Manufacturing Processes - 1
Prof. Inderdeep Singh
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Module – 01
Lecture – 07
Sheet Metal Operations

A very warm welcome to all of you to this session on sheet metal operations, before we start a discussion on steel metal operations, a brief review of what we have discussed in these series of lectures on manufacturing processes? We have discussed powder metallurgy; we have discussed the basics of metal forming. In metal forming we have discussed, what is plastic deformation? How does plastic deformation takes place in metals? Then we have discussed the different processes like swaging, extrusion, forging, sheet metal operations and all that.

So, in basic lecture on plastic deformation or metal forming fundamentals, we have discussed that there are different types of operations that can be done on metals depending upon the requirements that are there. So, in our discussion on metal forming, we have till now we have had three lectures. In first lectures we discussed regarding the basic fundamentals of metal forming, what is metal forming? What are the plastic deformation phenomenon? Then hot cold and warm working. Then we discussed in the subsequent lecture, the basic principles of forging.

Then what are the various forging operations was discussed? Then we went on to discuss in the next lecture, swaging and wire drawing. So, in the last lecture we were discussing the basic principle of wire drawing, and some of the portion was left that will be discussed today, before we start our actual discussion on sheet metal operations. Now, sheet metal operations are also an important operation that is done, because sheet metal products are all around us, all of us usually travel in cars. So, these cars we see the main body is made up of sheet metal.

So, the sheet metal undergoes different types of operation, before it can be used in the way we see it in the car bodies or in different types of beverage cans etcetera. But, before we start our actual discussion on sheet metal forming operations, we will discuss the left over part of wire drawing, what is the die pull? And what is the different types of drawing equipment? And what is tube drawing? After we complete our discussion on wire drawing, we will then switch over the discussion to sheet metal forming operations.

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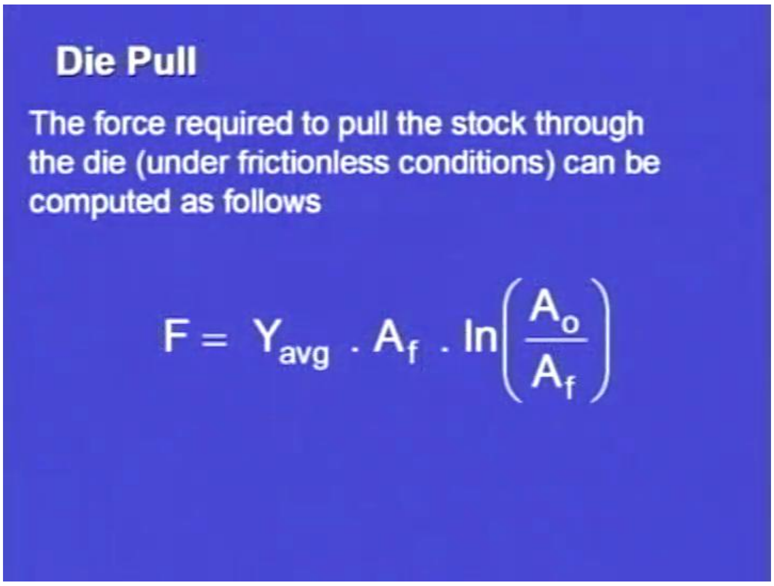

Now, what is die pull? We have seen in the last lecture that the diagram was shown in which the sheet, not the sheet it was the wire that was in the coiled form. It was coming and it was going through the lubricant, coming out of the die, and then it was getting rolled over or it was getting wound over the draw block. So, that was the basic principle of wire drawing, the wire comes it enters into the die cavity after it carries the lubricant, and after it comes out of the die, it is wound over. So, it is a continuous process. So, the pull is exerted by the draw block.

So, what is the pull? This die pull can be analytically calculated using a mathematical formula. So, the force required to pull the stock through the die under frictionless conditions. This formulation or this formula is only valid for frictionless conditions only. So, the force required to pull the stock through the die under frictionless conditions can be computed as follows. So, this is given by F is equal to Y average multiplied by A F multiplied by a ratio of A o and A f. So, what are these parameters? That is there in this mathematical formulation.

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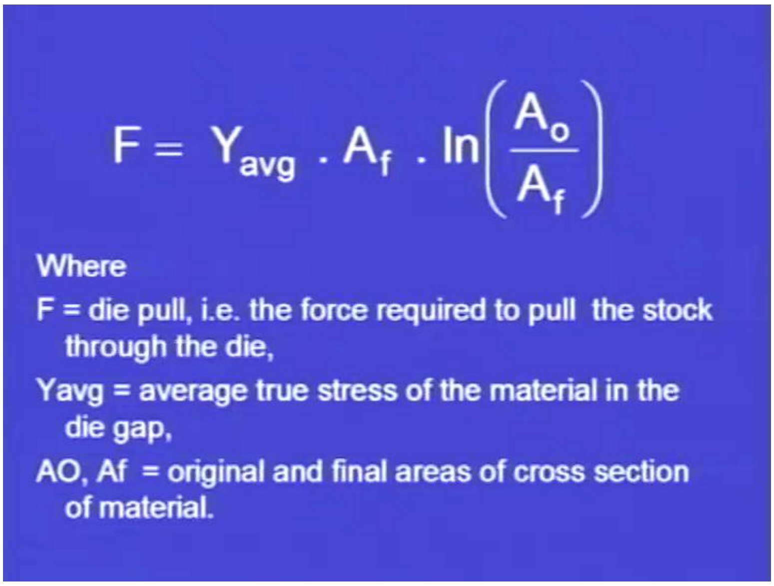

These are if we see these formulation, in this formulation we can see that F is the die pull that we want to calculate that what is the pull required to pull the wire out of the die. So, this die pull is the force required to pull the stock, the stock here in case of wire drawing is the wire. So, the force required to pull the stock through the die or the force required to pull the wire through the die is given by F. Now, this can be calculated, if we know what is Y average? So, Y average gives the average true stress of the material in the die gap. So, average true stress.

So, different stress strain curve is there, but here we have to take into account, the true stress of the material when it is inside the die. Then A o and A f is the original and final areas of cross section of the material. So, if we know what is the original and the final area of cross section of the material or of the wire, and we know the average true stress of the material. We can very easily calculate, what is going to be the die pull or the force that will be required to pull the wire out of the die. So, this formulation can be used to calculate the die pull.

Now, we come on to another important process of metal forming that is tube drawing. So, we have already seen what is wire drawing? What are the different types of processes like we have seen a diagram, how the wire drawing can be done. Then the wire has to be treated, before it is subjected to the wire drawing operation, cleaning and neutralization was discussed in the last lecture. So, all those are the important aspects of wire drawing operation. Now, very briefly we will go over the process that is the tube drawing instead of a wire when we need to make a tube, how we are able to draw a tube using the equipment?

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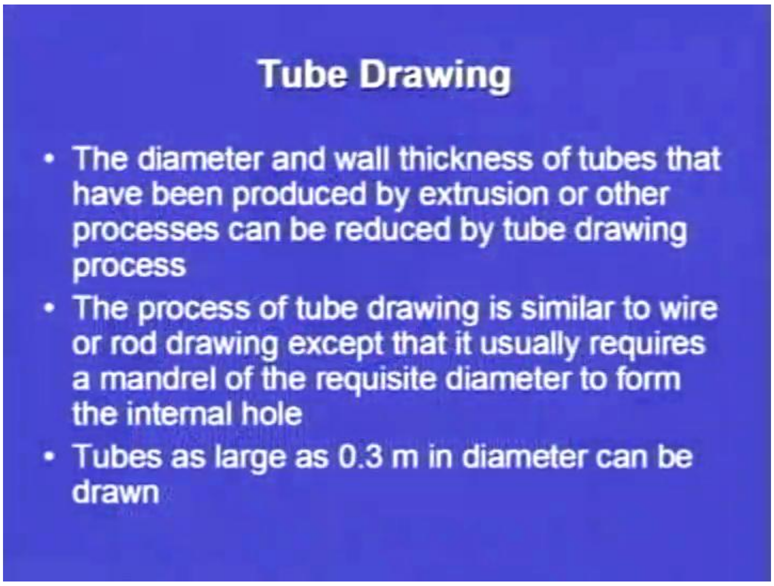

So, tube drawing basically the diameter and the wall thickness of tubes that have been produced by extrusion or other processes can be reduced by a tube drawing process. So, tubes can basically be made by the extrusion process. In subsequent lectures we will see what is extrusion? Extrusion can be forward extrusion, it can be backward extrusion. So, in case of tube drawing, whatever tubes we have made using any of the manufacturing processes like extrusion or other processes can be reduced by the tube drawing process.

The process of tube drawing is similar to wire or rod drawing except that it uses, it usually requires a mandrel of the requisite diameter to form the internal hole. So, a wire is a solid section, a tube is a hollow section. So, in order to have a hollow section inside the cross sectional area or inside the tubular section, that hollow section can be made using a mandrel. So, we have seen in case of swaging that there are different types of shaped mandrels.

So, here also in case of tube drawing we can use a mandrel, and we can get a internal tubing or a internal cavity or a internal hollow cross section, that hollow cross section will be made with the help of a mandrel. So, the process of tube drawing is similar to wire or rod drawing. It is not too different from wire or rod drawing. The basic principle is the same, except that it uses a mandrel of the requisite diameter to form the internal hole.

So, the internal hole will have some dimensions, it will have some radius or diameter. So, depending upon the diameter or the radius of the internal hole, we will select the size of the mandrel, and we will be able to make an internal hole inside the tube. Tubes as large as 0.3 meter in diameter can be drawn. So, this gives the just a quantified value or just a value that tells us that the tubes up to a range of 0.3 meter can be drawn using the tube drawing operation.

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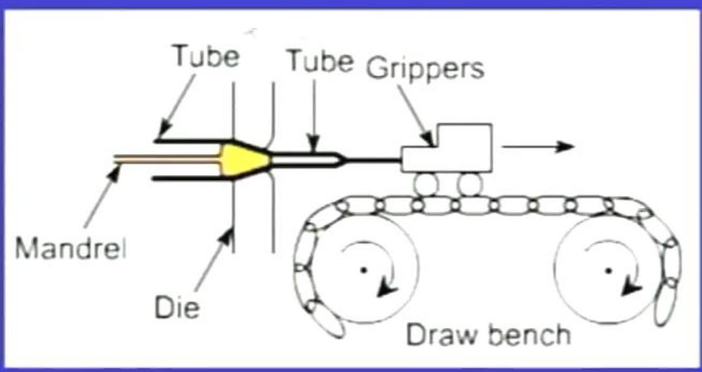

Figure 5. Typical tube drawing system

Now, here we see, this is the basic diagram of tube drawing very simple diagram, just to see what how the diagram has been labeled. We can see there is a mandrel as already discussed in the basic definition of wire drawing or tube drawing. That in tube drawing we make use of a mandrel, this is the mandrel we can see this is yellow color mandrel. Now, this is the tube the black color, the solid black section that is being drawn here. So, the tube is being drawn a mandrel, it is being used.

So, this size of the mandrel will give the size of the hole that will be or the size of the internal hole that is possible in a tube. So, using a mandrel when the tube is drawn, the pulling arrangement is here. So, using a mandrel, whenever a tube is drawn, we are able to get an internal hole inside the tube, and we are able to get a reduced cross section also. So, we can see that the cross section here is this much, and the cross section here is this much with the help of a mandrel, and with the help of a die. We have been able to reduce the cross section of the tube from a bigger cross section to a smaller cross section.

So, here also we are pulling it and we have a grippers, these grippers will grip the tube and these will this is being rotated by a draw bench. Now, this is a draw bench, here we can see that these rollers are rotating. So, this is the rotation of the rollers, this is another roller that is rotating. And this is arrangement for the gripper for moving the gripper in this direction, the gripper is moving in this direction, the direction of the gripper is also shown in the figure.

So, basically how this arrangement is working, there is a mandrel, there is a tube of greater cross section or a larger cross section which is being reduced to a smaller cross section. The size of the mandrel will decide the internal hole of the tubing that is possible. And with the gripping mechanism or with the gripping, grippers that are provided here, we will be able to pull the tube using this mechanism of draw bench. So, this is a typical tube drawing system.

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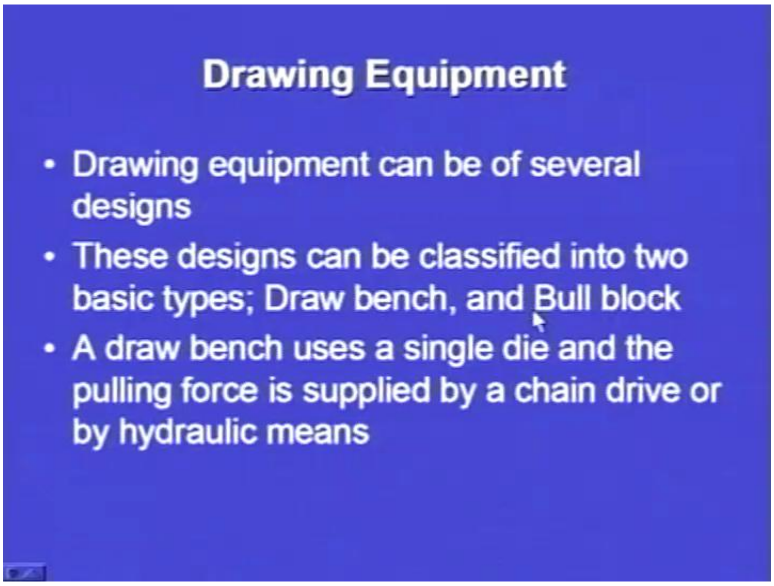

Now, we have seen that drawing equipment is required to reduce the cross section from a larger to a smaller cross section. So, if a wire or a solid wire is being is has to be reduced from a larger cross section to a smaller cross section or a tube has to be drawn from a larger cross section to a smaller cross section, we have to make use of a drawing equipment. So, drawing equipment can be of several designs.

So, we have seen here, 2, 3 different designs. In one of the design, the wire that was coming out of the die was getting wound over a draw block. In another case, there was a gripping arrangement in which the tube is being gripped, and with the help of a draw bench we are pulling the wire or the tube outside the die. So, these designs can be classified into two basic types, it can be a draw bench or it can be a bull block.

So, depending upon the requirements, depending upon the system that is available with us, we can choose that whether we can go for a draw bench type of arrangement or we can go for a bull block type of arrangement. So, a draw bench basically, let us discuss each one of them separately, there are two types of mechanisms possible. The first one is the draw bench, and the second one is the bull block. So, the draw bench uses a single die, and the pulling force is supplied by a chain drive or by hydraulic means.

So, a draw bench we have already seen in the diagram, it has a single die and the pulling force is supplied by a chain drive or a hydraulic means. So, there was a chain drive in the mechanism that we have already seen, the chain drive pulls the gripper, and the tube is being drawn in the tube drawing operation. So, that was basically a draw bench.

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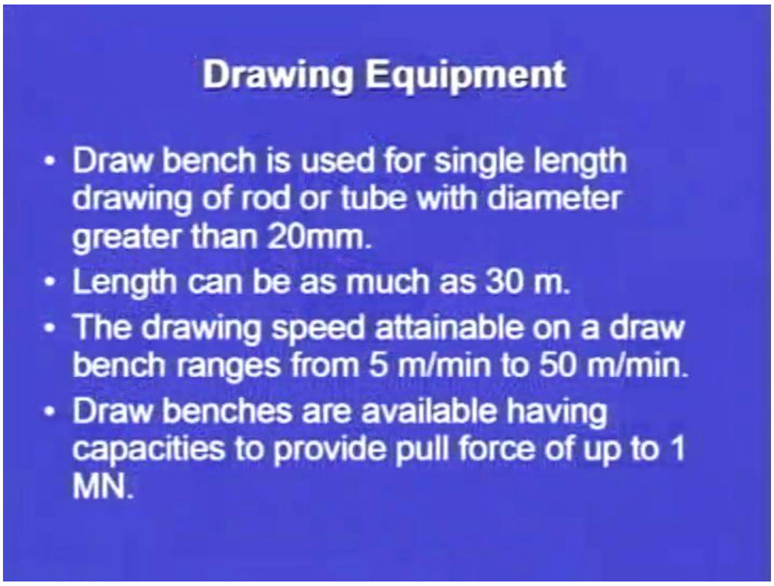

Now, a draw bench is used for a single length drawing of rod or a tube with diameter greater than 20 millimeter. So, there is a limitation on the diameter, if the diameter is greater than 20 millimeter we can use a draw bench, and it has single length drawing process. So, single length drawing of rod or tube is done, and the diameter should be more than 20 millimeter, if we are going to use the draw bench as the pulling mechanism for wire drawing or tube drawing operation. Then the length can be as long as 30 meters.

So, the length 30 meter and the diameter 20 millimeter, these are two important design aspects, when we are going to use a draw bench as a mechanism of pulling or draw bench for reducing the cross section of a wire or reducing the cross section of a tube. The drawing speed attainable the speed that is also an important design aspect. So, the drawing speed that is attainable on a draw bench ranges from 5 meters per minute to 50 meters per minute. So, 3 important design aspects of draw bench we have seen, that is the diameter of the wire or the tube.

We have seen the length of the wire or the tube or that speed. The speed can range from 5 meter per minute to 50 meters per minute. The draw benches are available in capacities to provide pull force of 1 mega Newton. So, these are all the design aspects of the draw bench that what is the diameter of the tube or the wire? What can be the pulling force or the maximum pull force that can be exerted? What can be the length of the wire that can be drawn? What can be the speed by at which the draw bench can operate?

So, all these equipment details help to decide that what type of the material can be drawn or what can be the shape of the material that can be drawn or what can be the size of the material that can be drawn using the draw bench? Then when the length of the rods or the continuous operation we have to do that is we have to draw the length of the wire that run into kilometers. Then we can make use of a rotating drum.

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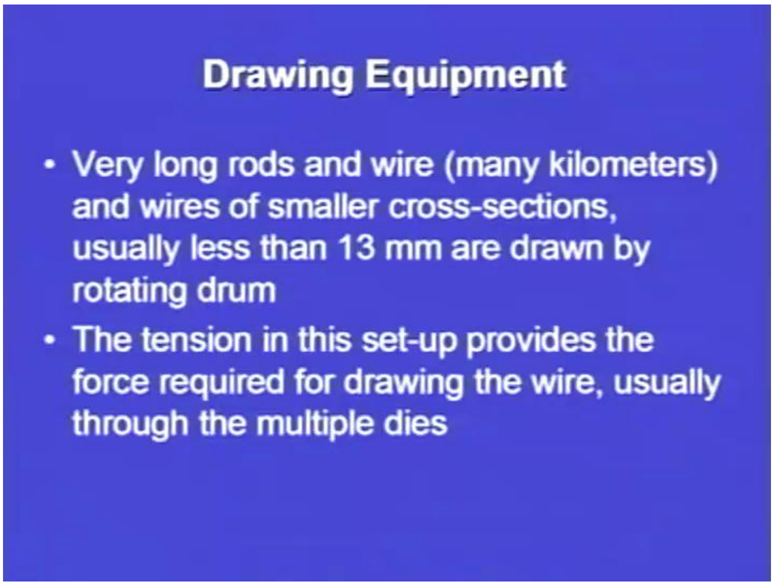

So, very long rods of rods and wires, if the rod is very long or the wire is very long and the length may run into many kilometers, and wires of smaller cross section that can later on be coiled, usually less than 13 millimeters. So, in case of draw bench the limitation was 20 millimeter, here in case of rotating drum, the limitation is 13 millimeter. If the diameter is less than 13 millimeter, we can draw it using a rotating drum.

So, very long rods and wires that may the length may run into many kilometers of smaller cross section, usually less than 13 millimeter can be drawn using the rotating drum. Now, how the tension can be given in case of a rotating drum. In case of a draw bench we have seen that there are grippers, this gripper will grip the rod or the tube and this will exert a pulling force. So, in case of rotating drum, how the tension has to be given or how the die pull has to be provided. The tension in this set-up provides the force required for drawing the wire, usually through the multiple dies.

So, there is a tension that is provided, a pre tension that is provided using the rotating drum that gives the adequate die pull to pull the wire from the die. So, we have seen that there are different types of drawing equipment that is possible. Two different mechanisms like draw bench or a rotating drum can be used to draw wires and tubes, and thus reducing the cross sectional area of the wire or the tube to the desired level. Though, that was all regarding the discussion on wire and tube drawing.

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Now, we shift our attention to another important aspect of manufacturing processes that is sheet metal operations. In sheet metal operationsm, we will see that what is basically sheet metal operation from where did sheet metal operation or sheet metal working originated, what are the advantages of sheet metal operations as regard to other manufacturing processes like forging and casting. Then we will see, what are the different types of sheet metal operations like shearing, nibbling, perforating, lancing. There are different, there is a series of operations that fall under the category of sheet metal operations. We will try to see that, how we can cut a sheet or what are the various aspects involved in sheet metal operations.

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Now, just to have a brief introduction regarding the sheet metal operations. Products made by sheet metal are all around us, while sitting here delivering a lecture on sheet metal operations, are you see that there are number of products around me that are made up of sheet metal. You are listening to this session on sheet metal operations, if you look around you will find that there are number of products that are made up of sheet metal like, some of the examples of sheet metal products can be metal desks. The desks on which we work, they are made up of sheet metal.

Then file cabinets can be made of sheet metal, car bodies all of us travel in cars, all of us travel in busses, trains. So, most of the parts or most of the bodies are made up of sheet metal only. Then the beverage can, all of us drink different cool drinks. So, the cool drink cans are made up of sheet metal. So, sheet metal products are all around us. So, the understanding of the sheet metal operations is an important aspect, and which is dealt with in under the broad category of manufacturing processes.

So, sheet metal forming is nothing new, it dates back to 5000 B.C when house hold utensils and jewelry were made by hammering and stamping gold, silver and copper. So, in 5000 B.C people use to hammer, a sheet of gold, silver or copper, and they were making the utensils or they were making the jewelry. So, similarly these processes have been developed over the years, and certain new things certain new design aspects have been added to get the product up to the desired level.

So, sheet metal operations basically are very important in manufacturing technology, and we need to understand the basics, and the fundamentals of sheet metal working operations. Now, as we have seen that there are different ways to process a product. We have a product, there are number of different techniques by which we can make that final product. We can make it by casting, forging, machining, finishing, metal working different types of processes are there.

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So, where does sheet metal has its advantages? So, sheet metal part, sheet metal parts offers the advantages of light weight and versatile shape as compared to those by casting and forging. So, the products that are made by casting and forging, they have the weight relatively higher as compared to sheet metal parts. Moreover the shapes that we can get out of a sheet metal are completely complex or they can be very intricate, whereas if the shape becomes intricate, it becomes difficult to make that product by casting or to make that product by forging.

But, if we have to make some intricate profiles like sometimes we have some aerodynamic profiles in the aerospace. Aerospace components are sometimes we have some aero plane profiles that are of is a special shape. So, in order to make those special shapes, it becomes difficult if we choose our forging and casting as the manufacturing process. So, sheet metal operations give us an advantage, when the part is complex and it is a very versatile process. Moreover, wherever we want to reduce the weight, there we go for sheet metal forming operations

So, what are the different types of materials that we can work using sheet metal operations like, low carbon steel is the most commonly used sheet metal operation, sheet metal material. So, low carbon steel, why to go for low carbon steel? It has certain advantages, first of all the cost is comparatively less, moreover the strength is high, and the another important aspect is the formability, when we discussed forging we discussed the aspect called forcibility. In case of sheet metal, there is an important aspect that is called formability that how formable the material is.

So, low carbon steel basically is very formable. So, low carbon steel is an important material that can easily undergo the sheet metal forming operation. So, formability we will discuss in our subsequent lectures, but here just to have a basic understanding. We can make use of low carbon steel as our basic material for any sheet metal operation. Moreover, there are other materials that can easily be formed using sheet metal operations, what are these materials? These materials are aluminum and titanium.

And what are the application areas of aluminum and titanium? Aluminum and titanium are most common sheet materials for aircraft and aerospace applications. So, already I have told that aerospace applications require light weight. So, whenever light weight applications come into picture, sometimes we make parts out of sheet metal. So, the materials that are can be chosen for light weight applications in aerospace and aircraft industry or aluminum and titanium. So, we have seen that sheet metal forming offers some advantages as compared to casting and forging. And what are the different types of materials that can be used for sheet metal operations to name a few it can be low carbon steel, it can be aluminum or it can be titanium.

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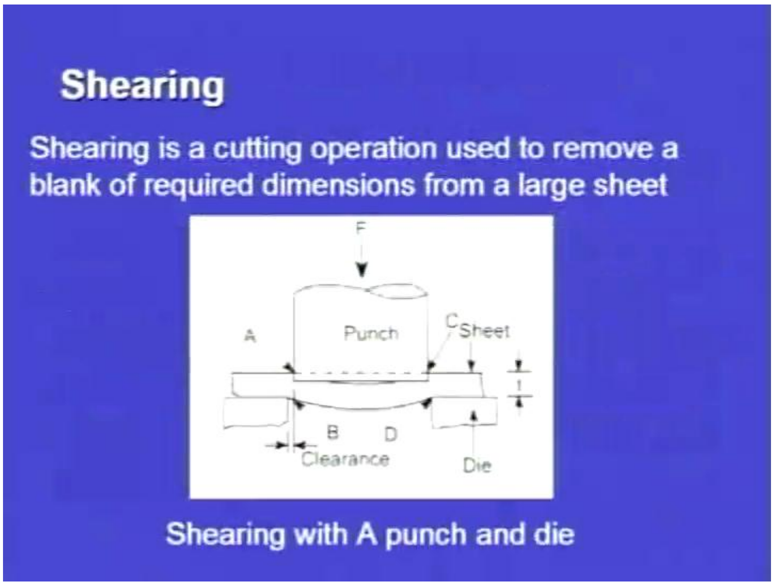

Now, this is the basic shearing operation as on your diagram, as on your screen you can see a diagram, this is the basic sheet metal forming operation. So, this is the shearing operation that is taking place here. So, how shearing is taking place, there are 4 sections here this is A, B, C and D. There are 4 sections, 4 points that are important here. Then there is a punch that is been given some force, this punch is coming from top, and this is the work piece, this is the job that is getting sheared and this is the die, this is the die and this is the die.

Then you can see that in between the punch and the die, there is some clearance that has been provided. Moreover, this is the sheet that is getting punched, and then this is the thickness of the sheet this t, small t; small t gives the thickness of the sheet. So, in this diagram we are seeing that the punch that comes, and it shears off the sheet. So, this shearing is taking place here, and we can see that it is getting sheared at this section A, B and C, D, so shearing with the punch and the die.

So, shearing can also be done using the cutting type of arrangement where we can have a shearing machine, in which we have a diagram where we will see that different sections are being sheared off. There are number of ways to cut a sheet that we will discuss towards the end of this lecture. So, this is the die punch type of arrangement for causing the shearing operation in a sheet metal. A sheet is given and the thickness is also given in this diagram.

The clearance also plays an important role in deciding the quality of the sheared surface that we get after the shearing operation has been completed. Now, shearing is a cutting operation used to remove a blank of required dimensions from a large sheet. So, there is a large sheet and we are going to cut the sheet according to our desired dimensions.

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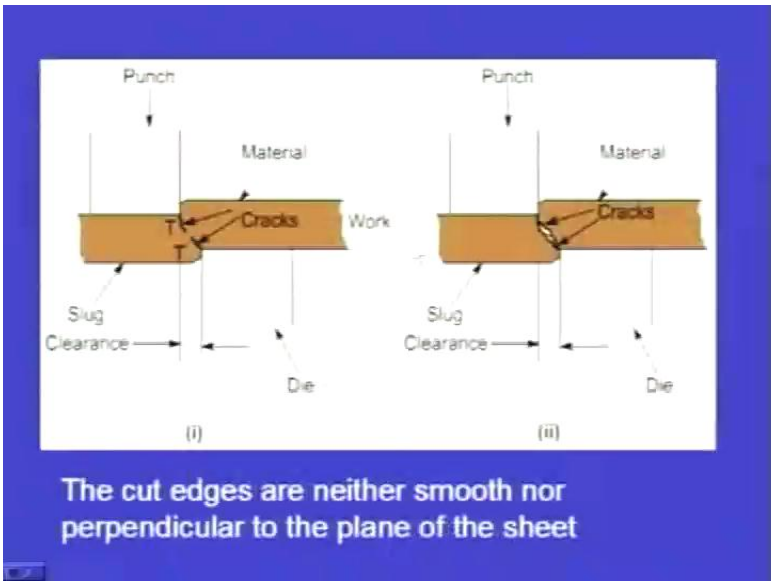

Now, here we see this is the punch that is coming from top, then there are certain cracks this T, T, these are some cracks that are appearing. So, this is the material that has to be sheared. This colored material, this is the work that has to be here; this is the slug that will be formed after the shearing operation. The clearance is provided between the die and the punch. Here this is the die, this portion gives us that this is the die, this is the punch.

So, the punch is given the motion, die is stationary in this case, when the punch comes from top it shears of the material from here under the application of shear forces and then, certain cracks appear in this region. When these cracks they appear individually, when they grow under the shearing load under the load of the punch, these cracks will meet each other, and then finally result into the fracture of the surface.

So, this slug will be fractured off from here or will be sheared off from here, and the fracture will appear in this cross section. So, here we can see in second diagram that here the cracks are meeting each other; there are two individual cracks here. These two individual cracks are meeting each other here, and then there is the propagation of a larger crack that will result in the shearing of the plate or the shearing of the sheet. So, the punch will cause the shearing at this particular section.

So, this clearance and die and punch, this is the same labeling as has been given in diagram number 1. The cut edges are neither smooth nor perpendicular to the plane of the sheet. So, now they are not very smooth. So, the edges that have been shown here, this is not a straight line we can see these are very rough edges here in the diagram, it is very, very clear we get very rough edges. So, the cut edges are neither smooth nor perpendicular to the plane of the sheet. So, that is important to note here the surface or the finishing here is not up to the desired level.

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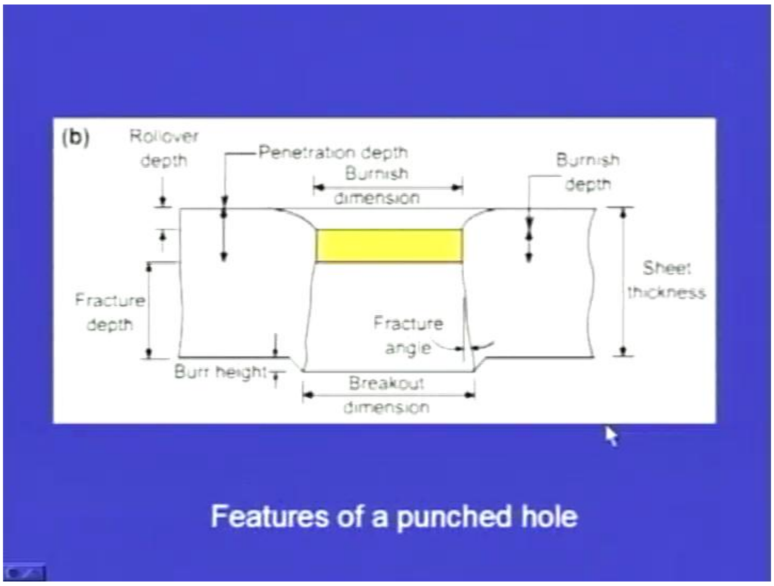

So, this is another diagram showing the die and punch type of arrangement. So, here we can see this is a sheet thickness, there is a rollover depth that is this is this much portion, this is the rollover depth. Then there is a burnish depth which is shown here, this yellow portion this is a burnish depth. Then there is a break down breakout dimension. There is a burr height, some burr will burr is being formed here, when the material the punch goes like this, there is a burr height that has been formed here.

So, burrs later on have to be removed after the shearing process has been completed. So, this is the fracture depth, this depth from here and till the end of the sheet, this is the edge of the sheet. So, this is the fracture depth where the fracture has taking place. So, from here the punch enters and it fractures off the sheet. Then we get a particular slug, this is the slug that has been formed.

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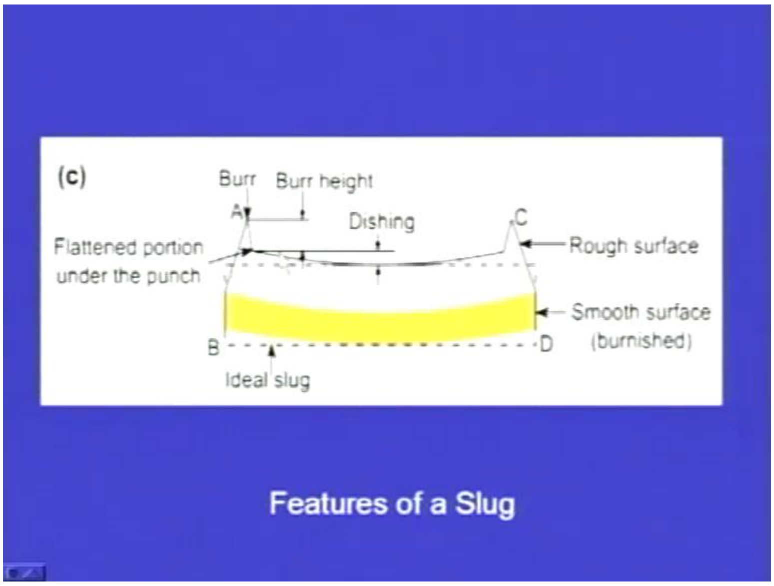

So, this is now we can see that the ideal shape of the slug, the ideal this is the dotted line we can see. In the previous diagram we have seen that there are 4 important sections that have to be taken care of during the shearing operation that is the section A, B, C and D. So, when it is getting sheared off, we are seeing that there is some burr that is forming at A, and that is forming at C. So, this is the burr that is forming which is not required.

So, we have to avoid this type of burr formation, how it can be avoided? It can also be avoided by properly choosing the clearance between the die and the punch. So, this is basically what was required this dotted portion, but this is what actually we are getting. So, the actual slug as well as the ideal slug is given here. So, this is smooth surface that is the burnished portion, the burnishing takes place when the metal rubs against the walls of the die.

Then this is the rough surface that is being formed here, because of the fracturing at A, B, C and D. So, this burr height has to be avoided. So, this is A, B, C, D; this is the portion that has been formed after the shearing operation. These are some of the features of the slug. So, flattened portion under the punch, this is the flattened portion that comes under the direct contact under the punch.

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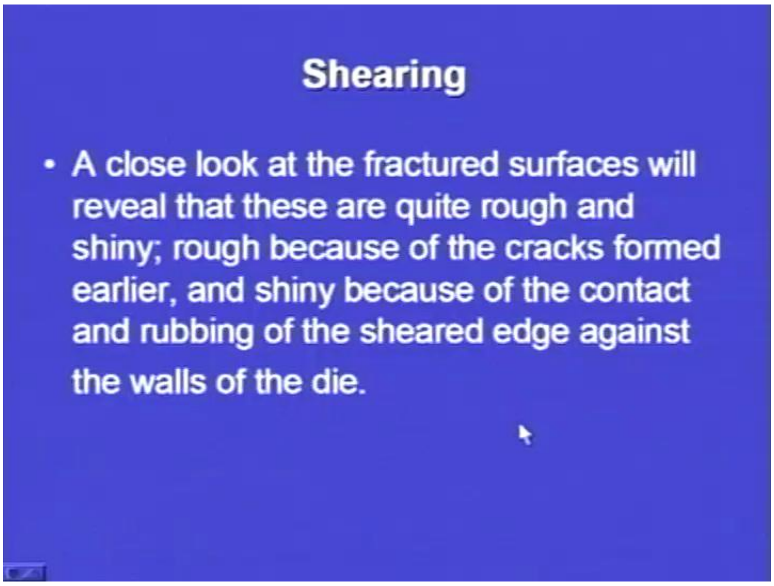

Now, just whatever we have discussed we have seen with the help of the diagrams, what are the important aspects in shearing operation? Here we will just try to address them, and try to understand them in a better possible manner. So, close look at the fractured surfaces. So, the fractured surfaces we have seen these are formed, because when the die there is a stationary die, and the punch that shears off the metal of the sheet. So, the fractured surfaces are formed, when we have a close look at the fractured surfaces, this will reveal that these are quite rough and shiny.

So, why these are rough and shiny? Rough, because the cracks formed earlier, and shiny because of the contact and rubbing of the sheared edge against the walls of the die. So, they are rough as well as shiny. They are rough why, because the basic mechanism is that whenever shearing takes place. There are formations of small cracks, these cracks when different cracks will meet each other. They will form a bigger crack that will later on result into the fracturing of the sheet.

So, when this fracturing takes place, the surface finish already I have shown in the diagram that the surface finish that we will get, will not be up to the desired quality level. So, the surface that we get will be a rough surface, but it will also be shiny, why it will be shiny, because this will be in contact with the die surface. So, die basically made up of a very wear resistant material will rub against the sheet, and it will result in to the shiny portion.

So, shiny because of the contact and rubbing of the sheared edge, so edge that has been sheared off will rub against the wall of the die, and we will get a shiny portion. The clearance between the die and the punch also plays an important role in deciding that what kind of surface finish we are going to get. So, we have seen the edges that we get, these edges are rough as well as shiny. So, rough and shiny, why they are rough and shiny that has already been addressed here, but the clearance plays a very important role.

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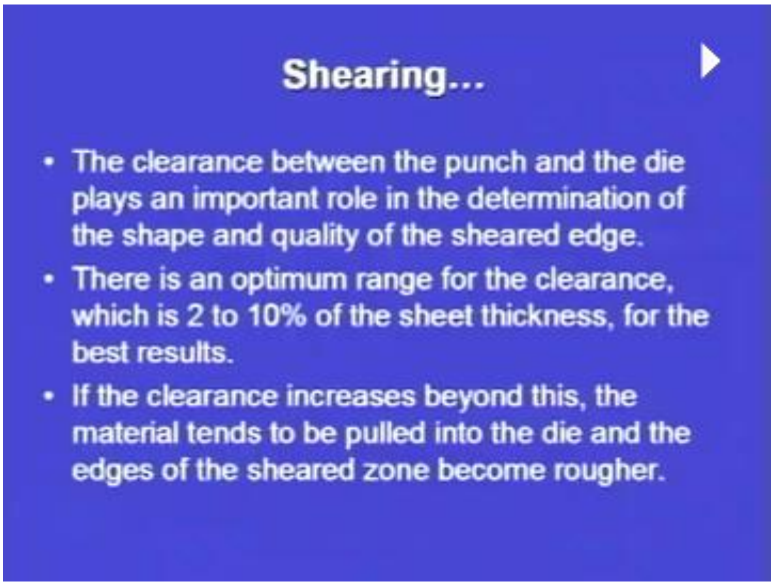

The clearance between the punch and the die plays an important role in the determination of shape and the quality of the sheared edge as already has been addressed. There is an optimum range for the clearance. So, there is an optimum range that has been decided depending upon certain experimental findings. Some research work that has been done in this field of shearing of sheet metals, that there is an optimum range that varies from 2 to 10 percent of the sheet thickness.

So, if we want to have the best possible results. So, the optimum range that we should choose for the clearance is 2 to 10 percent of the sheet thickness, if the clearance increases beyond this. So, 2 to 10 percent of the sheet thickness is chosen as the clearance, but if under certain circumstances. If we increase, if we go beyond this particular optimum level of the clearance, then the material tends to be pulled inside the die, and the edges of the sheared zones become rougher.

So, there is an optimum level that has been decided that has been developed, that has been researched that we should choose the optimum level for getting the desired quality of the edge. If we exceed that limit, then the quality of the edge or the sheared zone that we will get will not be of a very good quality.

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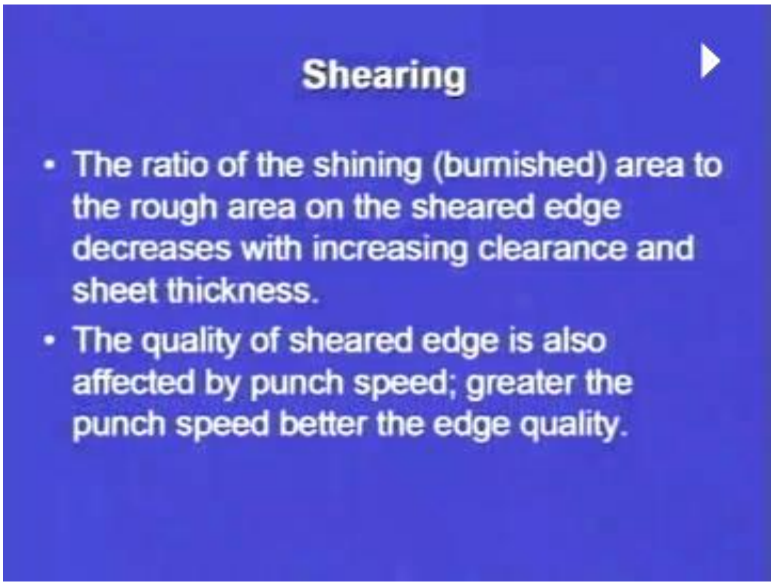

The ratio of shining burnished area to the rough area on the sheared edge decreases with increasing clearance and sheet thickness. So, two important aspects have been addressed here, first one is the clearance, and the second one is the sheet thickness. So, the ratio of the shining the burnished area, the burnished edge that was shown in the diagram of the slug to the rough area on the sheared edge decreases with increasing the clearance and sheet thickness. Moreover, the quality of the sheared edge is also affected by a punch speed.

So, another important aspect has been added into the operation that is the punch speed. So, the quality of the sheared edge that we will get also depends on the punch speed. So, the punch speed as we have seen, the punch comes from top and then shears off the sheet metal. So, the speed of the punch by which it is shearing of the sheet metal will also affect the quality, it can come very slow it can come at a very fast pace. So, depending upon the speed of the punch, we will get the quality of the sheared part.

So, the quality of the sheared edge is also affected by the punch speed, greater the punch speed better the edge quality. So, if you are shearing at a very slow speed, the quality of the edge that we are getting way no may not be off to the desired level, but if the punch speed is high or it is having the large or if we can say it is having impact type of phenomenon. Then the quality of the sheared edge that we are getting will be of desired level. So, 3 important aspects are there that is clearance, the thickness of the sheet, as well as the punch speed that decides the quality of the sheared edge that we will get.

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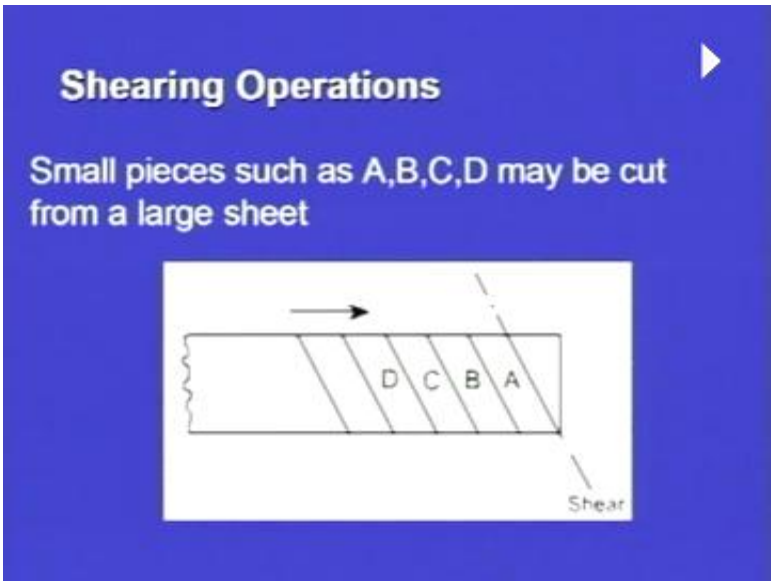

Then these are certain shearing operations. In shearing operations as we have seen that either we can shear off the sheet metal using the die punch type of arrangement or we can cut it using normal shearing machines. There will be a blade that will be used to cut the sheet metal, but that also depends upon the thickness of the sheet. The thickness of the sheet is too much, then we cannot cut it. If it graduates from the sheet into a plate, then it becomes difficult to cut it using a normal shearing machine.

Then there are different other ways to cut a sheet metal. So, there other device that we will discuss or other cutting mechanisms that will be discussed towards the end of this lecture. But, here we assume that the thickness of sheet is not that much, it is within the sheet thickness range only that we can cut it using a shearing machine. So, small pieces such as A, B, C, D as in the diagrams we can see this is part A, then B, then C, then D. So, we can cut it small pieces using the shearing machine.

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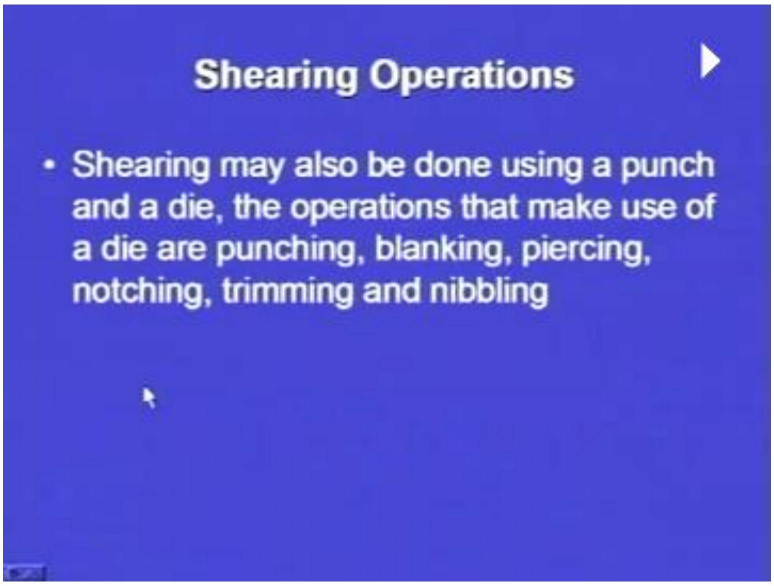

Then shearing operations, shearing operations may can also be done using a punch and die type of arrangement, earlier we have seen two three diagrams in which it was shown that there is a die, then there is a punch that is coming at optimum speed, and it is shearing of the sheet metal. So, there are two ways either we can use simple shearing machine, in which there will be a cutting blade, and we will cut the sheet according to the desired dimensions. Then we can also perform the shearing operation we can also shear the sheet using the die punch type of arrangement.

Now, shearing may also be done using die punch type of arrangement that make use of dies. Certain operations are there, what are those operations that make use of die-punch type of arrangement. These operations are punching, then blanking, piercing, notching, trimming and nibbling. So, there are certain operations that can be done using die-punch type of arrangement. And these operations fall under the broad category of shearing operations. We will try to address the basic mechanism or the basic technique of these shearing operations.

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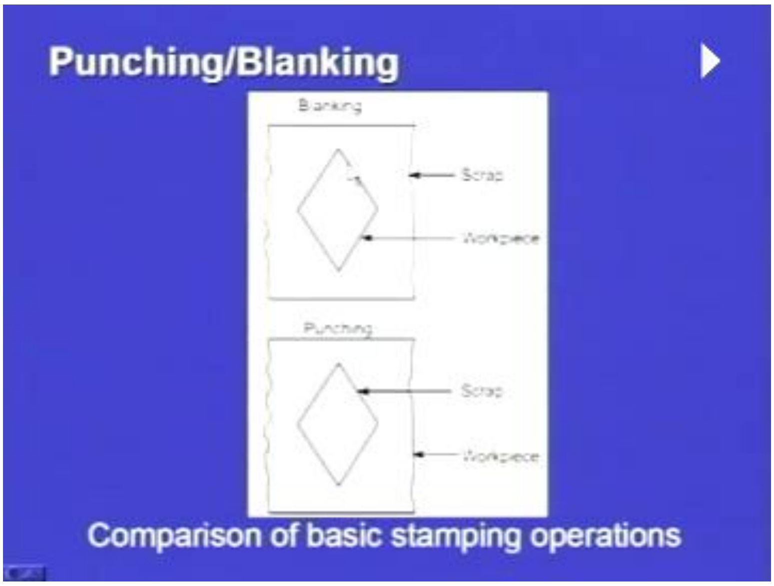

Now, what is the difference between punching and blanking? These are two different operations. Here we can see, there is a diagram that depicts the punching and the blanking operation. So, in the diagram, how the diagram has been labeled? Let us first understand that this is the blanking, blanking operation being done. So, this is scrap, this portion outer portion, this is the scrap, and this is the work piece. In case of punching, this is the scrap, and this is the work piece. So, this is comparison of basic stamping operations. So, stamping can be done either by punching or by blanking.

So, what is the difference between punching and blanking? The diagrams easily make it clear. In blanking the work piece is this, and in punching the work piece is this. So, in punching we are punching of some of the material from the basic sheet metal. In blanking, the left over portion is this, and whatever we are shearing off will be used as the final product. So, this is the final product in case of the blanking operation, and this outside portion is the final product in case of the punching operation.

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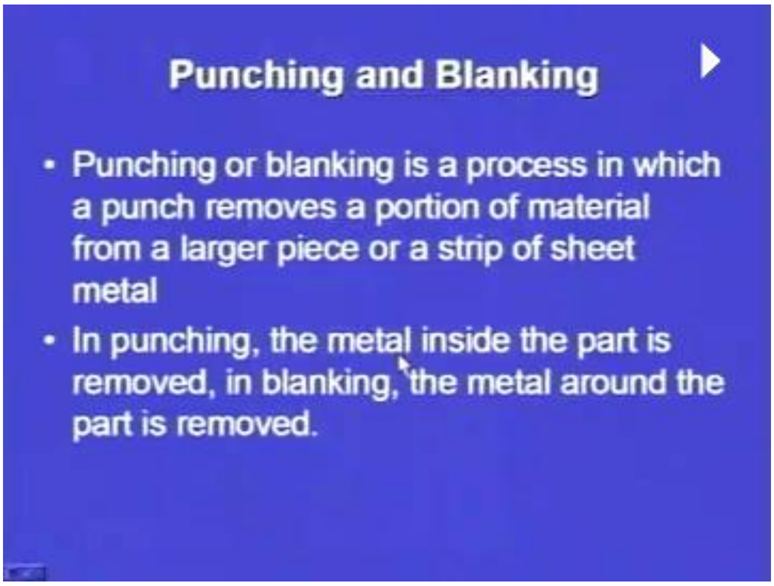

Now, punching or blanking is a process in which a punch removes a portion of material from a larger piece or a strip of sheet metal. So, a piece of material is getting removed. Here this piece is the material that is getting removed, and this is the work piece in case of blanking. In this case this is the material that is getting removed; the remaining portion is the final product that we are aiming to. So, punching or blanking is a process in which a punch removes the portion of the material from a larger piece or a strip of sheet metal. In punching, the metal inside the part is removed; in blanking, the metal around the part is removed.

So, this gives a very basic difference between the punching and the blanking operation. In punching, the metal inside the part is removed; in blanking, the metal around the part is removed. So, in blanking whatever we are producing, whatever we are bringing under the punch will be used as the final product. But, whereas in punching, we are removing some material, and whatever is the larger sheet metal that is remaining will be used as the final material. Just once again we can see this is the punching operation, this is the work piece that is being used this is being removed. In case of blanking, this is the work piece and rest all is the scrap.

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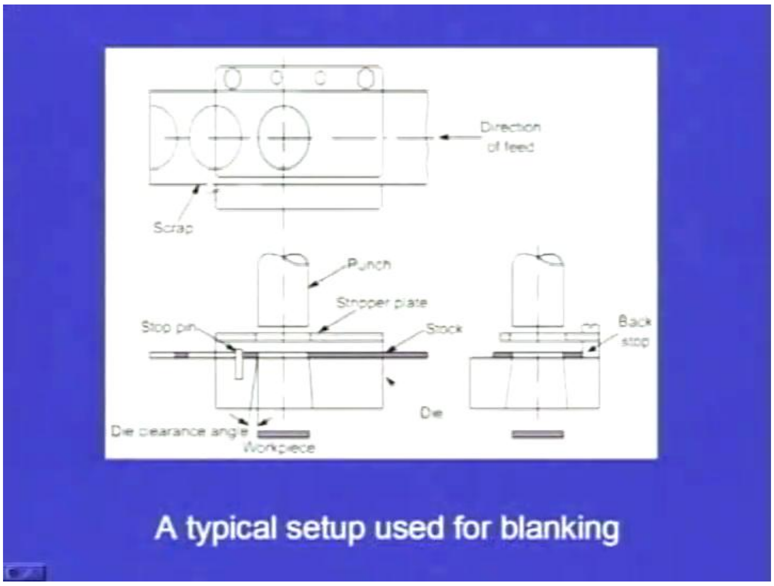

Now, this is the typical setup for blanking operation. We can see that this is the direction of it this is what is the scrap? This is the sheet that is being fed as the raw material. So, this is the scrap only this portion that is getting removed, this is the portion that is getting removed. This is the top view, if you see this view from here we can see this is the punch, the punch is here. This is the axis as has been shown see, the cursor is moving along the axis.

So, this is the axis, here the punch is there, this punch is going down, and it is removing some material from the sheet metal, where is the sheet metal, this colored portion this is the stock. In this diagram, the sheet metal has been represented as stock. So, this is the stock basically you can see. So, this is the stock pin, this will guide the material into the punching for the blanking operation. Here we can see, this is the punch that is coming.

So, the stock is coming from here, the punch will go down. It will be given a motion in this direction, if we can call it as Z direction, so the punch will move in the Z direction. So, it will come down, and this will shear off the metal piece or the sheet metal from here. So, this is the work piece that we are getting. So, if it would have been a punching operation, we would have use the remained portion here, but as this is a blanking operation, we are using this work piece.

Then we have seen that clearance is also one of the important aspects. So, where the clearance has been provided, the clearance is always provided between the die and the punch. So, here we can see this is the punch, this is the die, this solid portion blank portion, this is representing the die. And this is the die clearance angle, this angle that has been provided with the help of the arrows, we can see that this is the die clearance angle.

So, clearance will definitely affect the edge. So, whatever is the edge that we are getting here, will be the quality of this edge will depend upon the clearance, the amount of clearance that has been provided here. So, this is another particular portion, this is another view of this blanking operation, a typical setup used for blanking. So, we can see that the punch is coming, there is the sheet metal that is being fed into the machine, and thus we are getting a work piece here. So, this is a typical blanking operation.

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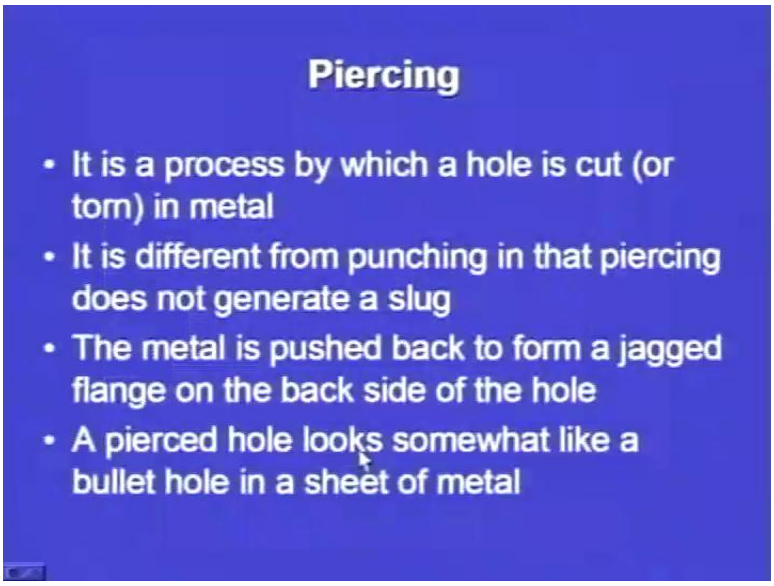

Then there is another important sheet metal operation that is piercing. Now, piercing is a process by which a hole is cut or torn in a metal. So, in punching also we can make a hole, in piercing also we can make a hole. So, what is the basic difference between a punching operation and a piercing operation? It is different from punching in that piercing does not generate a slug.

In punching, whenever the punch will shear of some part of the sheet metal, a slug will be formed, whereas in case of a piercing operation no slug formation will take place. The metal is pushed back to form a jagged flange on the back side of the hole. So, a jagged flange will be formed on the back side of the hole, the slug will not be formed in case of the piercing operation.

So, how the pierced hole will look like? A pierced holes look somewhat like a bullet hole in a sheet of metal. So, suppose we make a sheet metal, we make a sheet metal and we pierce a bullet in this sheet metal. So, the hole that will be formed by the bullet will be a piercing operation, and we will get a jagged flange on the back side of the hole. So, this is another operation that is a piercing operation that is done on a sheet metal to make a hole in the sheet metal.

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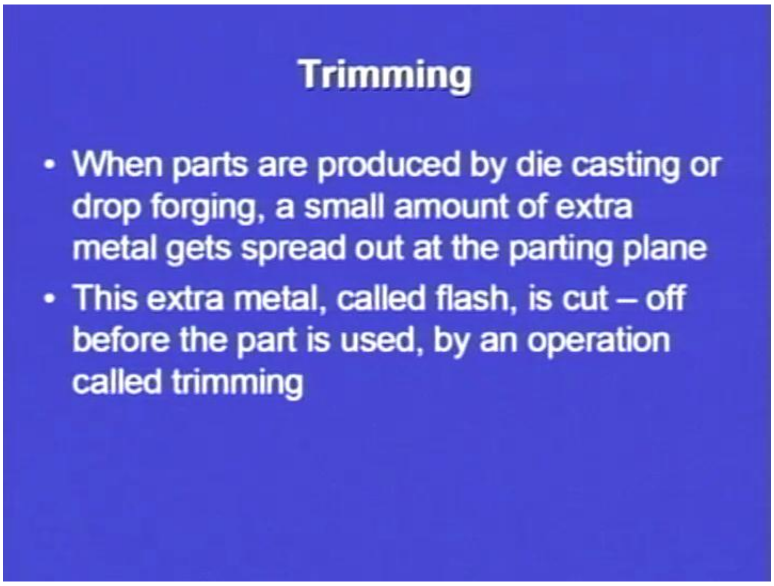

Then another important sheet metal operation is the trimming operation. So, in trimming, when parts are produced by die casting or drop forging, already we have seen what is a drop forging or we can make any product by die casting. So, whenever a product has been made using the die casting operation or it has been made using a drop forging operation, a small amount of metal gets spread out at the parting plane.

So, whenever two parts of the die are meeting, there is a parting line. So, whenever the metal is there, either it is being pushed or it is being injected in case as in the case of die casting. So, when the metal solidifies at the parting line some kinds of fringes of metal are developed. So, these fringes later on have to be removed using a subsequent operation. So, that subsequent operation for removing this flash of metal or removing this fringe of metal is called the trimming operation.

This extra metal, this is called flash already I have told. So, this flash is cut off before the part is used by an operation called trimming. So, why that is required, because some particular cases the surface finish of the final product that we make is very, very important. So, in order to get a desired surface finish, we have to trim of this extra flash or the fringe that has been developed as a process of die casting or as a process of drop forging.

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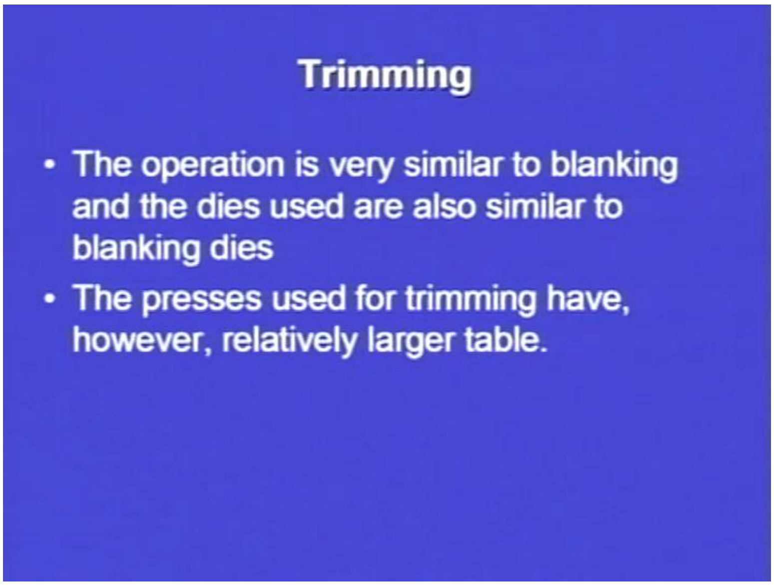

So, the operation is very similar to blanking, and the dies used are also similar to the blanking dies. So, trimming is not a very different operation from blanking. It is like blanking only, and the dies that are used for blanking are the similar to the dies that are used for trimming. So, the presses used for trimming have however, relatively large table. So, larger work pieces can be handled in case of trimming, the presses used for trimming have however, large tables. Then there is another important sheet metal operation, that we call notching.

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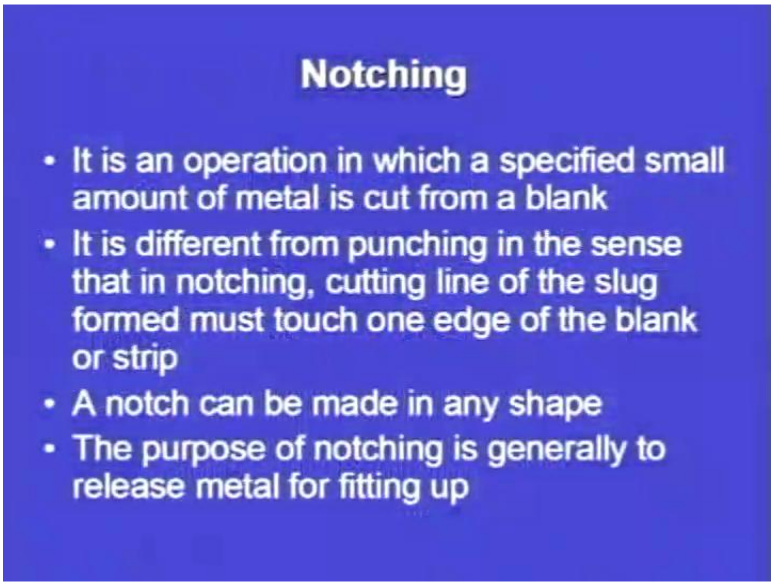

Now, what is a notching operation? It is an operation in which a specified small amount of the metal is cut from the blank. So, there is a metal blank, we can think of a piece of paper as a metal blank. Then a specified small amount of metal will be cut from any edge of the metal sheet or it can be if we take the example of a piece of paper, on a piece of paper if we cut a small notch or a small section on one edge of the paper that is called a notching operation.

In sheet metal forming operation, we are using a sheet metal. So, we will cut a notch at one edge of the sheet metal. So, it is an operation in which a specified small amount of metal is cut from a blank. It is different from punching in the sense that in notching, cutting line of the slug formed must touch one edge of the blank or strip. So, there is a difference between a punching as well as a notching operation. We have already seen that there is a difference between punching and piercing operation.

Similarly, there is a difference between punching and a notching operation. In punching, there is a blank, and in between anywhere in the cross section of the blank or anywhere inside the blank we will punch a hole or we can punch any particular cross section depending upon the shape of the punch. But, in case of notching that operation will only be performed at the edge, it will not be performed anywhere in between.

So, it has very clearly been written on the slide that cutting line of the slug. The cutting line of the slug formed must touch one edge of the blank or strip. So, notching is an edge operation, notching will be carried at the edge, so one edge of the blank or strip. So, the cutting line should, the cutting line of the slug formed must touch one end of the blank or strip.

Then a notch can be made in any shape. So, it is not the shape is not a limitation, we can make any type of a notch, it can have a square cross section or we can make a notch that looks like a V, we can make a notch that looks like a U. So, a notch can be made of any shape. The purpose of notching is generally to release metal for fitting up. So, sometimes it is not that whatever operations or sheet metal work we are doing, we are doing it for the final part only.

Sometimes some different parts, because of the complexity in the final product, we develop some parts using different sheet metal operations, and then finally we assemble them. So, for fitting different parts together, sometimes we need to develop certain kind of notches. So, these notches can be of different shapes as we have already discussed. So, this basically notching operation has its application, when we have to release some metal for fitting up.

So, when we have to join some sheets together, we may need to develop certain type of notches. So, notching operation is there by used on sheet metal. Then there is another operation that is called nibbling. So, in this lecture we are discussing, what are the different sheet metal forming operations? We have already seen what is punching? What is piercing? What is blanking? What is notching? Now, we discuss what is nibbling?

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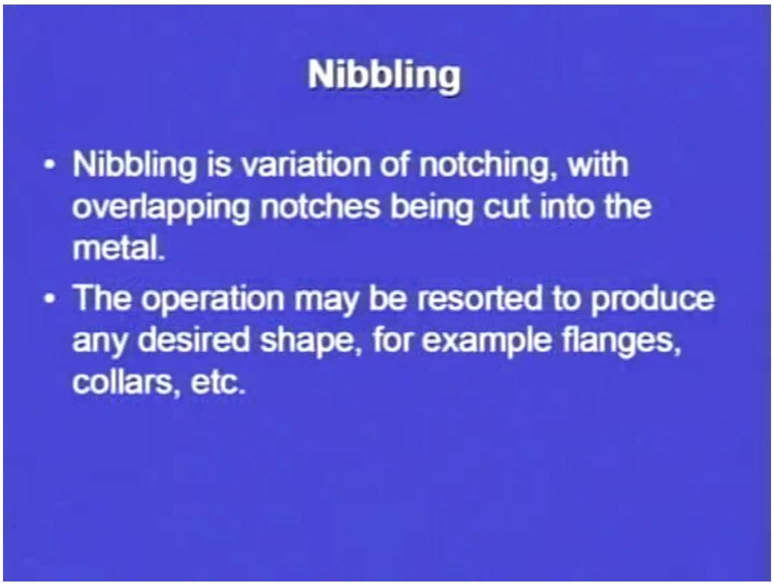

So, nibbling is a variation of notching, in which overlapping notches being cut into the metal. So, in case of nibbling we will form overlapping notches. So, these can be overlapping circular notches or hemispherical notches or depending upon the shape that we are making. So, nibbling is a variation of notching with overlapping notches being cut into the metal. The operation may be resorted to produce any desired shape for example, flanges, collars etcetera. So, if we want to make flanges or collars in sheet metal, then we can go for this process of nibbling.

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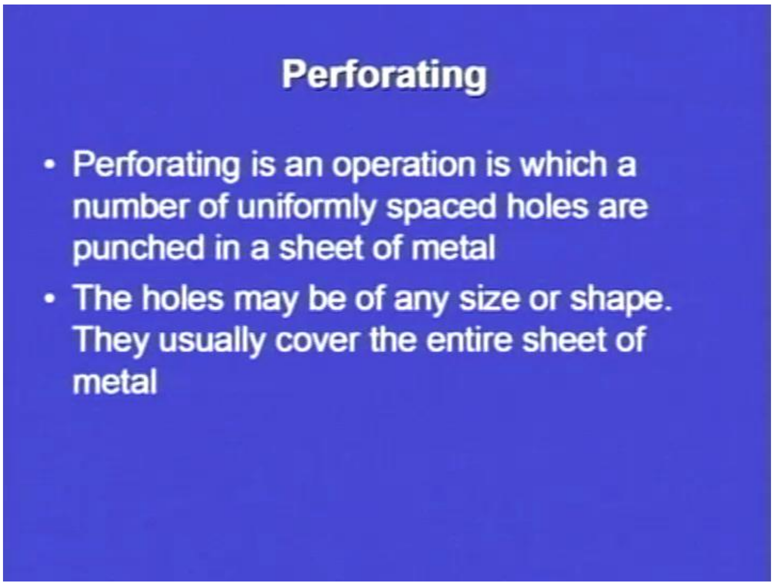

Then there is another important process that is called perforating. Now, what is the process of perforating? Now, perforating is an operation in which a number of uniformly spaced holes are punched in a sheet of metal. So, important point here is uniformly spaced holes are punched into a sheet of metal. So, numbers of holes are punched and these are uniformly spaced. So, if we want to make a series of holes on a sheet metal. So, this can be done using the process of perforating.

The holes may be of any size or shape. So, holes when we talk of a hole, usually we say that it will be a circular hole only. But, in case of perforating we can use as punching arrangement, in which we can make different types or different sizes or shapes of holes. So, these will cover usually the entire sheet of the metal. So, whenever over an entire sheet of the metal, we have to make holes for perforating.

This process is called perforating, because sometimes this kind of a sheet metal is required, this can act as a strainer, this can act as number of different application are there where we have a number of holes, uniformly spaced holes over a sheet metal. So, we have seen till now that sheet metal can be formed in different ways. Basic operation in shearing though shearing can be done using a shearing machine.

Then there are other subsequent operations which can be done using a die and punch type of arrangement, what are these operations that can be done using die and punch type of arrangement? These are nibbling, perforating, notching, blanking, punching, so depending upon the final requirement of the product. Now, sometimes a large number of holes may be required, we can very easily choose the perforating operation. Sometimes, for fitting up different sheet metals together, we may use the process of notching.

Sometimes, we may require that some flange or collar has to be made then we can make process that is called nibbling. So, different types of processes are there, which can be chosen depending upon the final requirement of our product. Now, coming on to the die material and lubrication, we have already seen that the dies are the most important parts, because if the die is wear resistance, then we can make a large number of parts.

If the die is not wear resistant, and it wears at a very fast pace, then the number of products that we will get out of the die is limited, and the cost of the die will be added to the cost of the product. So, die material is an important aspect, similarly the lubrication is also equally important. So, die material and lubrication as we have already seen in our previous lecture, these are important in all different aspects of metal working.

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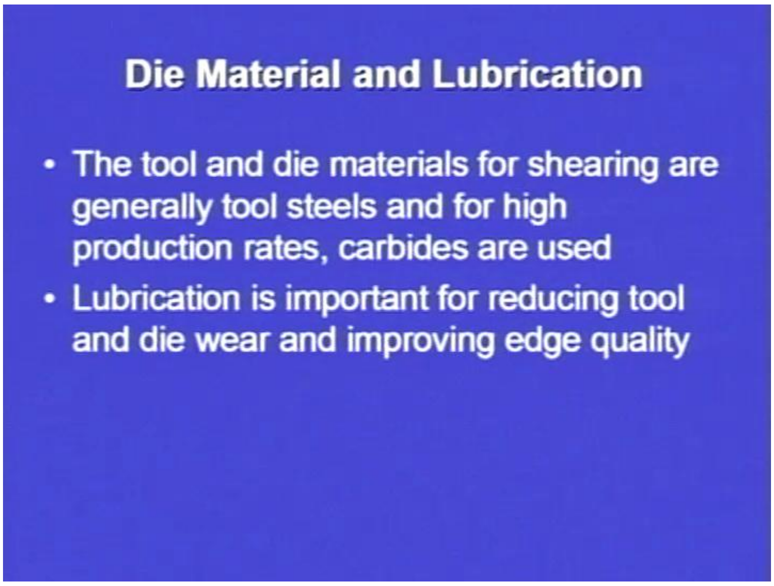

So, the tool and die materials for shearing are generally tool steels, and for high production rates carbides are used. So, there are two different tool materials that had been specified for die material, and these are tool steels and carbides. So, how to differentiate that should we go for tool steel or should we go for carbide. So, one important aspect has already been mentioned that when the volume of production is going to be too large, there we will go for carbide dies, if the volume of production is relatively small, we may go for tool steels.

So, in case of carbide, the cost, the relative cost between the carbide and the tool steel will be more in case of carbide dies. So, when we are incurring a higher cost, then we want that the volume of production should be more. Using the same die, if we produce a large number of parts, then the cost of the die will be spread over all that number of parts, and that will result in the cost of the product that can compete with the other competing products. But, if we use a very sophisticated and a very good material as the die materials like diamond, and we make very small parts out of that.

Then the cost of the diamond die will be spread over that small number of parts, and the cost or the input cost or the cost to the company for that particular product will be considerably higher. And it may not be able to compete with the similar products made by another manufacturer, who is using a cheaper die. So, depending upon the requirements, the volume of production, the life of the die, we can choose that which material we are going to use to make the die. So, either we can choose tool steels or we can choose carbide.

Similarly, the lubrication is important, why lubrication is important? Because it reduces tool and die wear. Here we see that the punch is coming that is going into the die. So, there is the although there is some clearance provided, but in between the punch and the die there is metal, so there is a continuous friction that is always present. So, lubrication is important as it reduces the tool and dies wear. So, wear of the die is avoided, if we use the proper lubrication arrangement.

So, if lubrication is there, the tool and die wear will be avoided, and moreover it will improve the edge quality. So, there is no point in discussing that whether we should use a lubricant or we should not use a lubricant. Here lubrication is one of the important aspects as it reduces the wear, and it improves the surface finish or it improves the edge quality that we are going to get using the sheet metal operation which is making use of die and punch type of arrangement.

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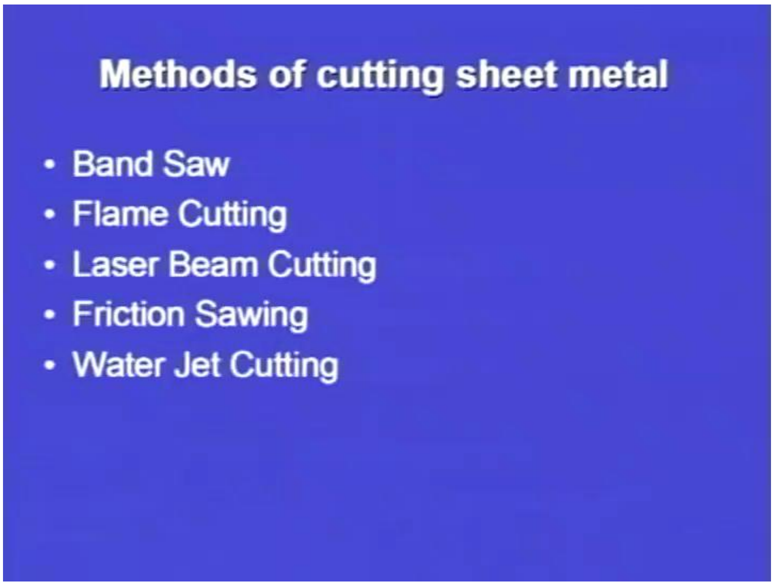

So, now there are other methods of cutting sheet metal. So, these are by using a band saw where we use a cutting blade, which will silt the metal into 2 parts. It can also be cut if the thickness is more, we can cut it using flame cutting. Otherwise, we can go for laser beam cutting, which is the advanced technique for cutting the sheet metal. We can go for friction sawing, even water jet cutting can also be used where a jet of water that is laden with some aggressive particles can be used to cut a sheet metal.

So, depending upon the requirement of the final product, we have to make a decision that which particular process or which particular sheet metal operation, we are going to use for making our final product. So, coming on to the end of this lecture, we have discussed in this lecture some of the aspects of tube drawing and wire drawing, in which we saw what is die pull? What is tube drawing? And then we shifted our attention to the sheet metal forming operations that was the title of this lecture, in that we saw what is the introduction from where did the sheet metal originate?

Then what are the shearing operations, different types of shearing operations like, nibbling, perforating, piercing, punching, blanking was discussed. And then we saw, what is the different type of die material? That can be used in case of sheet metal forming operations. Then we have seen that lubrication is a must, and towards the end of the lecture we briefly discussed that what are the various types of other cutting operations that can be done on sheet metal to get the desired shape? So, that is all in this lecture on sheet metal operation.

Thank you.