Processing of Polymers and Polymer Composites

Dr. Inderdeep Singh
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture – 13
Blow Molding

[FL] friends. Welcome to our session 13, in our course on Processing of Polymers and Polymer Composites. If you remember in the previous sessions we have discussed various processes that are used to make products out of plastics or polymers. In the series today, we are reaching or concluding with a process called blow molding. Why I am saying concluding, because, we have covered number of processes that are used for processing of plastic parts and I have tried to summarize whatever we have covered in one slide that we will be covering today towards the end of our session.

But, today, we will be ending our discussion on processing of polymers and in subsequent session we will be focusing on the processing of polymer composites because the polymers have their strength for specific applications. But for a number of engineering applications we need to reinforce them with certain additives, certain fibers, certain reinforcements and then we get another material that we call as a composite material and we will start our discussion of composite material in the next session. So, we are concluding today, with one of the most important widely practiced process for processing of hollow plastic parts that is called as blow molding.

If you remember, we have already covered rotational molding. Now some of you may be wondering, what can be the difference between rotational molding and blow molding. Because, in rotational molding also we have discussed that it is used for making hollow parts, large in size and blow molding is also used for making of hollow parts axis symmetric parts.

So, if we can try to differentiate between the two, in rotational molding we will use a very large size mold, so, it will be used for making a large sized product. For example; the overhead tanks that we have at our houses, overhead water storage tanks specifically, they can be made by the rotational molding process, whereas, in case of blow molding process, our size of the product will be smaller. In case of rotational molding process, if you remember, there was minimum pressure required. The heat or the temperature was

more, pressure was less. So, we used to input the raw material inside the mold cavity and then we were rotating the mold into principle axis, the horizontal axis and the vertical axis, the mold was rotating or we were giving a rocking motion to the mold, so that, the molten plastic inside the mold is well distributed at the inner wall of mold.

And finally, even during the cooling process also, we were giving rotation or rocking movement to the mold, so that, the material solidifies inside the mold and finally, we were opening the split mold and taking out the final product. That was the basic principle of rotational molding. So, there was no external pressure required; only the rotation of the mold was leading to the distribution or the spread of the molten plastic at the inner walls of the mold.

But specifically, in blow molding, as the name suggest because this processes have been named based on the fundamental principle that is used for forming the plastic. Let us take the example of injection molding. Why the name injection is coming into picture? Because, we are injecting the molten plastic through the nozzle into the die, so, injection can be through a plunger or a ram type arrangement, it can be through a screw type arrangement, but injection of the molten plastic is taking place and therefore, we name the process as injection molding. Rotational molding the mold is rotating about 2 principle axis rotational molding.

So, from these 2 examples, let us see why blow molding and before going to blow molding let us take another example that is transfer molding. In transfer molding some transfer has to take place. Now, what is the transfer? The transfer is the transfer of the molten plastic from the transfer port through the screw into the mold cavity.

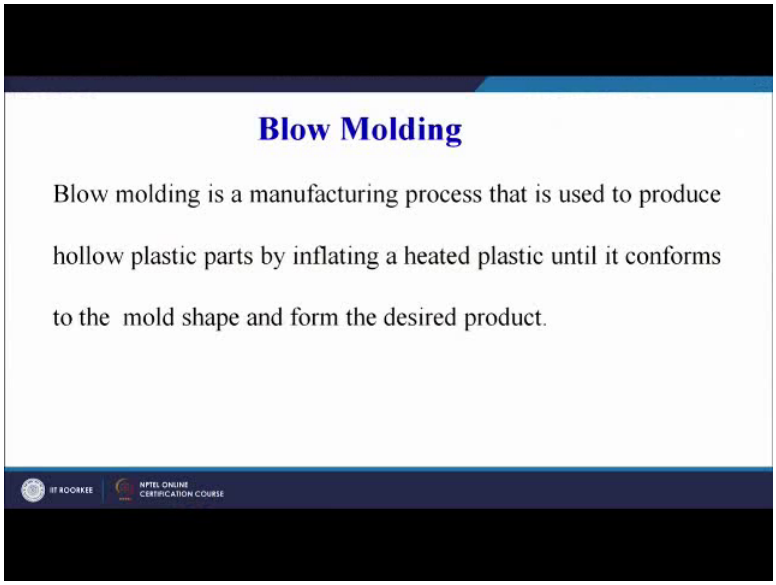
So, at least 3 examples we have taken injection molding, rotational molding, transfer molding. Let us take another example, compression molding. Compression, we are applying the compression force. The names are coming out from the basic mechanism involved in the process of deforming the molten plastic into the desired shape.

So, here you consider blow molding. Now blow molding means we have to blow the air like usually blow the air by our mouth. So, that is the principle of blowing. Here also, the plastic will be deformed by pressurized air and the plastic will be pushed towards the valves of the mold and it will take the shape of the mold.

So, whatever we study, whatever we learn, we have to take into account that why we have to always answer why, that why this name is given and once we are able to understand, appreciate that why this name is given we will never forget the process throughout our life. So, blow molding means there will be a mold and we have to blow something. Now that blowing thing is the air; pressurized air and that will force the plastic against the valves of the mold and the plastic will take the shape of the mold. So, that blow molding procedure we are going to understand today. We are going to understand it with the help of diagrams; we are going to understand it with the help of animation.

So, that it becomes clear in our mind, throughout our life we remember that what is the process of blow molding. Even if we see a plastic bottle we should be able to we explain that how this process has been made. So, that is the basic fundamental, we can say objective of today's session that is blow molding session let us now go step by step.

(Refer Slide Time: 06:46)

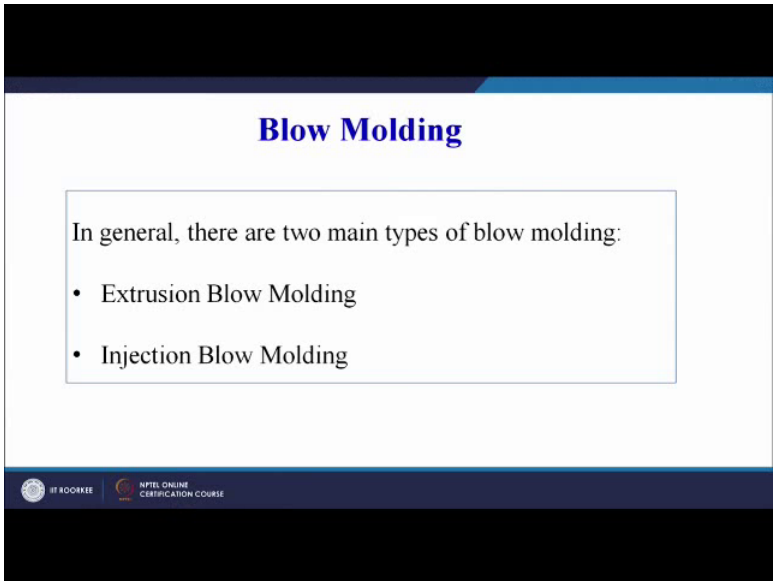


Now, what is blow molding blow molding is a manufacturing process that is used to produce hollow plastic parts. First thing we should remember, the application why this process has been developed that is used to produce hollow plastic parts by how that is done, by inflating a heated plastic. So, inflating means we have to blow we have to inflate it, we have to inject air inside, so that, the plastic inflates and takes the shape of mold until it conforms to the mold shape. We will apply the air pressure in such a way

that the plastic is forced against the inner valves of the mold and sticks to the inner valves of the mold and then it will form the desired product.

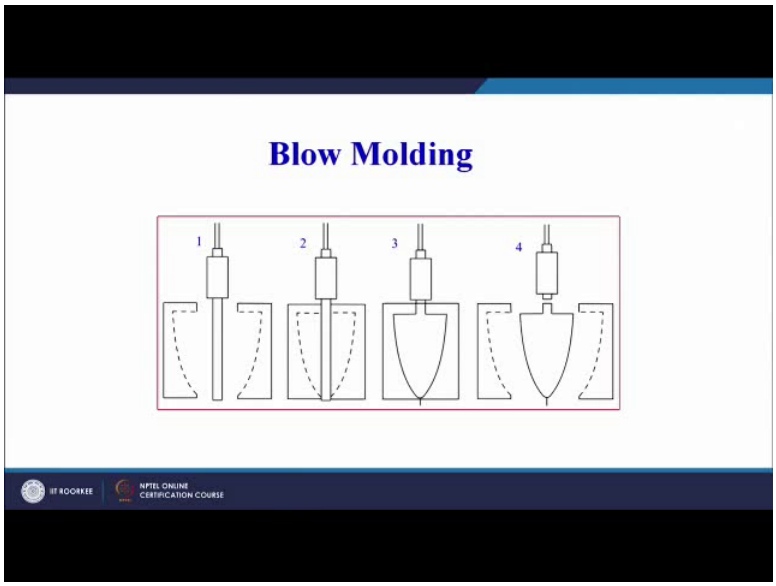
So, there are 3 important things first is a raw plastic material which usually called as a parison, then we are injecting pressurized air inside, it is blowing like a balloon and then it adhere outside to control the shape of the plastic there is a mold and inside the mold is plastic you can see it gets inflated and it is forced against the inner parts of the mold and when the mold opens we get our desired product and before that there is cooling of the plastic. So that, it becomes sufficiently rigid and solid; so that, it do not deform once the mold has opened. So, that is the basic principle of blow molding process. I think you will be able to appreciate it better when you see the diagram.

(Refer Slide Time: 08:18)



So, blow molding process can be broadly be classified into 2 categories; there can be other classifications also. These 2 classifications are extrusion blow molding and injection blow molding. Now, these 2 classifications are based on the raw material that we used for extrusion process. So, the parison, p a r i s o n, is used as a raw material in blow molding and the method for making the parison. If it is extrusion then we call it as extrusion blow molding and the method of fabrication or processing of parison is injection molding, in that case we will call the blow molding process which uses a parison made by the injection molding process as the injection blow molding process. So, they are combination of 2 processes.

(Refer Slide Time: 09:06)



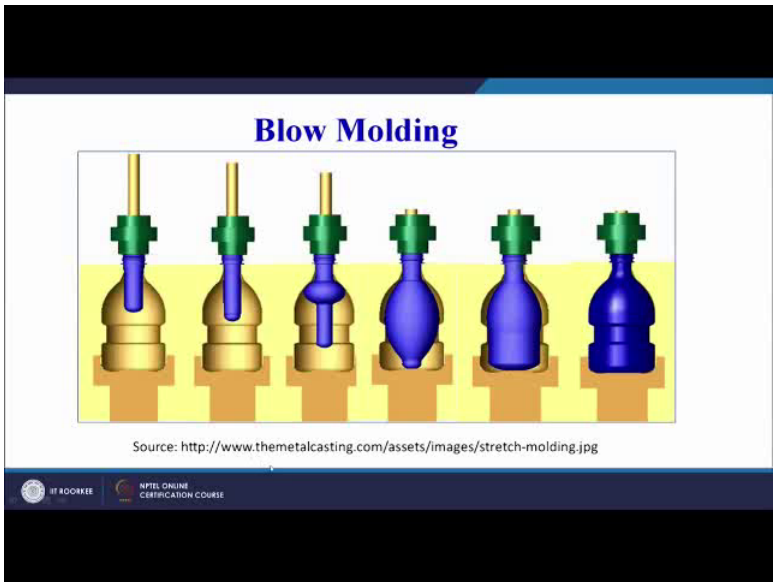
Now, most simplistic diagram is given, a schematic on your screen. So, you can see initially this is the shape that the dotted portion is the inner part of the mold and this is a shape that we want to make this inner portion. And this is split mold; this is one half of the mold and this is another half of the mold. Through this pipe we will have pressurized air that will come inside and this is the parison or the raw material that can be made by a extrusion process also, this can be made by injection process also. So, this parison is hollow and it is open from here, so air can be pressurized through this particular nozzle into this parison and the parison will blow.

So, the second stage is, we can have pressurized air. The mold has closed in this case. Here, you see the mold is open. Second stage mold has closed down and we get our final cavity or the final replica of the product that we want to make. So, this is a hollow cavity. Third; air pressure from top, the parison you can see here blows and takes the shape of the cavity inside the mold and finally, the mold opens and the product is taken out. So, this is our final product.

We can see pressurized air is used in this case and if you remember and if you have attended or heard to the discussion in the case of extrusion process, there was a blown film extrusion process; in which there was again this pressurized air was used, in order to blow the plastic and then finally, there was a you can say breaker in which the 2 films got collected.

So, that was similar type. Here also pressurized air is used, but here, we are making a hollow product. There, after going there were breakers, so, the 2 films were again combined together and we were able to make a film. It was a blown film extrusion process, there also pressurized air was used, here again pressurized air is used, but to blow the parison as per the desired shape of the product. So, this is the basic working principle of the blow molding process.

(Refer Slide Time: 11:29)

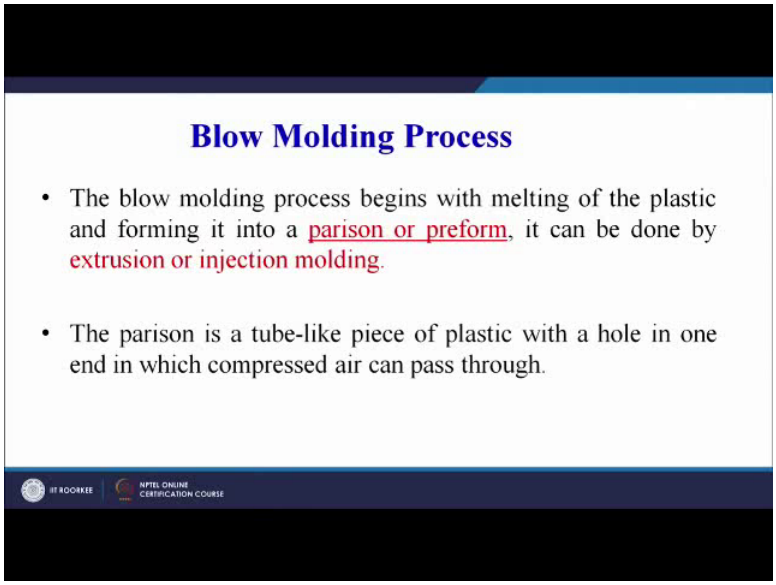


So, here you can see another diagram 3D, which is much more explanatory as compared to the previous one. The source is given, themetalcasting.com on your screen. The name of the processor stretch molding. I think the basic principle remains same. This blue color is the raw material this is called parison and through this section we will have our pressurized air. So, this is the first stage. The second stage it has started to blow, you can see the size difference between this and this, and finally, when the air pressure is maintained, it further blows next stage and the final stage. It finally, takes the shape of the bottle.

So, this is the basic principle of blow molding. The mold will first close. There is a parison raw material which is there inside the mold. Pressurized air is supplied from the top and then it gets inflated in sequential or stepwise manner and finally, takes the shape of the final product.

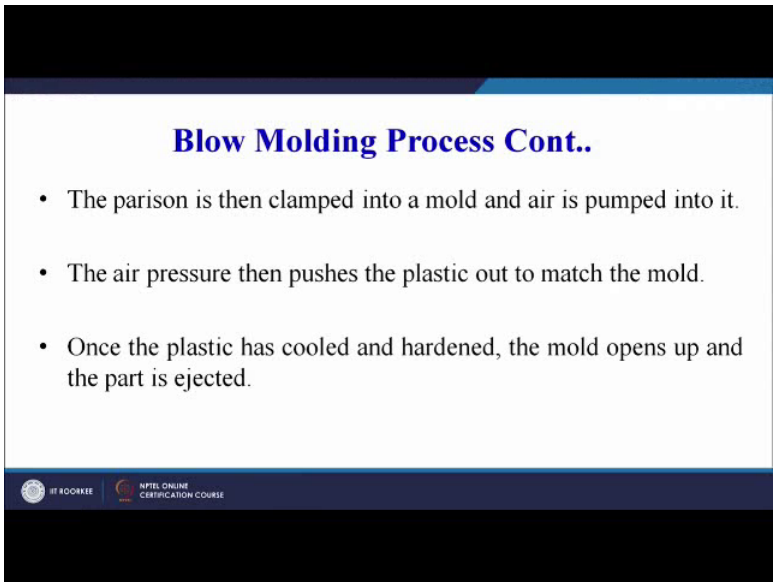
Now, whatever I think we have understood from these diagrams let us read all these points to just strengthen our understanding.

(Refer Slide Time: 12:42)



The blow molding process begins with melting of the plastic and forming it into a parison or a preform; so that, blue color raw material, that is basically parison. It can be made by extrusion or the injection molding process. It can be done by extrusion or injection molding that is the first stage. The parison is a tube like piece of plastic with a hole in one end in which compressed air can pass through. So, it has to be open from one side and closed from the other side. The opening side will allow the air to pass through.

(Refer Slide Time: 13:16)

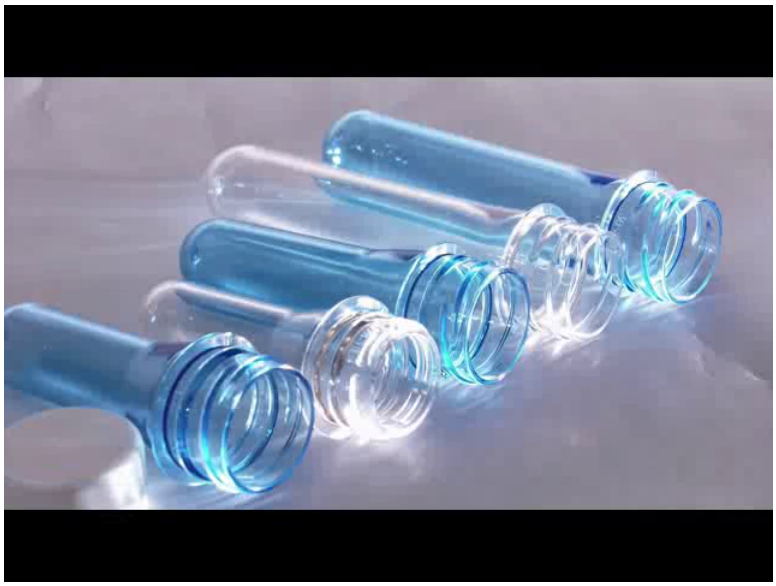


The parison is then clamped into the mold and air is pumped into it. The air pressure then pushes the plastic out to match the mold. So, I have already explained when it will inflate, it will go to the inner cavities of the mold, it will adhere to the inner shape of the mold.

Once the plastic has cooled and hardened the mold opens up and the part is ejected. So, this is as I have told you again a spilt mold type of process. Once the product has solidified, that has to be decided earlier, that we will see in the process parameters that we can control in this process. So, once the product has solidified the mold will open and our product would be released.

Let us try to understand the whole process with the help of a simulation. The steps will remain same whatever we have already discussed.

(Refer Slide Time: 14:19)

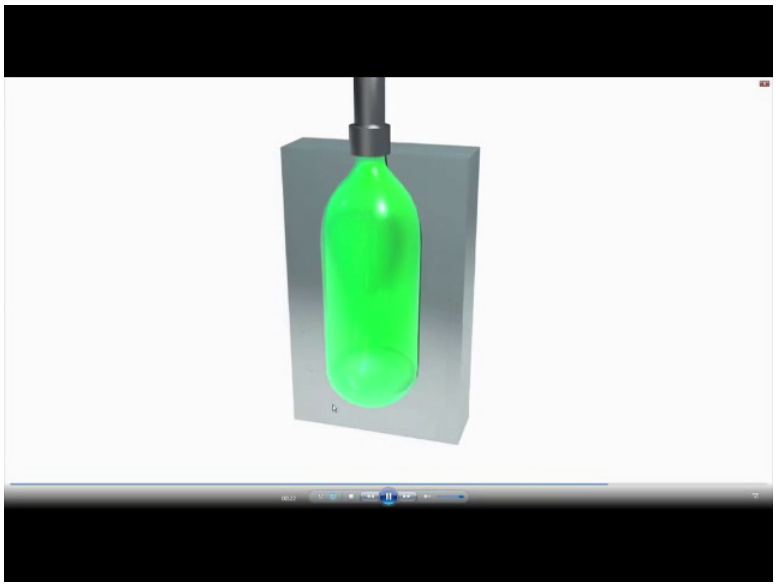


So, this is the material which is generally used polyethylene terephthalate. So, this is these are the parison the raw material that will be used to deform.

(Refer Slide Time: 14:23)

This is you can see the mold is already closed. This is a parison, air is coming from top and it is inflating the raw material.

(Refer Slide Time: 14:27)



It is adhering to the shape of the mold and finally, the mold will open and take the final shape.

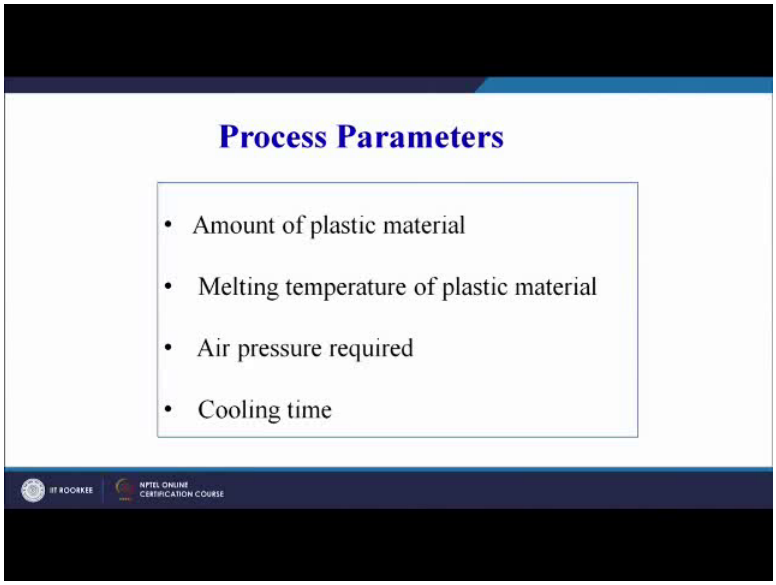
(Refer Slide Time: 14:39)

So, there you can see most simplistic the representation polyethylene terephthalate once again you can see the simulation.

There are number of such simulations available on YouTube. So, you can refer to them for better understanding and all the steps may be mentioned there; that is, from mold closing to the fixing up of the first will be the fixing up of the parison at the desired

position, then closing of the mold, then starting of air pressure and then inflation or may be blowing of the parison, sticking of the parison or maybe the parison then takes the shape of the mold, cooling process, opening of the mold and ejection of the final product. So, this is showing maybe the most important part that is the blowing of the parison and molten sorry the plastic taking shape of the mold. But, there are other steps also, afterwards also and prior to the blowing process also. So, you can see other videos which will give you even better representation of the blow molding process.

(Refer Slide Time: 16:10)



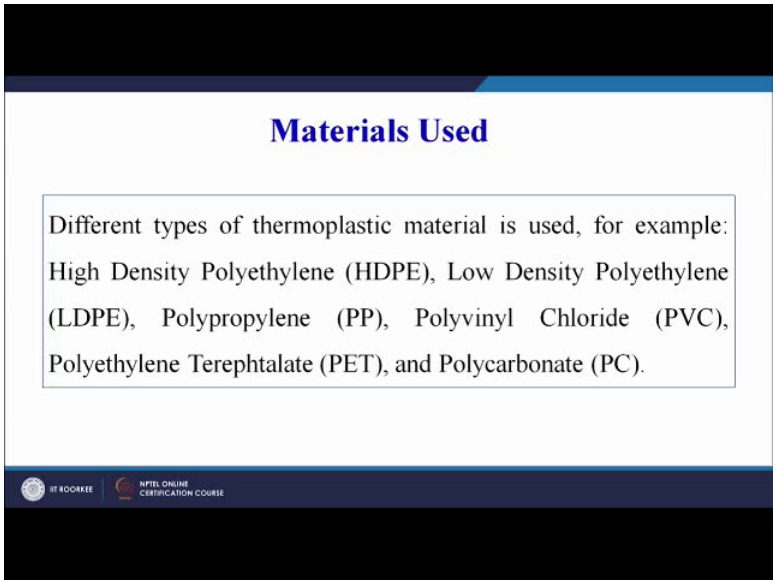
Now, what are the parameters that need to be controlled in this process? You can see the amount of plastic material that will definitely depend on the thickness of the parison, because, we need to see what will be the thickness of our final product. So, the amount of plastic material is one thing that is the raw material that we need to control that what type of parison should be made, the melting temperature of the plastic materials. So, these 2 are important from the manufacturing of parison point of view, because that parison once it is ready, then we have to just blow it and it will take the shape of the mold.

Air pressure required definitely. During the blow molding process we have to see, very high air pressure may lead to certain defects in the blow molded part and very low air pressure may leave the mold unfilled and the parison may not take the exact shape of the mold. So, the pressure has to be optimal and then as I was just discussing, the cooling

time, the period for which is the 2 halves of the mold will remain closed that has to be judiciously selected, because once the mold opens and the product is taken out form the mold, it should be sufficiently rigid and it should be sufficiently we can say solidified, so that, it do not deform after coming out from the mold. So, we have to ensure that during the cooling period the 2 halves of the mold remains closed and the product becomes sufficiently hard and sufficiently cool. So, that has to be taken into account.

Now, what are the materials used? One is the most common bottle; plastic bottles that we use mineral water, soft drink plastic bottles so that is already you have seen.

(Refer Slide Time: 17:52)



Polyethylene Terephthalate PET bottles, then this can process can also be used as for HDPE – High Density Polyethylene can be used, for Low Density Polyethylene, Polypropylene, Polyvinyl Chloride, Polycarbonate. So, different types of materials can be used as we have seen from the literature.

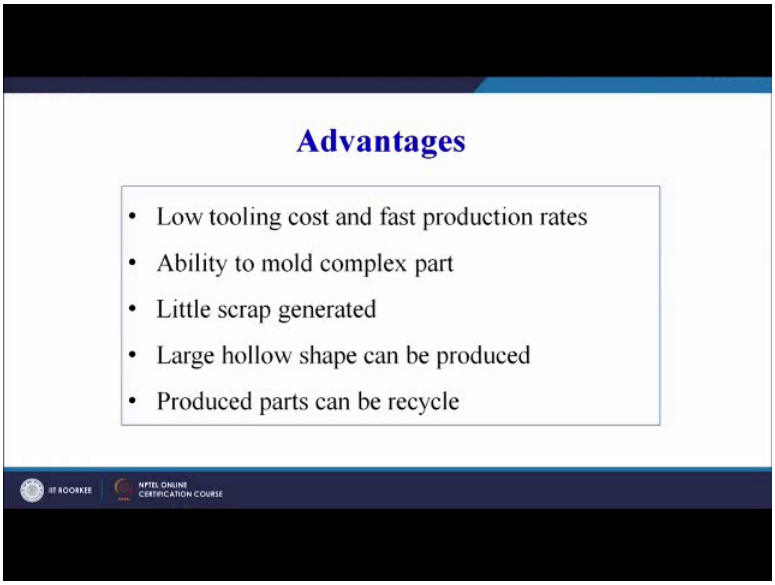
Now, what can be the advantages of this blow molding process? As you have seen it can be completely automatic process; so once it is automatic with no manual intervention, the fast production rates can be achieved. You can make hundreds of bottle per hour. So, that kind of flexibility can be there. So, may be different types of machines are there, blow molding machines are there with the different process capabilities, but the production rates are extremely fast in case of blow molding. As we have seen in rotational molding the hollow plastic parts that are made by rotational molding we have

seen the process cycle is may be extended. So, a lot of time is taken to make a product by rotational molding process, but in blow molding process that problem is not there it is a very fast process and the tooling cost is also not that high.

Then you have seen in one of the diagrams that very typical geometry of a bottle can be very easily made by blow molding process. So, the above it has the process has the ability to mold the complex parts or the complex products. Scrap generated is minimum. as you can see a parison is predefined, as we have already seen in the process parameters, that, we have to decide on the amount of raw material, we have to decide on the melting temperature of the raw material. So, we take decision prior to bringing the raw material to the blow molding process that what should be the thickness of the parison.

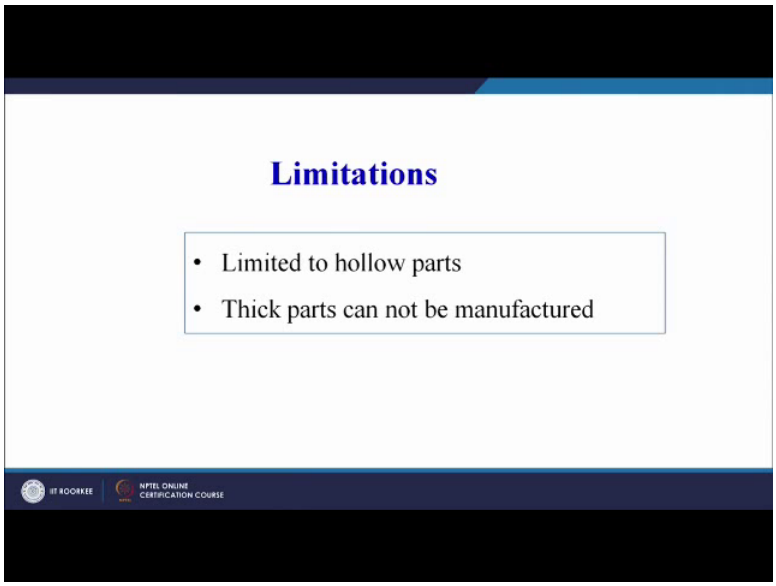
All those parameters are controlled. So, therefore, there is little wastage of the raw material. Only from the bottom side whatever is clamped between the mold that may have to be removed, that is one thing and from the top also a little bit of material scrap is produced. The little scrap generated, so, minimum wastage of raw material.

(Refer Slide Time: 20:10)



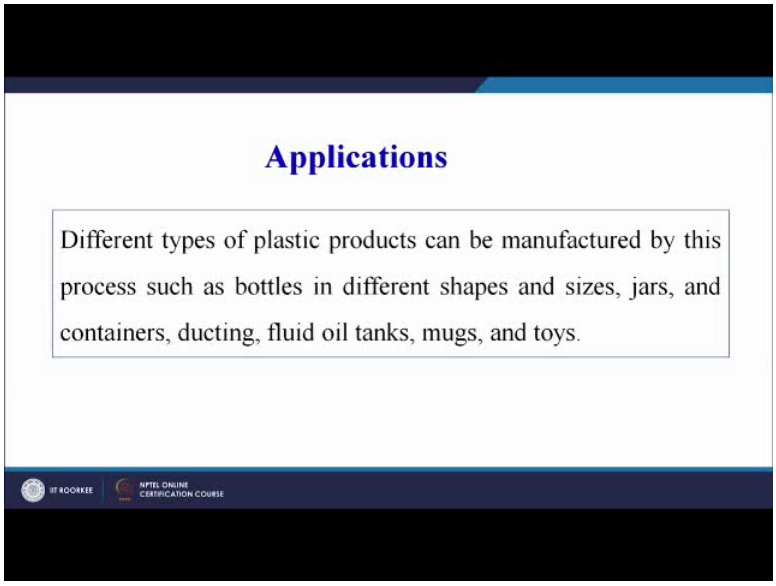
Large hollow shapes can be produced, but not as large as we can produce in rotational molding. Produced parts can be recycled. So, that that facility is also available and mostly is used for making thermoplastic parts.

(Refer Slide Time: 20:30)



What are the limitations of the process? Now, limitations; this process is only limited to hollow parts, thick parts cannot be manufactured. So, it is the thickness of the valve of the product that we are making if you see the plastic, soft drink bottles, the mineral bottle so the thickness of the part is not very large. So, the sheet thickness that is that we achieve that is not very thick in case of the blow molding parts. So, that is one limitation and another is that we can only make hollow parts using the process.

(Refer Slide Time: 21:13)

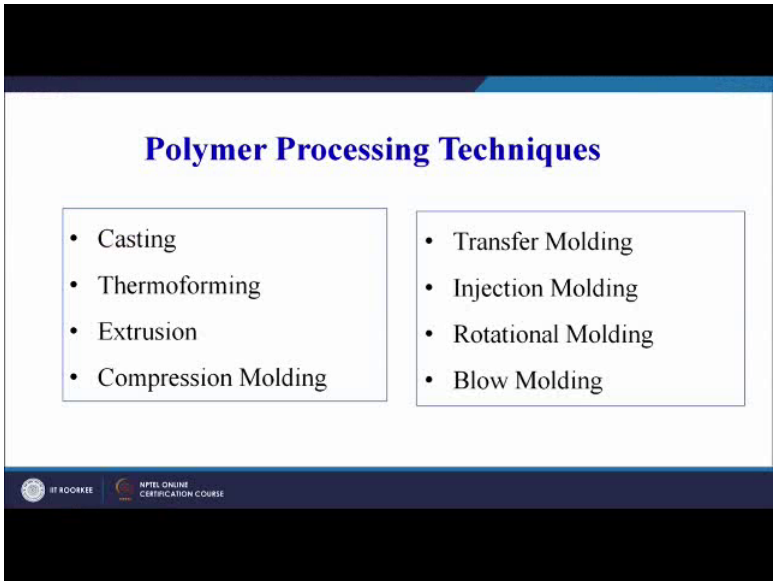


One of the applications is absolutely clear to all of you, as we have seen in the diagrams also, the simulation also or the animation.

Different types of plastic parts can be manufactured by this process such as bottles in different shapes and sizes as we have seen. You may be seeing number of plastic bottles for different products are coming; small size, large size, different geometries and then there may be a place for a gripping mechanism also. So, different shapes sizes can be produced. Only thing we have to design is the mold. So, the plastic will take the shape of the mold. So, whatever mold we design accordingly the shape we can produce. So, that is the beauty of the process, that we can produce different shapes using blow molding process.

Jars can be made, containers can be made, ducting, fluid oil tanks, mugs and toys. So, there are you can see there are number of engineering applications, non engineering, domestic, household applications that can are the product that can be made by the blow molding process. So, I think with this we have understood the whole process of blow molding. We have seen that which is the most commonly used plastic that is used for making of plastic bottles. In the simulation or the animation we have tried to understand that and we have understood that what are the advantages and limitations of blow molding process.

(Refer Slide Time: 22:40)



So, with this we come to the end of our discussion on blow molding just to summarize what we have covered, because, this is our course is divided into 2 broad areas; one is the processing of polymers or plastics and the another one is processing of polymer based composites. From our next session we will start our discussion on polymer based composites. So, today, I will just have a glimpse of what we have covered in polymer processing techniques and if you remember in the very beginning we have had little bit of discussion on the classification of plastics and what are the plastic what is the monomer and how what are the different types of monomers and how they polymerize to make a plastic.

So, all that we have covered in the very beginning, but from processing point of view as other courses on processing of polymers and polymer composites on your screen you can see the processes that we have already covered. We have a covered casting, thermoforming, extrusion, compression molding, transfer molding, injection molding, rotational molding and blow molding.

At least 8 different types of processes have been covered for the processing of polymers and if may be the learners, pay attention to what has been covered at least some fundamental knowledge related to plastics has been developed specifically related to the processing of plastics and I would advise that if possible you can look around and see the different plastic products and try to relate that this product may have been made by this process, may be by injection molding or by compression molding or by transfer molding. So, you can just have a look and I believe that if you know the fundamental, working mechanism and the applications of a particular process you should be, you must be and you will be able to identify that this plastic product must have been made by this particular process.

So, with this I think I will close the today's session and in future maybe in the next session we will start our discussion related to the polymer based composites and there are certain advantages that we definitely derive out of polymer composites over the polymers. So, our polymer products may have certain disadvantages that can be overcome by reinforcing them with different types of reinforcement.

So, we will start our discussion with the introduction to the basic concept of composite materials, then we will see that how composite materials can be characterized or how

composite materials, what are the properties of composite materials and finally, we will see what are the processing roots, processing techniques or manufacturing techniques that are specifically relevant to making products based on composite.

There is another topic which requires little bit of attention, that is, machining of plastics which is not discussed at the UG level and usually not discussed in the course curriculum of many universities. So, we will see that how the plastics can be machined or what are the techniques used for machining of plastics, when we will cover our topic on machining of polymer matrix composites.

So, the secondary processing part of polymers is remaining that is related to joining of polymers also. That also we have not covered. So, we have only covered that how the plastic parts can be made, how they can be joined, how they can be cut, how they can be machined that portion we have not covered till now. So, when we will go to the joining of polymer matrix composites, machining of polymer matrix composites there definitely we will discuss first that how polymers can be joined our machine and then we will switch the discussion to how polymer matrix composites can be joined and machined.

So, with this we come to the end of today's session on blow molding in our next session we will start our discussion on composite materials.

Thank you very much.