Fundamentals of Manufacturing Processes
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Lecture – 28
Metal working Processes: Extrusion

Hello, I welcome you all in this presentation related with the subject fundamentals of the manufacturing processes. And today will be talking about the another metalworking process which is called extrusion.

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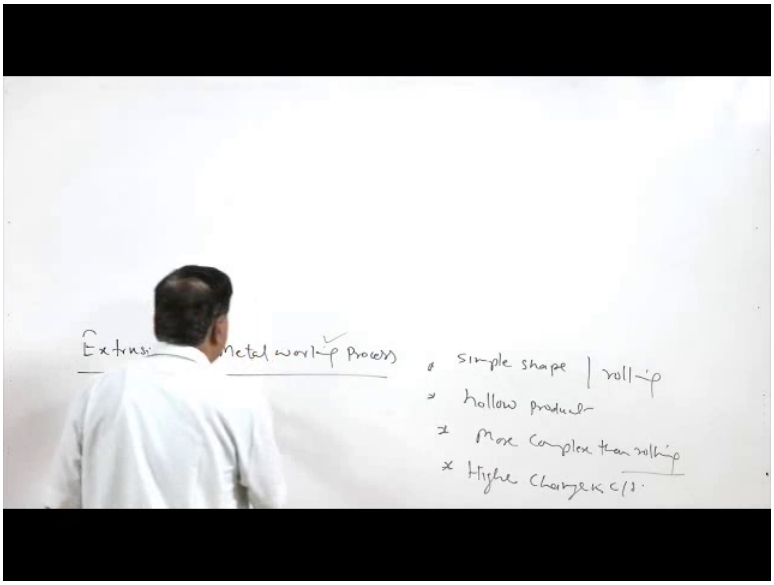

Extrusion is also used for making the, this is also one of the metal working process, is the plastic deformation is the main mechanism which is used for achieving the desired size and shape.

So, basically simple shape products like rolling are made using this process, but it can also be used for making the hollow products. And those which are a little bit more complex then those which can be produced by rolling. So, in that way the extrusion is somewhat better and as far as the comparison is concerned much higher reduction ratios can be achieved; higher change in cross section can be achieved.

So now we will see the kind of approach which is used in the extrusion process.

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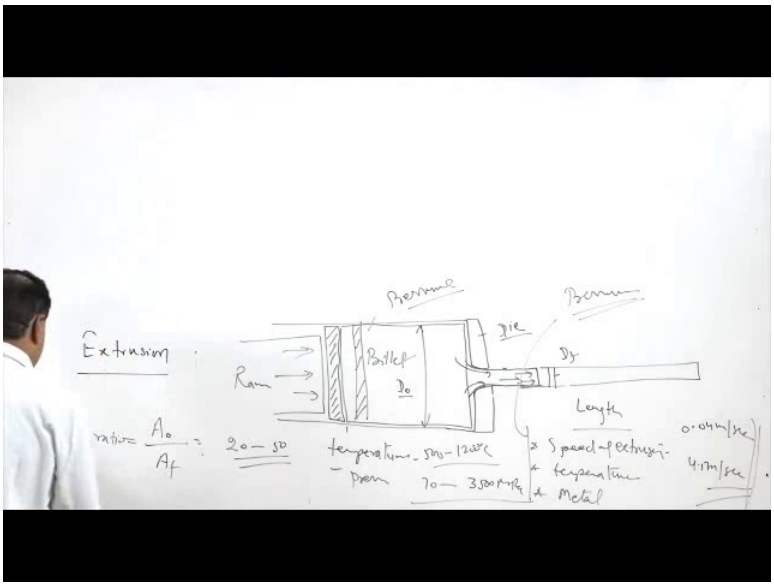

The most common approach in the extrusion process is that it uses one die here. And this opening can be of the any shape which is desired in the products. So, it can be circular, it can be square, it can be hexagonal or anything whatever we want. So, this opening decides the shape of the product which will be made.

So, here little bit like is a rounding of can be done in the opening. So, this is basically die having the opening as per the shape desired. And this is you can say cylindrical container or you can say cavity. In this cavity we put the hot metal or the stock or the billet which is to be processed. So, this is the billet and against this billet one dummy block is placed, which is normally of the a steel 3 to 20 to 30 to 40 mm thickness. And then against this dummy block force is applied with the help of Ram. So, this is Ram force is applied onto the dummy block onto the bullet through the dummy block.

So, application of the force results in the movement of the metal and it is starts coming out of the die or the opening. And then it takes the shape of the cross section of the die. So, this is how will keep on getting the cross section of the same. Same cross section along the length. So, the uniform cross section is achieved throughout the length.

So, as the met billet is pushed with the help of the Ram. So, it is pressurized and under the pressure metal is starts flowing out of the die and takes the shape of the opening in the die in order to produce the different shape cross sections. So, this is the basic

approach which is used, this is the simplest approach which is used in the extrusion process.

So, here if we see this is the cross section of the billet this cross section or so, like say this if it is the cylindrical diameter D naught. And the diameter after the extrusion is D f. So, we can determine the area, area before extrusion divided by area after the extrusion. And the ratio of these 2 which of course, can be determined by from the pi by 4 d naught is square divided by pi by 4 d f square like this.

So, this ratio is called extrusion ratio indicates the extent of the change in cross section of the billet has been brought to the extruded product. So, this extrusion ratio in case of the extrudon extrusion process this is very high it is 20 to 50 of the 20 to 50 value, while in case of the rolling the reduction in thickness is very gradual maybe 20 percent 30 percent like that of the thickness, but here the reduction in cross sectional area is very significant.

So, although process can be the hot or the cold working type, but the normally the temperatures depending upon the metal the extrusion is carried out like say 500 to that 1200 degree centigrade. and using the pressure very high ranging from say 70 MPA to the 3500 MPa, very high pressures can also be used. because here when the pressure is build up with the help of Ram on to the billet then starts flowing out, and takes the shape of the die opening.

So, speed of the extrusion speed at which metal comes out may vary significantly, like for the and non ferrous metals like aluminium and magnesium it is very low 0.04 meter per second, and for the heavy metals like copper system like 4.5 meter per second. So, this stress extrusion is speed is one factor the temperature at which extrusion is carried out is the another factor and the metal which is being walked out is the another factor. these are the 3 factors that will be affecting the pressure to be used for the extrusion. So, extrusion pressure is governed by the extrusion is speed the temperature of the billet and the metal which is being worked out. So, as per the kind of the process whether it is hot and cold are the different pressures and the different temperatures are used.

So, broadly now I will try to classify the extrusion process based on the way by which extrusion is carried out or the temperature conditions.

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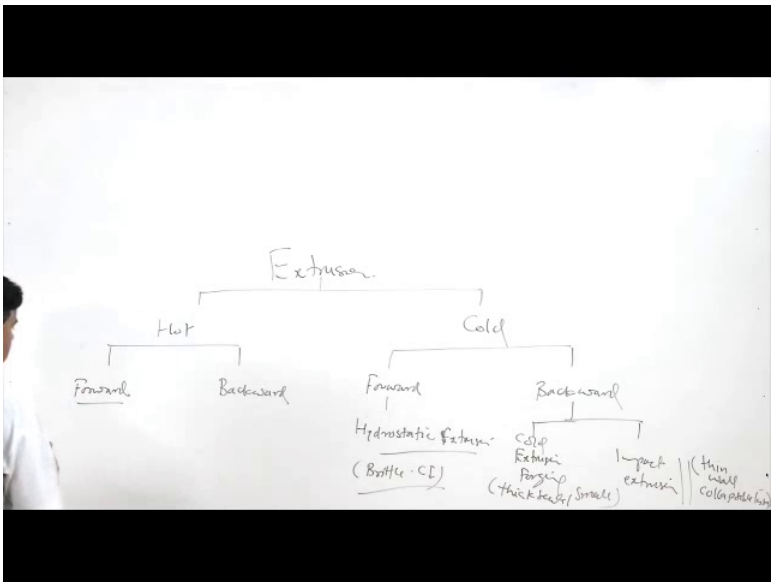

So, if you have to plot the tree for the extrusion process. There are 2 broad categories. One is the hot extrusion or hot working and another is cold extrusion. In hot extrusion variants again we have one is the forward extrusion, and another is backward extrusion. And in case of the cold extrusion again we have forward extrusion and the backward extrusion. In kit in the cold extrusion category where the where the temperature of the billet is the is below the recrystallization temperature one more one category of the forward extrusion is the hydro aesthetic extrusion.

Where the fluid pressure is applied through the fluid and in backward extinction. Further there are 2 processes one is called a extrusion cold extrusion forging and impact extrusion. Both are the backward extraction category carried out at the below the recrystallisation temperature and the forward extrusion. For a hydrostatic extrusion is mainly used for the brittle materials like cast iron which has to apply the uniform pressure. Impact extrusion is used for making the thin walled collapsible tubes.

While a thick section and a small components are made with the help of the extrusion forging. Forward extrusion is very extensively used and similarly hot backward extrusion for making the number of products. Now one by one I will be taking these different extrusion processes.

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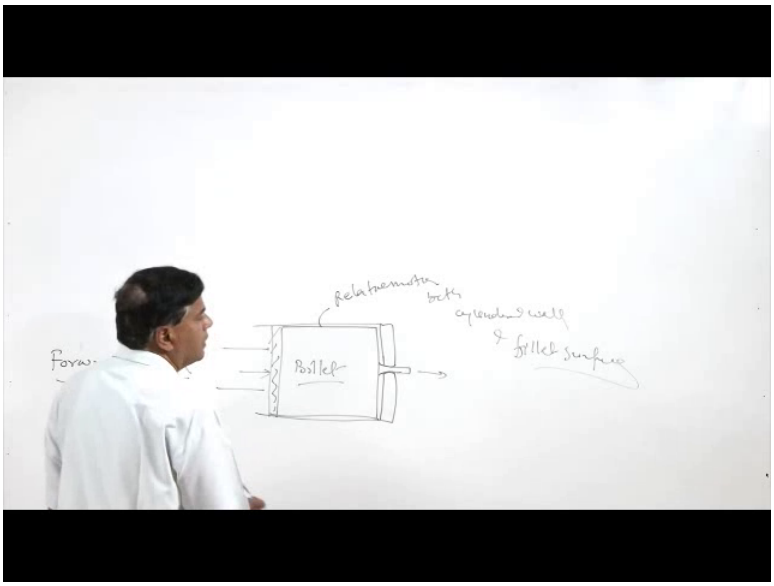

So, like Forward hot extrusion.

So, you know that in case of the cylindrical cavity where the hot billet is placed, and with the application of the this is the dummy block, and the Ram applies the force on to the dummy block. Then metal starts flowing out of the die like this, and takes the shape of the opening of the die like this when it flows. So, the metal as the metal flows out of the die gradually the metal of the billet will be consumed. And in this process there is always a relative movement, relative motion between the cylindrical wall and the billet surface.

So, this causes a lot of friction. So, the wall of the cylinder and the billet, both have the relative movement with each other. So, there is a relative movement between the 2, and at high temperature a lot of frictional forces are present. So, which makes the movement of the billet material difficult, or it needs more force from the Ram. So, this friction is one of the negative aspect related. With this process and it increases the energy required of the force required to facilitate the extrusion in this case.

So, in order to reduce this frictional effect normally the lubricants are used.

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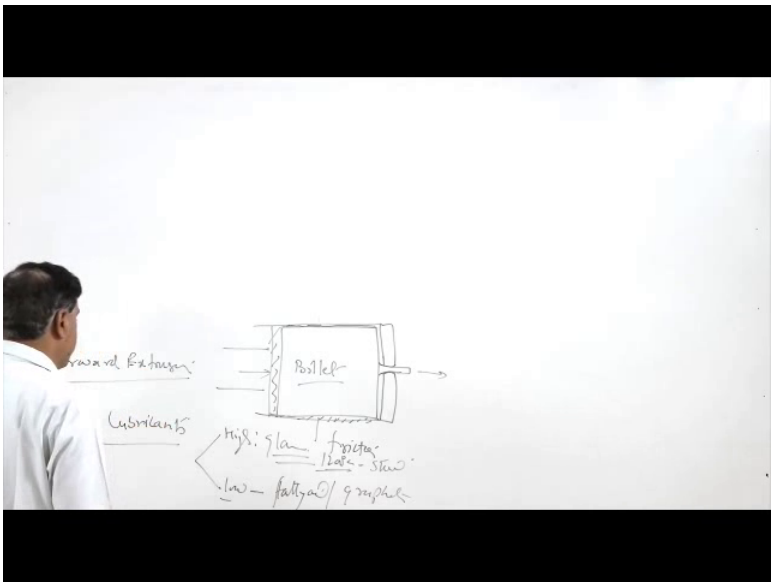

2 types of the lubricants are used one for the high temperature and another for low temperature conditions. For the low temperature conditions normally the fatty oils and the graphites are used, while the glass is used as a the lubricant for the high temperatures like 1200 degree centigrade for the steel. So, this steell since the melts under the heart temperature conditions not only it provides the friction, but also acts as a insulator.

So, the losses of the heat from the hot billet to the cylindrical wall and others gets reduced while facilitating the movement of the billet within this cylindrical container this. So, the friction between the billet surface and the metallic cylindrical surface is one of the negative aspect related with the forward extrusion.

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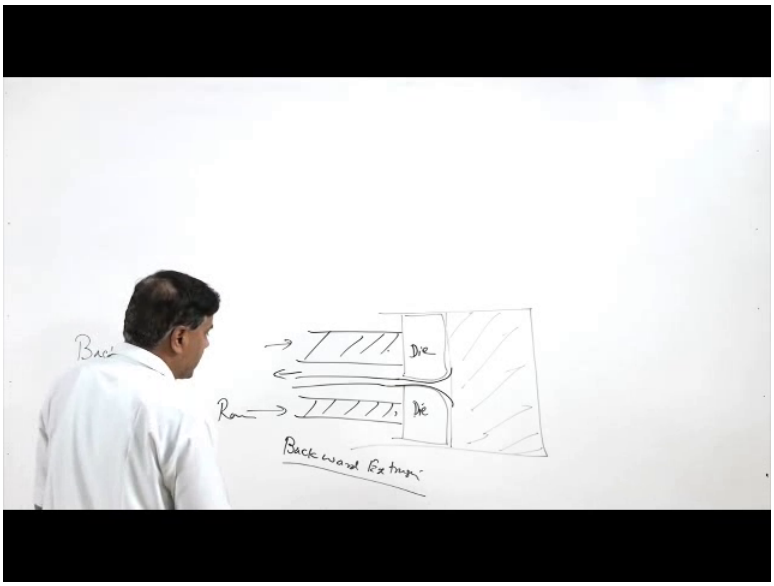

And therefore, to counter this the backward extrusion has been developed. In backward extrusion the configuration is slightly different here we have closed and die cavity, and the billet is placed like this in the cylindrical container. And then here we use one die like this having the opening.

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Ok having the opening of the desired shape and then pressure is applied. And then pressure is applied on the die itself through the Ram, Ram is hollow this is the Ram and this is a this Ram is hollow. So, the pressure is applied through the Ram on to the billet which acts through the die. So, this is die. So, the pressure is applied through the Ram onto the die and enforce x into the billet, and in this process the metal is starts flowing out of the die and it follows. The reverse direction movement means the flow of the metal through the die is in the direction opposite to the direction of the Ram movement. And that is why it is called backward extrusion.

In earlier case what we have seen the flow of the movement of the material, from the die opening was in the same direction of the Ram that is why it was called the forward extrusion. In this case there is no relative movement between the billet and the cylindrical container, this is this.

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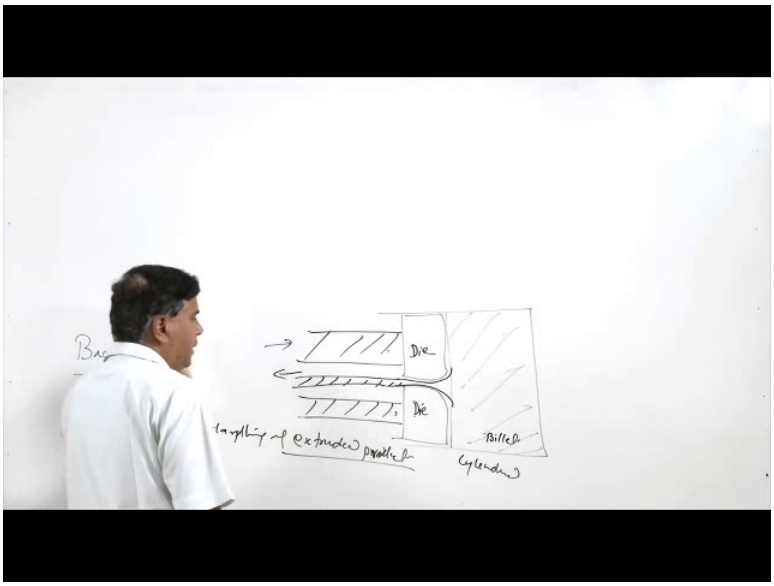

So, billet is fixed in this cylindrical container and the flow of the metal from the billet takes place directly into the die. So, there is no relative movement.

So, this the frictional effect between the billet and the cylindrical container wall is taken care of effectively using the backward extrusion process; however, in this case since the extruded metal comes out through the Ram itself. So, the handling of the of the extruded products becomes difficult. Because there is a Ram which is moving forward and through the Ram the job is extruded part is coming out which is hard. So, this makes the handling of the extruded products difficult in case of the backward extrusion.

So, these are the 2 hot backward and the forward extrusion processes. Now will talked about the cold extrusion processes.

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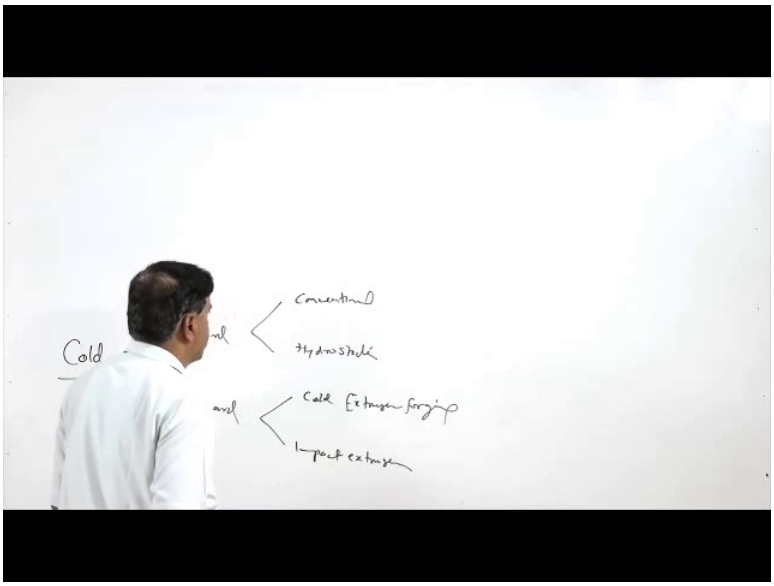

Also there is a forward extrusion and the backward extrusion. In the forward extrusion category the their 2 types, one is the conventional forward extrusion and the hydrostatic extrusion in the cold category. And here one is like impact extrusion, and another is the cold extrusion forging. So, these are the 4 processes.

So, the conventional forward extrusion is the same as what I have already talked.

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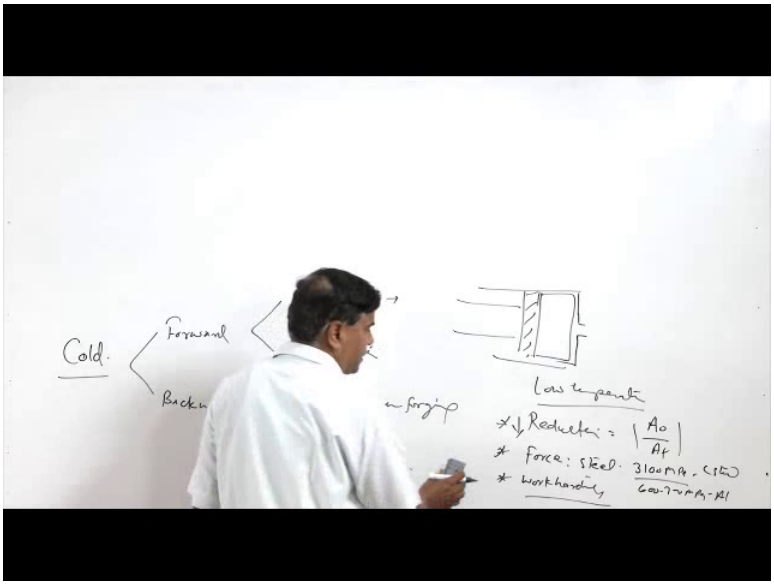

This is the die with the opening and this is a billet, and here we have dummy block, and this is a Ram the pressure is applied. Since this is carried out and under the low

temperature conditions, low temperature conditions. So, the reductions which are achieved reduction is achieved in the cold forward extraction conditions reduction is less. it is not like 20 to 50 units, but very low reductions which can be achieved and which means the difference in the cross section of the billet and the cross section of the extrared product is not as high as what it was in case of the hot extraction processes.

So, reduction is somewhat less means the initial area divided by final area ratio this area is less. Another thing the forces are too high, because at high temperature material loses it is yield strength it becomes the ductile. So, the force is required reduced significantly, but in case of the cold extrusion the force and the pressure requirements are too high, and like say for the a steels it is as high as 3100 MPa while in case of the aluminum it may be as high as 600 to 700 MPa. This is for carbon steel and this were aluminium alloys. So, cold extrusion makes it difficult now because of the low temperature conditions. Another thing the work hardening of the material at room temperature conditions increases the strength.

So, the mechanical properties are good of the cold extruded product as compared to that of the hot extruded products. So, the forward cold extrusion is similar to that of the hot extrusion, except that properties are better of force requirement is high and the reduction ratios are less.

Now, coming to the hydrostatic extrusion, this is mainly used for the brittle materials. In case of the conventional extension we know that the force is applied from the one side. And then under the pressure conditions it starts flowing outs out of the die.

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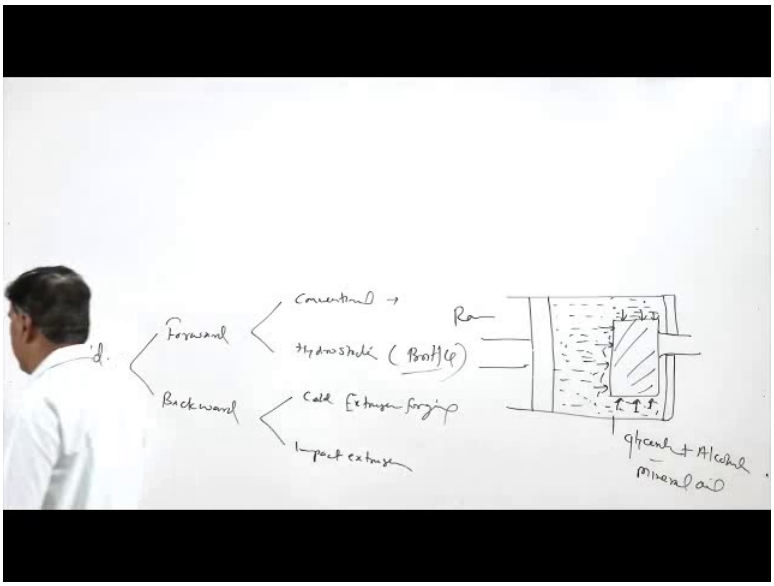

But in case of the hydro static extrusion here like this is the one end which is movable and bit this is the full of the fluid. And here we place the billet. And this is the here one side we may have the die opening like this. So, this is the billet and here it is surrounded by the fluid. This fluid can be like this glycerin plus alcohol it can be mineral oil or so, and the pressure is build up with the application of the Ram.

So, Ram applies the pressure onto the fluids. So, so the advantage of applying the pressure through the fluid is that pressure acts uniformly onto the material from all the sides, and it is not acting from one side. So, this facilitates the flow of the metal through the die without getting crushed. So, even the low ductility metals can be effectively extruded with the help of the, with the help of the hydro ecstatic extrusion.

So, I will be I will be now mentioning the kind of the difference which is there where regard to the use of the pressures for the cold extrusion and hot extrusion conditions and the pressure which is a developed in case of the hydrostatic extrusion. So, hydrostatic extrusion inverse the like the pressure which is build up onto the billet through the fluid is as is a 1100 to 3100 MPa. So, this is to high pressure to facilitate the extrusion of the metal. And another kind these a the kind of del oils or the fluids which are used. and there is one more ethyl glycol, which is also used as a fluid for the hydrostatic extrusion. castor oil is also one of them like castor oil.

Now, with regard to the kind of pressure requirements for the hot and the cold extrusion here just for a example and to have the idea I will be mentioning the pressure for Hot extrusion like for the lead may vary 275 to 400 MPa.

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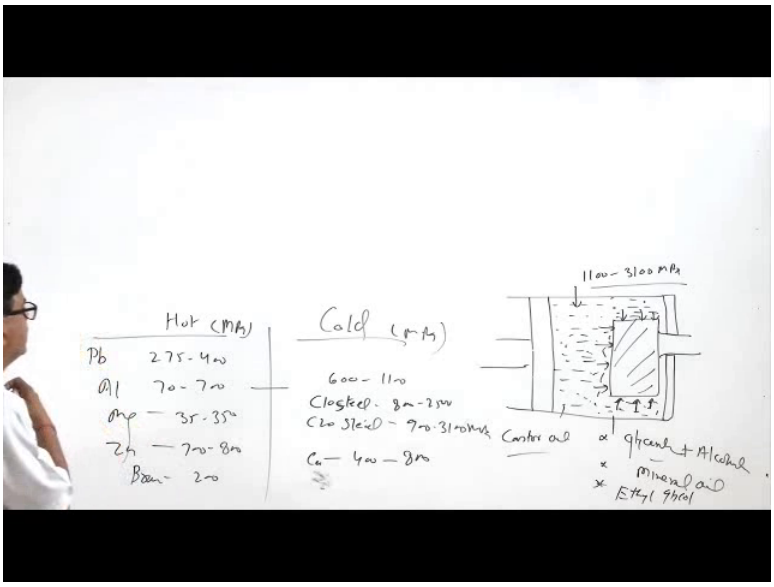

For aluminum it may vary from 70 to 700 for mg can vary from 35 to 350 MPa. For the zinc alloys 700 to 800 MPa. For brass it is 200, and while in case of the cold extrusion conditions like for aluminum here it is low, but for extrusion it is 600 to 1100 MPa, and that for it is for the copper alloys although for copper alloys it is 400 copper alloys it is 400 to the 800 MPa. For the steels like C 1 0 steel, C 1 0 steel it is like 800 to 2500 MPA and c 20 steel it is further higher 900 to 3100 MPa.

So, the pressure requirements increase when the cold extrusion is carried out s compared to the hot extrusion because at high under the hot extrusion conditions, the metal becomes of the lower yield strength and of the higher ductility. So, it facilitates the easier plastic flow in order to get the desired change in the cross section through the extrusion process.

Now, the 2 cold extrusion processes are left.

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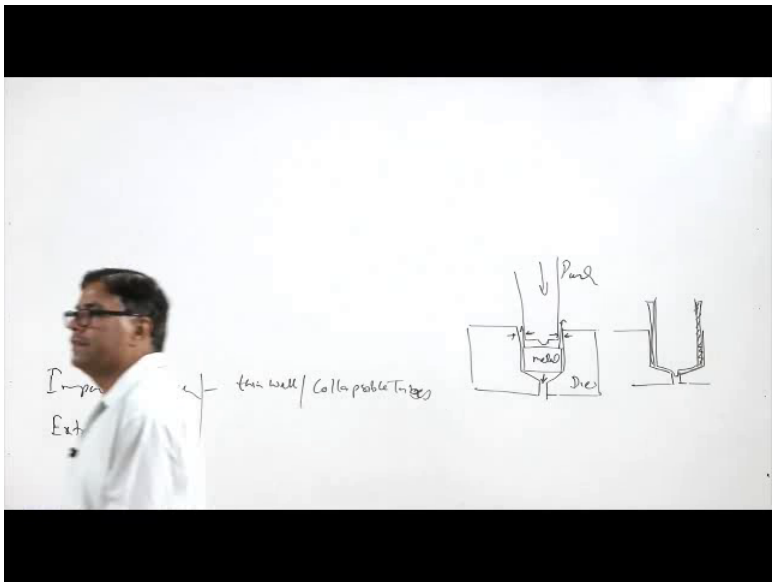

One is called impact Extrusion and extrusion forging, cold extrusion forging extrusion forging. So, impact extrusion is the simpler one like say this is mainly used for the thin walled collapsible tubes. So, here what is done basically, like this is the die, this is the opening. And this is how the metal is placed here initially like this. And this is the punch. So, when the punch move is in the die. So, here basically there is some gap between the die and punch both the sides.

So, when the punch impacts with the metal what happens? The metal is starts to flow back. So, here like this. So, basically the metal flows back like this, both the sides, and the punch goes down like this. And this is the metal which is really flowing back both the sides. So, here the metal flows back. So, basically the punch and die the punch impacts with the metal, this metal is starts flowing back side. So, this is basically the back extrusion, but and this will be flowing back side. and here this end will be making the opening for the tube basically.

So, here if this we can see with the help of this one here.

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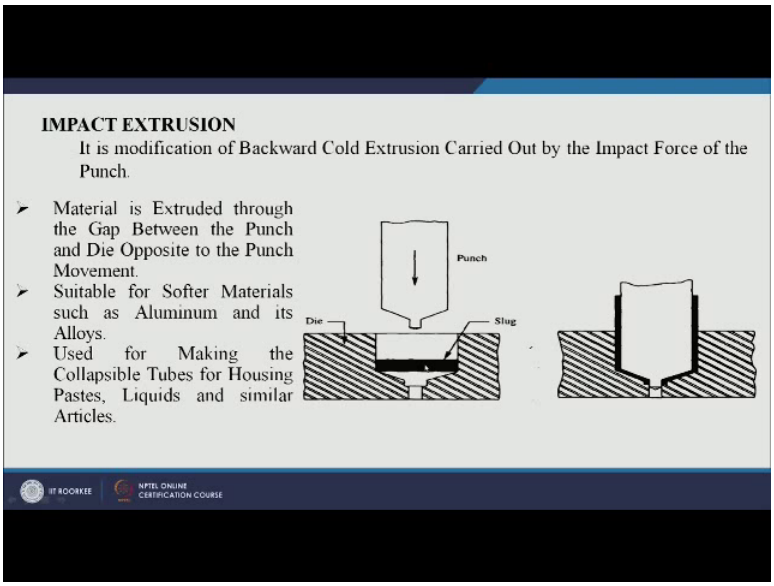

This is the impact extrusion, here what we can see this is the die this is the punch, and this is the slide or the metal these are the necessary opening. So, when the punch impacts with the metal the metal flows back and follows the path of the punch, but or follows the space between the punch and the die and takes the shape. So, here flow of the metal in backward direction opposite to the direction of the punch leads to the backward cold extrusion process and since it is the impact which facilitates the backward flow. So, it says the impact extrusion. This is mainly used for the softer metals. And this is used for the making the collapsible tubes so that it can be used for accommodating or holding the liquids and the pastes.

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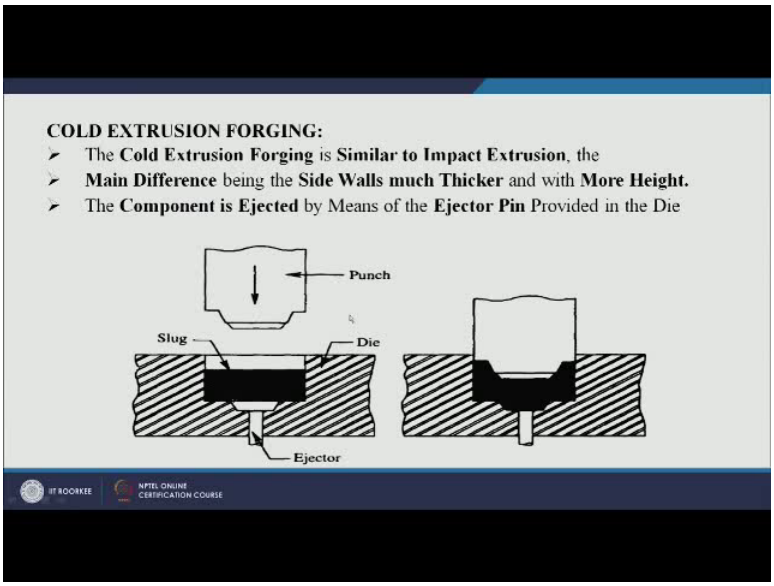

This is a cold extrusion, cold extrusion forging is used for making the thick a wild components, where in the length of the component is limited size of the component is limited. And basically it involves little bit flow of the metal in the backward direction. So, if we see here cold extrusion forging is similar to the impact extrusion. Main difference is that sidewalls are much thicker. In earlier case these were very thin, and the height is with more height.

So, in earlier case if we see here the height is more and wall thickness is less. Here it is just opposite wall thickness is very huge, and the height is less. So, here when the this is a slug this is the die and this is a point. So, points impact So, this slug it follows the cavity within this. And so, whatever little bit flow of the metal has to take place so that that flows back and takes the shape as per the requirement. once it fills the cavity is completely. Then the ejector hits the job from the backside and for a removal of the job from the die. So, the component is rejected with the help of the ejector pin provided in the die.

So, that is that is about the this is given the diagram for the hydrostatic extrusion, where this is the metal, which is mostly brittle in nature of the low ductility. This is a hydrostatic this is the fluid which is pressurized, and this is pressurized with the help of the this Ram. So, it helps So, pressurized fluid has to move the metal in the forward direction. So, this is basically the forward extrusion where the pressure is applied

through the fluid. Now we will summarize this presentation. In this presentation I have talked about the extrusion process, where in very high reduction ratios can be achieved and they are various variants of the extrusion process like hot extrusion, and cold extrusion. Hot extrusion helps to achieve the larger reduction in cross sections like 20 to 40, while the cold extrusion help us to achieve the limited extrusion ratios.

Thank you for your attention.