embossing.

Coming to something more about this drawing operation; so as we are discussing about drawing and deep drawing so, where we are talking about the, you know, drawing operation. In that you have certain blank holding force is required. So, when we talk about the draw die design.

(Refer Slide Time: 25:28)



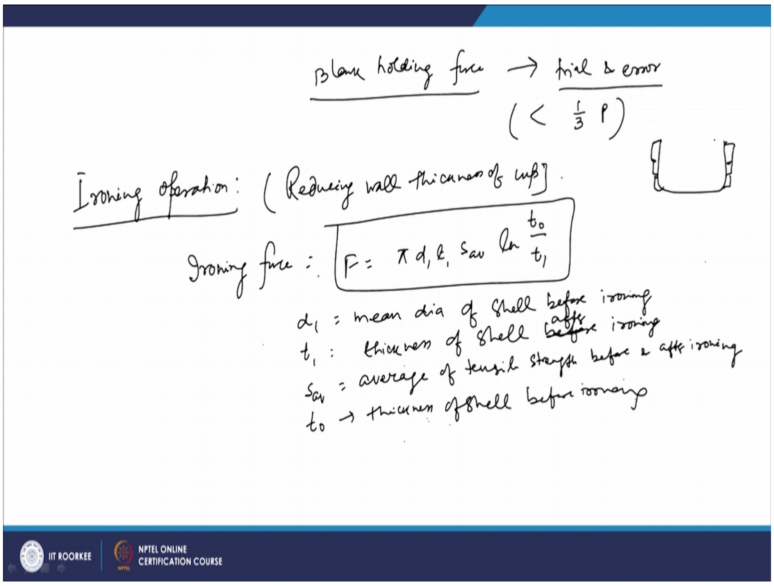
Now, in this case what happens that, normally you have, you know, blank holding force. Now similar to one for that you have the, you know, draw radius first of all what we what is the draw radius which is there on the die. Now this draw radius which is they are provided on the die, it is basically normally the 4 t for the normal operations and it is for 6 to 8 t; when you use the blank holders, and it will be used as so, also the 0.8 pi into d minus capital d minus small d into t. So, that will be used for the circular objects.

So, when they were t is becoming thickness; when we have to calculate the draw force. So, basically draw force will be given by so, it will be depending upon the cup material and also dimension and configuration. But otherwise the drawing force is empirical calculator using a formula that is P. So, P will be pi d t s into D by d minus c. So, this is the empirically used formula which is used for the drawing force. So, p is the driving force, and t is basically the thickness of the blank material. That is in m m; then you have s. So, s is basically yield strength of the material, that are is in mega Pascal.

Now, c is a constant here, this c is used as a constant. And this constant is used to cover friction. So, this is to constant to cover friction and bending. And it is value basically will be between 0.6 to 0.7. So, so normally this is your drawing force. Similarly, you have also a force which is required for the holding of the blank, and that is known as the blank holding force.

So, if you talk about the blank holding force.

(Refer Slide Time: 28:05)



Now, this blank holding force is basically not very (Refer Time: 28:15) I mean easy to determine basically, and it is normally found by the, you know, trail and errors that how much force will be used to that hold this blank. And is normally it is upper limit is one third of the drawing force which you have calculated. So, it has to be less than one third of the P that is your drawing force. Now there is another operation that is known as the ironing operations. So, in ironing operation what we do is, that when we have to decrease the, you know, thickness of the cup and then we have to increase it is, you know, height or it is length, that process is known as the ironing operations.

So, we have to reduce the wall thickness of the cup. So, we are basically reducing wall thickness of cup. So, what is there is in that so, in this no blank holding is required basically you are punch will be closely fitting inside the cup. And in this case the force so, ironing force which is, you know, calculated is normally f, and it will be pi d 1 t 1 as average, and this is l n of t naught by t 1. So, this is how this ironing force is calculated. And this d 1 is basically the mean diameter of cell before ironing. So, that will be, and t 1 again that is the thickness of cell before ironing. Then you have, you know, as average so, you have, you know, as average is the average of tensile strength average tensile strength before and after ironing. Now, t 1 basically is the thickness of the cell after ironing, and t naught is the thickness of the cell before ironing.

So, this where once so, what happens that in that case you have thickness is there. So, that that thickness so that will be reduced once the punch distance down. So, that will be reducing the thickness as it goes down. So, that process is the ironing operation, in that case this ironing force which is required to iron out the thickness of these cup wall thickness of the cup so based on that you can find this ironing also. So, this way you have these different sheet metal operations which are carried out, and you can analyze these operations read more in detail from the standard books and have more practice of the numerical questions which are solved based on this operations.

Thank you very much.