Processing of Non-Metals
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Module - 4
Plastics: Properties and Processing
Lecture - 5
Injection Molding

Good Morning to all of you a warm welcome in this lecture on injection molding, as you are well aware that we are in the process of discussing the processing of plastics. Whatever we have discussed till now, let us just have a brief overview or review of what we have finally discussed. We have discussed the basic difference between the thermo sets and thermoplastics are the types of plastics in the very first lecture. In lecture number two, our focus primarily was on the mechanical properties; in which, we have seen some of the important mechanical properties in context of the plastics.

If you remember in lecture number two, we have seen the stress-strain behavior that how the thermoplastics would filled if they are loaded in the tensile direction. We have also seen in lecture number two that what is the casting process specifically in context of the plastics, because casting is a very general process, which is used in metals. But in plastics also, we can do the casting process we seen what are the application areas of casting, specifically for plastics. And also we have tried to understand that what are the advantages and limitations of the casting process, because as the title of our module is processing of plastics. So, our focus primarily was just to have an overview of what the plastics basically are, what are the important characteristics of the plastics And finally, we shifted our attention towards discussing the processing aspects of the plastics.

So in the lecture number two, we have discussed one of the important processes that is casting. In lecture number three, our focus was on the extrusion of plastics in which we have seen that what are the various process variants in extrusion. What are the different types of or we can see in other words what are the different types of extrusion processes depending upon the requirements, which are done on plastics. And what are the different types of products which can be made by the extrusion process. Then in lecture number four, we have discussed what do we mean by transfer molding. In transfer molding, we have seen that what is the basic process, we have tried to understand it with the help of a

diagram. Also we have seen that what is the compression molding process. In compression molding also, we have drawn a very simple diagram and tried to understand that how compression molding of plastic is done, and what are the important process variables in compression molding process.

So, this is just an overview of what we have already discussed in this particular module that is processing of plastics. Why I emphasize the revision of what has already been discussed, because if somebody is interested in some other topic then he can get an idea that this particular topic is available in this particular lecture. So, we have already discussed a few processes again, I would name the processes like casting of plastics, we have discuss extrusion of plastics, we have discuss transfer molding in context of plastics and we have also covered the compression molding of plastics.

So, today our attention is the injection molding of plastics. So, there are large number of videos which are available on the internet which give us an idea about the injection molding process, but as a learner we should try to understand that how actually the injection molding process takes place. And what are the important process variables that have to be taken into account when we are under trying to understand the basic principles of the injection molding process. So, it is a very very widely used process the machine are commercially available that is the injection molding machines are commercially available and a wide variety of project, products are made by the injection of molding process. And we see a large number of applications of injection molding process in our daily life also, but most of the engineers do not get an opportunity to study the processing of plastic in their regular curriculum.

So, this particular course that is processing of non-metal has been designed, so that whatever material are not covered in most of the curriculum can be covered here in this particular course. For example, we have already seen that what are ceramic, we have seen what are glasses, and subsequently we would be focusing on some other material important material like polymer matrix composite and ceramic matrix composite, which are not usually covered as a subject material in most of the syllabi.

So, today of our focus is on injection molding, and injection molding I am emphasizing again can be used in polymer matrix composite also. So, in our module on processing of polymer matrix composite, again we would be discussing injection molding, but with the

important point that how the reinforcement can be added. But today our focus would be to primarily discuss the basic principle of injection molding; in which, the raw material is a plastic. So, we have a raw material which is a plastic, and we are converting this raw material into the final product. So, the final product that will get out of the injection molding process would be a plastic product; it would not be a polymer matrix composite or a fiber reinforce plastic product, because that particular product we will discuss specifically when we will be discussing our next module that is processing of polymer matrix composite. So, today our focus is the processing of plastic and the process that we are focusing on is injection molding. So, with this introduction, now let us start our discussion on the injection molding process.

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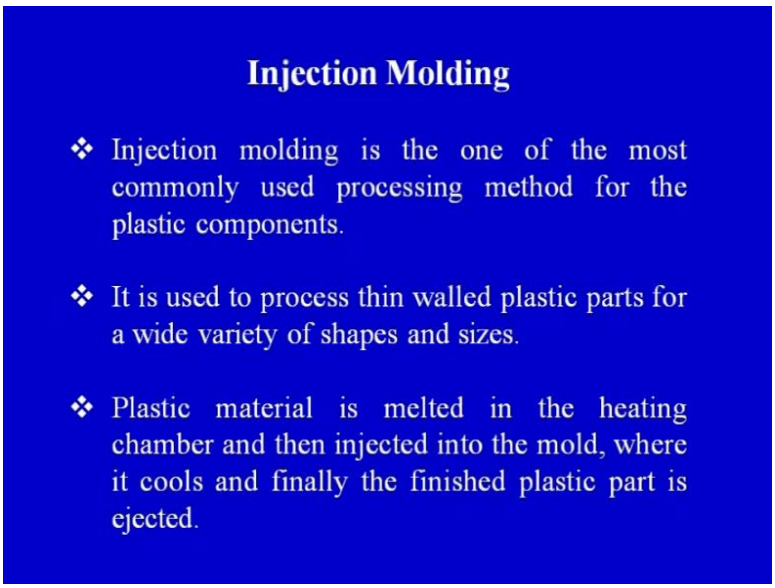

Injection molding: Injection molding is one of the most commonly used method for plastic components. It is a fully automatic process and the raw material is converted into the final product. The shape and size of the final product depend upon the mold or the dye, which is used in case of the injection molding process. So, it is automatic process, it is a commercialized process, and it is a very fast process - the production rate is also very very high. So, again I am emphasizing on point number one that is injection molding is one of the most commonly - most commonly means it is widely used. And this is one of the important processing methods for processing of plastic components.

Point number two on your screen, it is used to process thin walled plastic parts for a wide variety of shapes and sizes. This point I have already emphasized that we can make a wide variety of components using the injection molding process. So, the size can be variant means, we can have different sizes, we can have different shapes; for examples, the syringes - surgical syringes can be made by the injection molding process, even the plastic buckets or mugs can be made by the injection molding process. So, the application spectrum of injection molding is very very wide. So, we can have different shape, different size products made by the injection molding process.

Point three on your screen, plastic material is melted in the heating chamber and then injected into the mold, where it cools and finally finished plastic part is ejected. So, while this point has been emphasized here, because if you remember in the process in our lecturer on processing of plastic or the basic fundamentals of processing of plastic, I have emphasize three important points or three important alphabets that was H, F and C. H means heating, F means forming, and C means cooling. So, H, F and C are three fundamental words which are used or which are important when we talk about the processing of plastics.

So, here also the three words are coming into picture, again I am reading the sentence on your screen, you can have a read again. Plastic material is melted in the heating chamber. So, first word is coming into picture that is heating. So, the plastic material is melted in the heating chamber and then injected into the mold that is forming, because the final product would conform to or would adhere to the shape of the mold. So, we are now changing the shape of the molten plastic into the desired shape and the desired shape is the shape of the mold or the desired shape of the final product is the shape of the mold. So, first is we are heating it, that is the alphabet H, then we are forming it that is in the mold; and finally, it is allowed to cool. The two mold half would remain in contact until the plastic has solidify into the final product. So the final stage is the cooling stage.

So, once the final product has been formed inside the mold cavity, and it has cool down to the respective temperature that two mold half open and the final product is ejected out of the mold cavity. So, again the three alphabet are coming into the picture, that is heating of the plastic, the forming or changing the shape of the plastic, and finally, the cooling of the plastic. And the last stage is the ejection of the finish product out of the mold cavity, which is achieved by the ejector pins.

So, I will first draw very simple diagram, and we will see how the injection molding process actually take place, and finally, we will revise this diagram with the complete diagram on your screen. And then we will see what are the important units of the injection molding machine or the injection molding process. And we will try to see that what are the important points to be taken care of when the injection molding process is taken place, and finally, our focus would be to understand that what are the advantages, and what are the limitations of the injection molding process. And finally, we will see some of the products which are made by the injection molding process. Now this is the outline of the today's lecture. So, let us start by understanding the injection molding with the help of our simple diagram.

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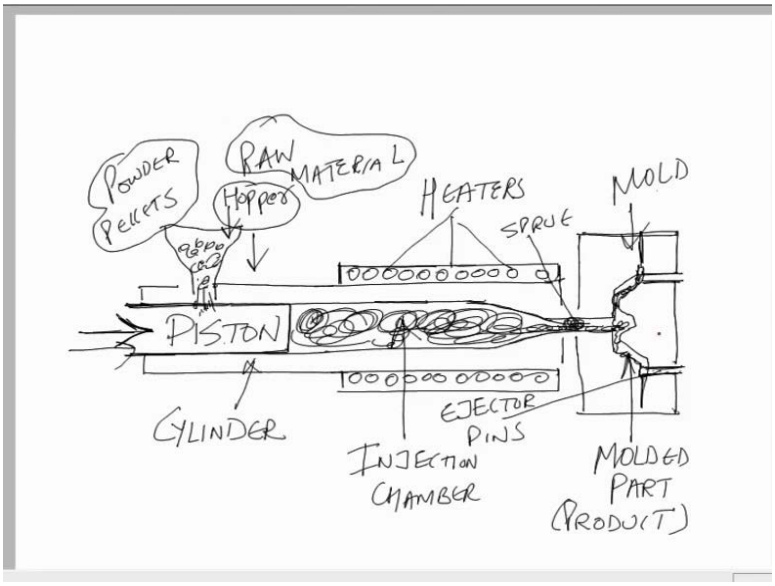

So on your screen, you can see, I am going to draw a very simple diagram of the injection molding process. This is the hopper through which the raw material is going to come this is hopper. And the raw material is available in the form of powder or it can be available in the form of pellets. So, we can have a raw material, the raw material can be in the form of pellets or it can be in the form of powder. So, this is the hopper; in which, the raw material is kept, then we have on your screen you can see I have drawn a cylinder - this is the cylinder. So, we have a cylinder and a hopper. So, the raw material is there in the hopper, we can say this is a our raw material. So, the raw material is coming from the hopper, and it is entering the cylinder. And here, we have a piston, we can call this is a piston. Now this piston will have a movement in this direction. So, the

piston will be used to push this material that ever is coming from the hopper into the cylinder towards the mold. Now where is the mold, the mold is placed at the end of the cylinder. Now this is the mold, it is made in two half. I am drawing the two half of the mold, and this is the mold cavity or we can say the final shape that we want to create.

Now, this is the final shape, again we can say this is our molded part or the final product; we can say that we want to produce, it is a plastic product that we want to produce. So, this our mold, the mold is made up in two half. And we have on your screen, you can see, we have two ejector pins; now these are called the ejector pins. What is the role of the ejector pins? That we will see in the subsequence slide, but important point is that the mold design is also very, very important. So, let me first complete the diagram and then finally, we will see that how actually the process takes place.

So, till now we have seen that we have a hopper in which the raw material or the plastic raw material is kept. The raw material is in the form of the powder or the pellets, and then this raw material from this hopper it enters into the cylinder. And in cylinder, we have piston and cylinder type of arrangement; in which, the raw material that is entering into the cylinder is pushed towards the mold. The mold is at one end of the cylinder and then we have the ejector pin, which are used to eject the final product out, but this is not the total process as the whole. Because if you remember the three important words that we have discuss before, what are those three important words, first one is heating. So, there is no heating taking place in this process till now. So, we have to have arrangement for the heating elements also. Second is forming; the forming is going to take place inside the mold. And finally the cooling; the cooling is going to take place inside the mold that two mold half's would be close, and finally the ejection. So, the ejection would be done with the help of the ejector pins that I have drawn. So, where would be the heating elements be, so let us now draw the heating elements.

So, on your screen, you can see, we can have different heating elements around the cylinder. Now these are the heating elements or we can say all these are the heaters and on the bottom side also we have the heaters. So, this is going to heat the material, and here we have this is the we can say is the heated plastic which is going to go come and enter into the cavity, which is generated between the mold, and we have the ejector pins. Heating is there, forming is there, and finally, the cooling is taking place. Now the

diagram as a whole is complete. Now this is also called this particular section is also called the injection chamber.

So, we have an injection chamber, we have a piston, we have a cylinder and heating element, we have a mold, and we have a we can say ejector pins which are used for ejection and a hopper from where the raw material is going to enter. And the raw material would be available in the form of powder or pellets. So, let us now see how actually the process is going to take place. So initially, we have a hopper; on your screen, you can see, we have a hopper; in which, we have the raw material. So, we have a hopper in which the raw material is kept. The raw material can be in the form of the powder or the pellets. From here, the raw material will enter into the cylinder; and in cylinder, we have the piston and the injection chamber type of arrangement. The piston would be pushing this raw material to in the cylinder, and there is a heating arrangement, which would be used to melt the raw material, which is the plastic material. Once it has melted, it will be pushed through the sprue. This can be called as this particular section on your screen can be called as a sprue.

Through the sprue, the material would be entering into the mold cavity. The mold cavity is being generated between the two half's of the mold. One half of the mold would be in contact with the cylinder, and the other half of the mold would be movable. So, the cavity which is generated between the two half of the mold would be filled by the molded plastic under pressure by the piston. And the two half's of the mold would remain close until the plastic has solidify, and it has taken the shape of the mold cavity. After the solidification or the cooling process has taken place, once the product has cool the the movable half of the mold would move back, and most probably, in most of the cases, the product which has form will move away with the movable half of the mold. And finally, the ejector pins which are hydraulically operated will push the product away from the movable half of the mold, and the product or the plastic product would be collected. So, this is a simple representation of the injection molding process, and we will try to understand this with the help of the diagram again.

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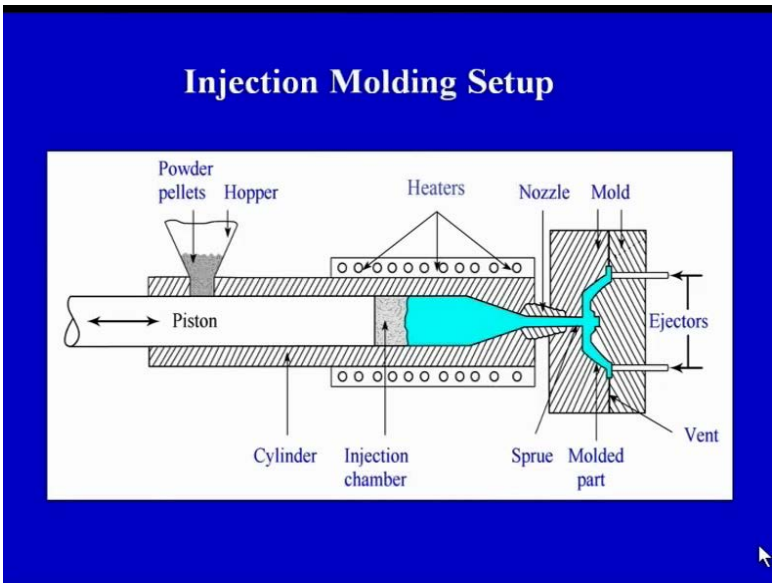

Now let us see the diagram on your screen that complete and a very clear diagram, which is available on the screen. You can see, again this is the similar type of diagram. Let us now again try to see how the actually process is taking place. Now we have a hopper; in this hopper, we have the raw material, which is available in the form of the powder or the pellets. We have a piston, which can move in this direction, it will push the molten plastic into the mold half. The mold is made up of two half's one is fixed; another half of the mold is movable. And then once the raw material enters into the cylinder, it will be push by the piston. There are the heating elements, the heating elements will melt these pellets, and the molten pellets or the molten plastic would be push into the mold here. This is the final product that we want to make this the cavity which is generated between the two half's of the mold.

And finally, this particular plastic would be allow to cool, after cooling the movable half of the mold - this half would move back, and will travel along with the movable half. And finally, the ejector pin will operate and this will push (( )) of this particular product out or away from the movable half of the mold. This is the total injection molding process.

So, basically we will again try to revise what we have seen in this particular diagram. Basically there are three or four important steps that are taking place. If you remember there are closing of the mold that is creating of the cavity or the mold cavity which is in

conformist to the final product that we want to generate that is clamping of the mold. Where the cavity is being form raw material is fed into the cylinder it is push by the piston. The raw material is heated and melted by the heaters, and finally, under pressures it enter it into the mold cavity. It tries to fill in each and every corner of the mold cavity and where it is allow to solidify or it is allowed to cool.

And once it cools the two half of the mold is open, the movable half of the mold move back the final product is also attached to the movable half of the mold. And finally, the ejector pins are actuated hydraulically or numerically, and this will push the final product out of the mold cavity, this is one cycle. Again the two half's of the mold would close down, forming a cavity, confirming to the final shape of the product. Again the raw material would enter from the hopper into the cylinder, the piston would push this material, the material would get heated inside the cylinder because of the heating element and under pressure it would be injected into the mold cavity. Were it would be allow to cool and take the shape of the mold cavity and that of the final product. Now this is a simple single cycle of injection molding. So, number of cycles per hour or number of cycles even sometimes per minute can be done. So, this is very commercial or widespread used and the production rate are also very very high.

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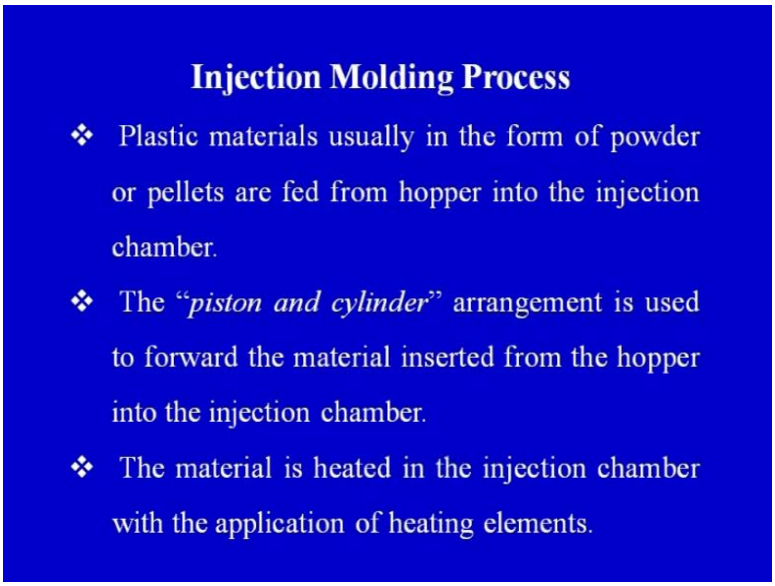

Now, let us try to understand the various stages of the injection molding process. Now although I understand that most of you have got an idea that how the process actually

takes place I have drawn a diagram. We have also seen the complete diagram, we have also seen the complete diagram two three time. We have revise that how the actual process is taking place. Now let us just read the various stages of the process plastic material usually in the form of powder or pellets are fed from the hopper into the injection chamber. So, that is the first point from the hopper the raw material is being fed into the injection chamber. So, this piston is used to push the material towards the injection chamber. Secondly, the material is heated in the injection chamber with the application of heating elements. So, again we have to melt the raw material in order to push it into mold cavity finally. So, first thing is the raw material is coming from the hopper it is being push by the piston towards the injection chamber in the injection chamber there is a heating arrangement. So, heating is going to melt the raw material into the molten stage.

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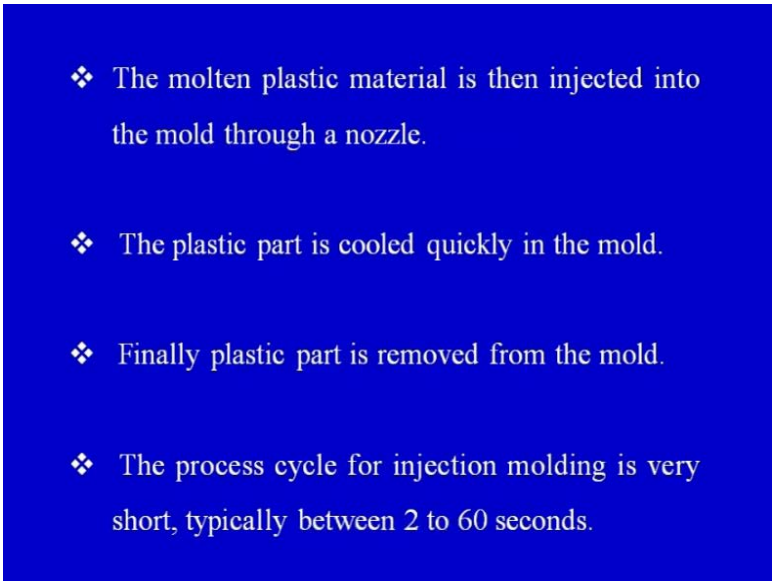

The molten plastic material is then injected into the mold through the nozzle. So, there is a nozzle towards the end of the injection chamber through which the molten plastic would be injected into the mold cavity the plastic part is cooled quickly in the mold sometimes we may have a cooling arrangement in the mold itself. So, that the cooling process is accelerated. So, the plastic part is cool quickly in the mold, the finally plastic part is removed from the mold after the cooling process has taken place. The final product would be remove from the mold the process cycle for injection molding is very

very fast, but burn an average may be 30 to 35 seconds once particular product can be made using the injection molding process

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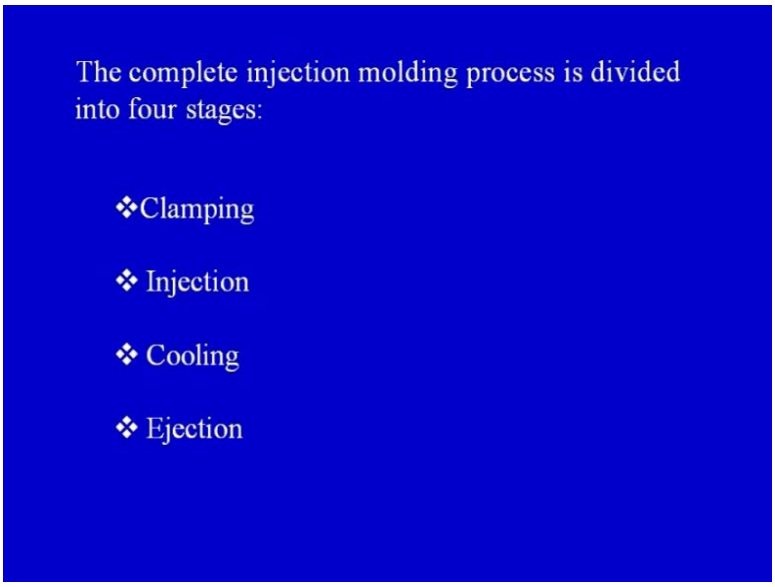

Now, the complete injection molding process can be divided into four stages. Now as we have already try to understand. Now let us break the total cycle into its constituent and independent stages. First stages is the clamping; the clamping means that the two half's of the mold which are in the beginning separate will be close down or would be clamp why would. They be clamp because the cavity is generated or cut inside the two mold half. So, one mold half is fixed; another is movable. The movable half would travel towards the fixed half and the two mol half would be clamp together forming a cavity inside. So, the first stage is the clamping or the formation of the mold cavity, so first stage is clamping.

Second stage is injection. In injection, there are two three small small steps that is raw material would be entering from the hopper into the cylinder from where with the help of a piston. It will be push into the injection chamber and injection chamber it would be heated by the heating elements and finally, with the piston and cylinder type of arrangement it would be push towards the through the nozzle into the mold cavity. So, all there micro steps or small steps. So, first is closing down of the mold or clamping of the mold, two mold half and then the injection. In injection, there are these three four steps that we have already covered.

Again I will revised, the raw material in the form of powder or pellets would be coming from the hopper, it would be coming into the cylinder. In the cylinder piston would be pushing this raw material towards the injection chamber, in injection chamber we have heating arrangement and this heating arrangement would melt the raw material and finally, using the piston cylinder arrangement it would be push through the nozzle into the mold cavity that is the total injection step. And finally, once the mold cavity has been injected into the mold cavity it would be allowed to cool for our specific period of time depending on the total injection - total injection molding cycle.

So, the cooling will take its own time, and once the cooling has take place, the two mold half would open the final product would be attach to the movable half of the mold the movable half of the mold would move back. And finally, the ejection of the product would take place, there would be ejection pin present in the movable half of the mold and these pins would be actuated and this would give a gentle tab or a gentle push to the product which is attach to the movable half of the mold. And finally, this product would be collected as a finish product and as it has already been emphasis that it is a completely automatic process most of the injection machine that are available today are full automatic. So, all these steps would be time for each and every steps a fixed time would be fix and depending upon that time.

We can calculate that what is the production rate that in one particular hour or one minute, how many products can be made or in one day or one particular shift, how many product can be made. So, the four important steps or four important we can say stages are closing of the die injection of the plastic into the mold cavity cooling of the final product inside the mold cavity. And finally, the ejection of the final product from the mold cavity. So, these are the four important stages in the injection molding process.

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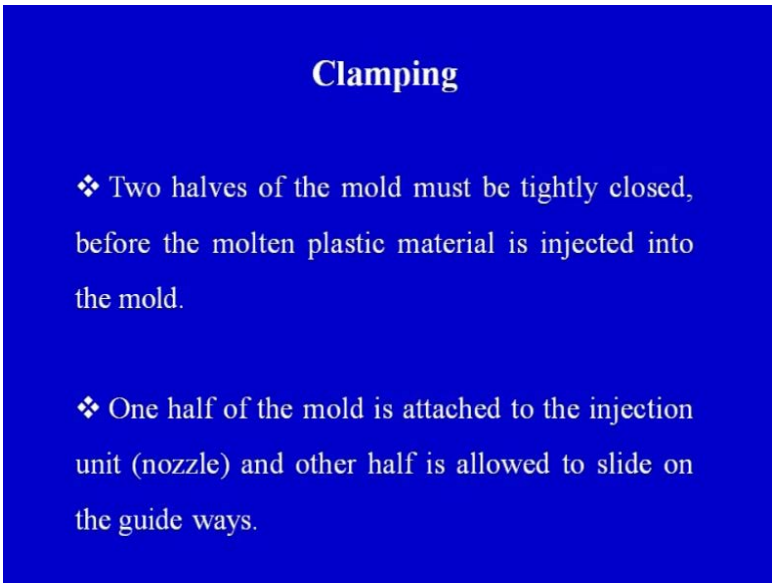

Now, let us see some important features of each stage first stage is clamping two halves of the mold must be tightly closed before the molten plastic material is injected into the mold. So, this is giving us the meaning of clamping which I have already explain one half of the mold is attached to the injection unit that is the nozzle that we have seen in the diagram, and the other half is allowed to slide on the guide ways. So, which mold is made up of two half one through the nozzle, and the other half is movable. So, the clamping is to down between the two half of the mold.

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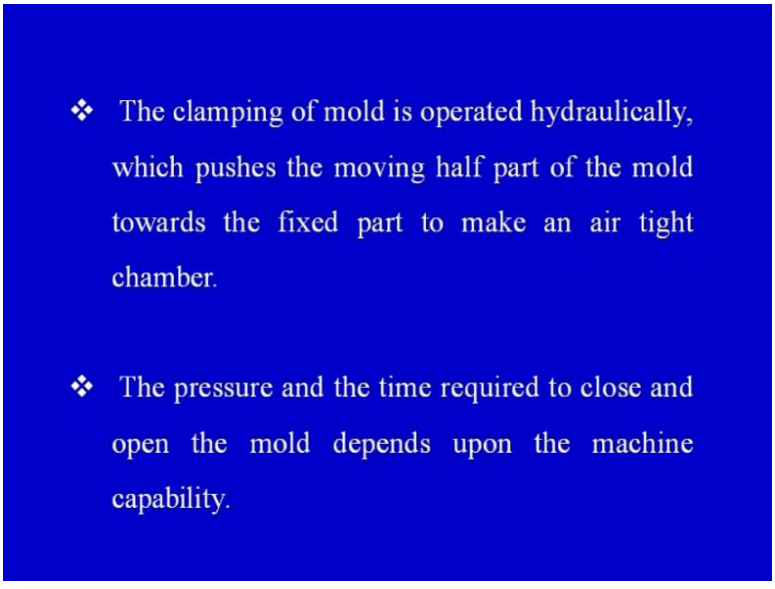

The clamping of mold is operated hydraulically. So, which means that it pushes the moving half of the mold towards the fixed part to make an air tight chamber or this chamber we can call as the mold cavity. So, the clamping unit is operated hydraulically. So, one half is fixed, another half would be made to move, and it will get clamp with the fixed half in between we will have the mold cavity. The pressure and the time required to close and open the mold depends upon the machine capability.

Now we can have machine with different clamping forces and the time required to close because this will finally dictate the production rate. If it take lots of time to close two mold half, the production rate would be less, but if this process of clamping and opening quick, the production rate would be very very high. So, depending how much force is required, we can have different type of machine again to revised. If the clamping is quick, the production rate would be high; if the clamping and the decamping is very very slow, the production rate would be very low or it would be a slower production rate machine.

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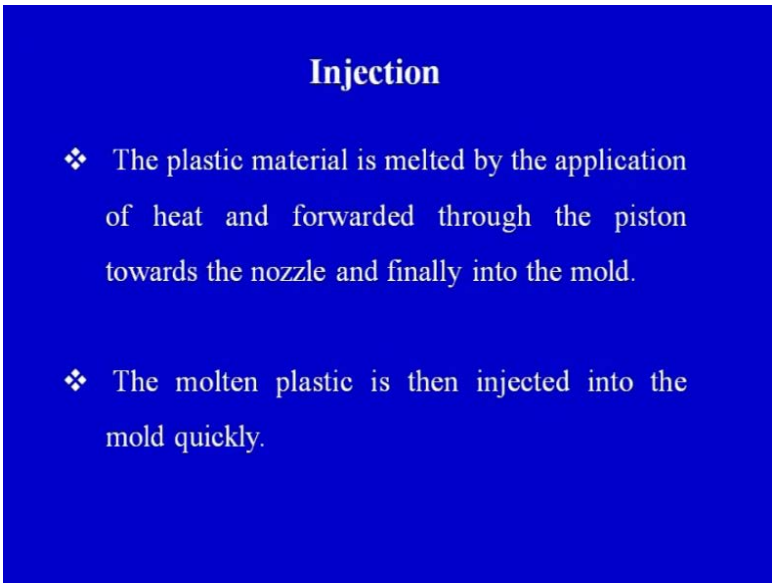

First stage clamping, second stage is injection the plastic material is melted by the application of heat and forwarded through by the piston towards the nozzle and finally, into the mold. So, in injection, as I have already told the raw material in the form of powder or pellets is fed from the hopper and it is the melted by the application of heat we have seen in the diagram there are heating element, and finally mold cavity the molten

plastic is then injected into the mold quickly. So, we want we do not want to stresses in our final product. So, the filling process of the mold should not be very slow. There should be optimal rate of filling of the mold cavity, it should not be too slow, and it should not be too fast also.

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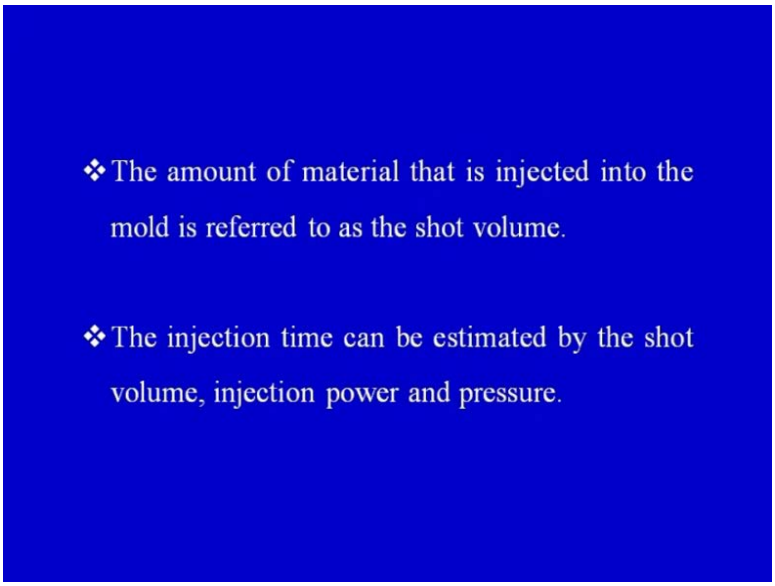

The amount of material that is injected into the mold is referred to as shot volume. So, this is another term that is coming into picture that is shot volume. So, the amount of material that is injected into the mold that is one shot. If one piston in one stroke of the piston, how much material is entering into the mold cavity, so that it may be term as the shot volume, the amount of material that is injected into the mold is referred to as the short volume. The injection can be estimated by the shot volume injection power or pressure. So, we can see that how much time would be required or how much injection time would be required, and it it will be depend on the shot volume the injection power and the pressure. So, all these are important point when we are going to optimized our injection molding process for our specific plastic material and for our specific product.

There are other parameters also which has to be taken it account the complexity of the final product, the size of the final product that characteristic physical and chemical properties of the plastic that we are processing. There would be a large variety of criteria which has to be taken into account while we are going to optimize the injection molding process for our specific product. So, they this particular points highlights only we can

say some of the important aspects which have to be taken into account when we are indicating or when we are advocating the used of the injection molding process of our particular product.

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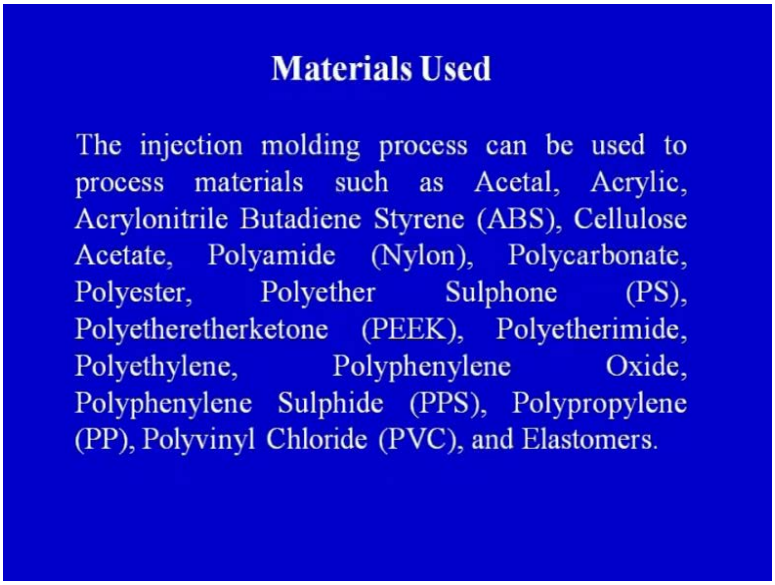

Now, what are the various type of material used this. This gives a long summary of material that can be used, but just I will read few of the important material which can be used the injection molding process can be used to process material such as acrylonitrile butadiene styrene - ABS which is written on your screen. Nylon, it can be used for polyphenylene sulphide or it can be for polyvinyl chloride. So, different types of plastic can be process by the injection molding process.

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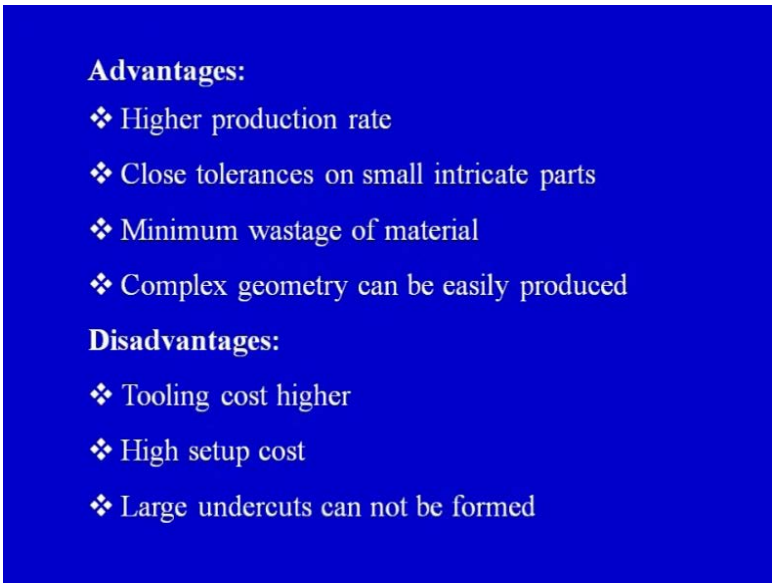

Now, let us come to the advantages and disadvantages of the process or the limitation of the injection molding process. Now what are the advantages? On your screen, you can see it has already been highlighted that the injection molding process can be used for a very high production rate. If you see the cycle time are very short and large number of product can be made in a day or in an hourly basis. So, the production rate of injection molding is far far high as compare to other processes that we have seen in the processing of plastic. Another important advantage is close tolerances on small intricate parts can be achieved. So, what does this means that there are two important points in this particular highlights that is close tolerances can be achieve that is one important point.

Second is small intricate part can also be process why because we injecting the raw material that is the plastic in this particular case at in at high pressure. So, the name also is injection molding. So, we are injecting the raw material into the mold cavity at high pressure. So, it means that the raw material can be supply to fairly intricate products as compare to the other processes. So, the minimum wastage of material is there because the metered amount of material is entering and finally, we are pushing the required material into the mold cavity. There would be some material left in this proof which later has to be cut off, but still the amount of wastage of raw material is minimize in case of the injection molding machine.

Complex geometry can easily be produced which I have already highlighted in point number two that intricate part or intricate product design can be achieved with the help of injection molding process. So, once again I am going to read what are the important advantages of the injection molding process. You can see higher production rate can be achieved, close tolerances with small intricate parts, and minimum wastage of material and complex geometry can be easily process.

But still there are few disadvantages that is tooling cost is higher. The amount of mold or the dye which is used for injection molding machine is very very high because it has to have certain specific arrangement as one of the arrangement we have seen that is the ejector pins which are operated mechanically. So, we have the cost of the tool which is high that is one of the limitation. The total setup cost is also higher as compare to the other processing technique for plastic that is another disadvantages which is related to injection molding, because we need to have a complete injection molding unit where we need to have a temperature control. And there can be other important aspects which are also important which are other control variable which have to be control for the effective and efficiency utilization of the injection molding machine.

So, there are a large amount of control parameter or control variables which have to be control and therefore, the cost of the injection molding unit is we can say higher as compare to the other processing technique which are used for processing of plastic and the large undercuts cannot be formed. Yes, there are few limitations in term of the product design or the geometrical features of the product design like one of the limitation shown on the screen that is the large undercuts cannot be made with the help of injection molding machine. So, although the process is widely used it can be used for large variety of material it has got we can say number of advantages, but certainly there are few grey areas where still efforts are required in order to further improve the application spectrum of the injection molding process.

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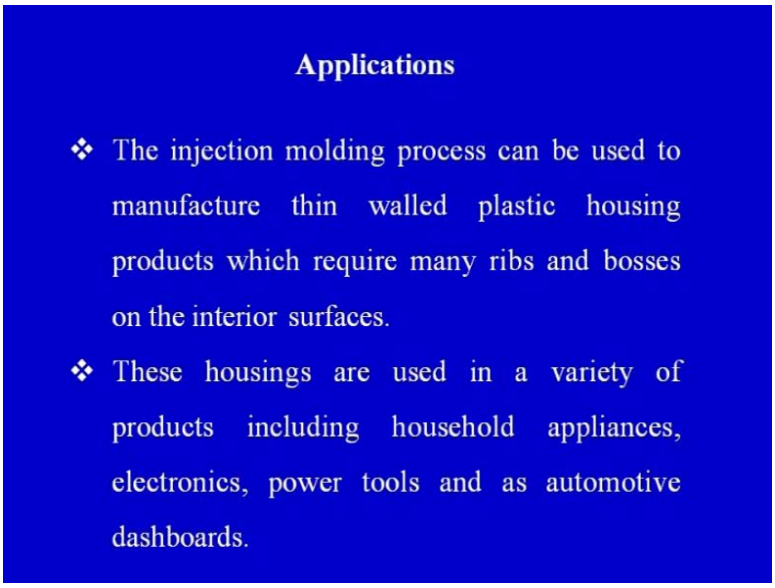

Now, coming on to the application areas that what are the important applications of injection molding. The injection molding process can be used to manufacture thin walled plastic. Such as you can say which required many ribs and bosses on the interior surfaces. Now suppose we want to have a drilling, drilling gun, hand drill in which we want to have a casing or plastic casing in inside the we can say body of the gun there would be so many ribs and so many additional attachment. So, it is a complicated product or plastic we can say housing of a hand drill which can be made by a injection molding process. So, the injection molding process can be used to manufacture thin walled where the cross sectional thickness or the thickness is less thin walled housing product which required many ribs and bosses on the interior surfaces. One examples I have given the housing which can be a plastic housing which can be used for housing the a hand drill.

Second important application is this housing are used variety of products including household appliances, electronics power tools and as automotive dashboard this I have already explained. The hand drill can be one of the power tool which is used and which is used for which which is uses for the housing plastic housing which can be made by the injection molding process. So, injection molding as in this two points we can just summarize this that it can be used thin walled section or it can be used for thin walled plastic housing product.

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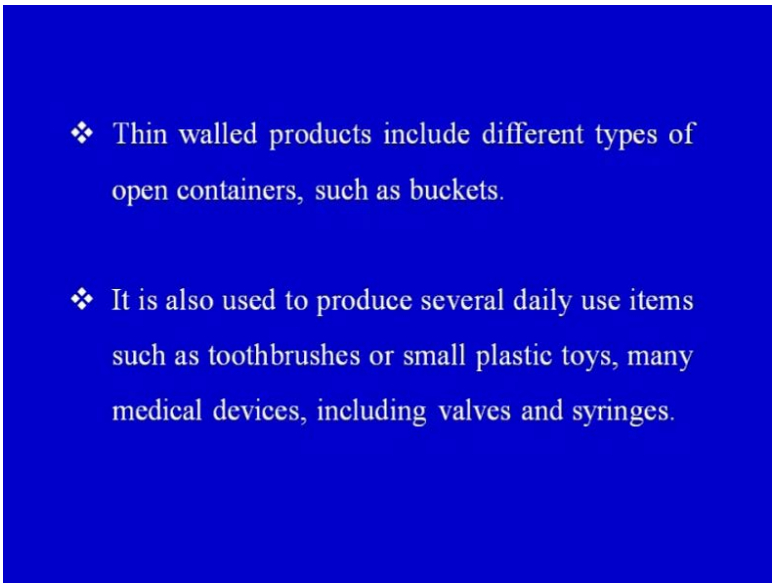

So, as we have seen injection molding can be used for thin wall product include different types of open containers such as buckets. So, in today lecture only in the very beginning I have taken this example that buckets can be made, mugs can be made by the injection molding process. There can be other examples where thin section of plastics can be made and this is the most suitable process for processing those plastic part. And finally, on your screen, you can see it is also used to produce several daily items such as toothbrush or small plastic toys many medical devices including valves and syringe which i-i have already indicated.

In the very beginning of today lecture that syringes can be made by injection molding process. So, this is just this particular examples are just an overview of the applications spectrum of the injection molding process, there are large variety of products which are made by injection molding and which we see all around us in our day. Today we see a large variety plastic product around us and many of them are process by the injection molding process. So, as the engineers the information of knowledge about the injection molding process is very very important and that was the basic idea of having this particular discussion on injection molding.

So, with this we come to the end of today lectures that is on injection molding, this particular lecture has been covered in module number four that is processing of plastic under the course processing of non metals. So, what we have covered today, we have

covered the basic process of injection molding, I have drawn a very simple diagram you to just represent the working of the injection molding process. We have seen that broadly stages can be classified into four that is first stages is the clamping, in which the mold cavity closes down or the mold closes down to form the mold cavity. Second stages is the injection, in which the raw material which is available in the form of powder or pellets is push by the cylinder piston and cylinder type of arrangement into the mold cavity. So, the raw material it is heated, it is melted and it is push through the nozzle into the mold cavity, and once the plastic has filled the mold cavity, it is allow to cool their once the cooling process has been completed the two mold half which have clamp together. In the very first stage of clamping, now open the final product which has cool is attached to the movable half of the mold the movable half of the mold move away. And finally, there are ejector pins which eject the final product out of the mold cavity or it pushes it away from the move ejector pin pushes the final product away from the movable half of the mold.

So, basically there are four stages. First one is clamping of the mold, second one is ejection of the raw material into the mold cavity, third is the cooling in which the final product cool inside the mold cavity, and finally the ejection were the final product is push out from the movable half of the mold with the help of ejector pins. And then we have tried to understand that what are the important advantages and limitation of the injection molding process. And finally, we have seen only few application areas of injection molding, and I have told that there are large variety of product which are made by the injection molding process. So, with this we finish our discussion on injection molding. In our subsequent lecture, we would focus our discussion on thermo forming aspect and some of the other processes which can be used for processing of plastic.

Thank you.