Processing of Polymers and Polymer Composites

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Lecture - 11
Transfer Molding

[FL] friends, welcome to session 11 in our course on Processing of Polymers and Polymer Composites. In the last ten sessions we have covered the basic aspects of plastics that is thermosets and thermoplastics. We have also seen the most commonly used processing techniques or processing methods or manufacturing techniques, for processing of polymers. We are covered casting thermoforming, extrusion, injection molding and try to cover up these processes with three or four factors in our mind that is that what is the fundamental working principle of the process, that is the first thing that we have try to cover.

Second thing is what are the application areas; although we have seen one or two slides each, but at least we get an idea that what type of products can be made by this particular process or a specific process. Then we have seen what are the advantages of that process we service other process for example, we have seen injection molding what are the advantages as compared do compression molding, we have seen; what are the advantages as compared to extrusion.

Similarly, we have covered limitations that each process or every process cannot be used for each and every type of product. It can be used for a specific category specific class of products only for example, compression molding can be used majorly for flat type of product in which we are working in x and y domain only and the z domain is limited to a particular thickness only. If we have a completely three dimensional product all three dimensions x y and z are in appreciable, may be numbers or appreciable dimensions in those cases our compression molding process may not be that useful.

Similarly, injection molding we have covered which is use for thin walled sections only if the thickness of the wall is too large we may not go for injection molding process. Similarly extrusion is used for long sections continues manufacturing of long sections or long products having a constant cross section, cannot be used for a variable cross sections; therefore, there are limitations of each and every process. So, why I am revising

this thing because now we are entering into the next stage, ten sessions already over we are entering into the eleventh session, today during these ten sessions we have covered number of processes starting from casting thermoforming, extrusion and injection molding.

Now, next process we that we are going to cover today is transfer molding, slightly modified form of compression molding, but specifically used for certain applications. So, what is the basic principle of transfer molding where this process is used what are the advantages what are the limitations and then we will try to understand the process mechanism with the help of a simulation or a video. So, let us start our discussion related to transfer molding.

Similar process of transfer molding is used for processing of polymer base composites also, that we will cover in our later part when we will discuss the processing techniques for polymer matrix composites or polymer based composite. And the process there is named as the resin transfer molding RTM and is a commercial process for processing of polymer based composites or polymer matrix composite, but processing of need polymers or processing of need plastics we are using the word transfer molding. So, sometimes the learners may get confused that what is the difference between transfer molding and resin transfer molding.

So, the basic principle as far as I know is the similar we have working principle, but we use resin transfer molding more often in case of composite parts, where the polymer is reinforced with certain types of fibers or certain types of continuous fibers. So, we will see resin transfer molding later, but today let us start our discussion with transfer molding process.

Now, transfer molding you can see on your screen.

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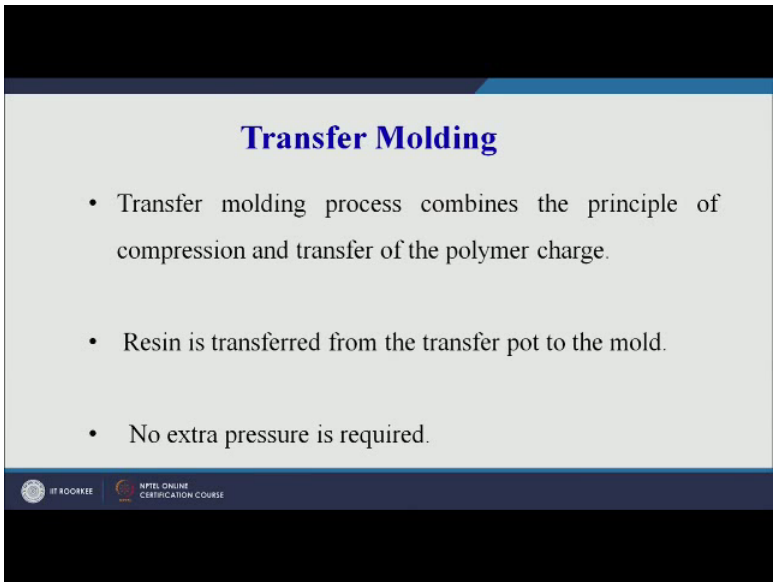

The transfer molding process combines the principle of compression and transfer of the polymer charge. So, as I have told you it is a slightly modified form of the compression molding process, and I think I was not able to emphasize in the beginning of today's session, we have also cover the process of compression molding in one of our previous sessions and therefore, this process we will see will be slightly advanced version of the compression molding that we have seen.

If you remember in the compression molding process we have seen there is a bottom half of the mold, and they are is a top moveable part of the mold and in between we keep our charge or the raw material and finally, when the two mold house close we control two important parameters, that is the temperature as well as the pressure that we are applying. And finally, we hold discharge between the two parts of the mold as per the requirement and after the holding time we open the mold and take out our product and there is a ejector type of arrangement that that gives a slight top on the part. So, that it is popped out or it is pushed out of the mold cavity. The cavity between the two halves of the mold conforms to the shape of the final product that we want to produce. So, that is the basic working principle of compression molding.

So, here also in this process we will have a split mold only two part mold, and the charge will be pushed into the mold and then finally, when the mold will open we will take out our product. Again I am emphasizing same thing I repeat number of time so that it gets

ingrained in your thinking process, that is the for any plastic processing technique three important parameters have to be taken into account.

We have to ensure the melting of the plastic we have to ensure the forming of the plastic into that desired shape. And we have to ensure the cooling of the plastics so that it takes the desired form. So, that is again going to happen in transfer molding process also and if you see on your screen, it is a slightly modified form of compression molding and here as the name suggests transfer molding. So, what is going to transfer in this case that may be a question in of interviews for all of you that transfer molding what is being transferred.

So, what is what we are transferring here is the polymer melt. So, we will melt the polymer and then we will transfer it into the mold cavity. Now injection in injection molding process also we are injecting the polymer into the mold cavity. So, that can also a maybe we can say that transferring of polymer melt is taking place there also, but in that case the process is slightly different, but here the melt will be transferred with the help of a plunger arrangement into the mold cavity and that we will try to understand here.

So, the resin transferred from the transfer pot to the mold. So, we will see in the diagram what is the transform pot, where the charge or raw material is stored, how it is heated and how it is pushed through to the mold cavity through the sprue. In this case no extra pressure is applied. So, if you see in injection molding we apply the pressure through the rotating screw and the molten plastic is pushed into the mold cavity through the nozzle, but here we are not applying any additional pressure, only the plunger will apply may be a little bit a force may be its own the force bites wait only there is no additional force or pressure that we are applying, it is the weight of the plunger that may force the plastic through the sprue into the mold cavity.

So, additional pressure may be pneumatic or hydraulic pressure we are not applying in case of transfer molding. A very simplistic representation of the transfer molding process on your screen, we can see here there are heaters.

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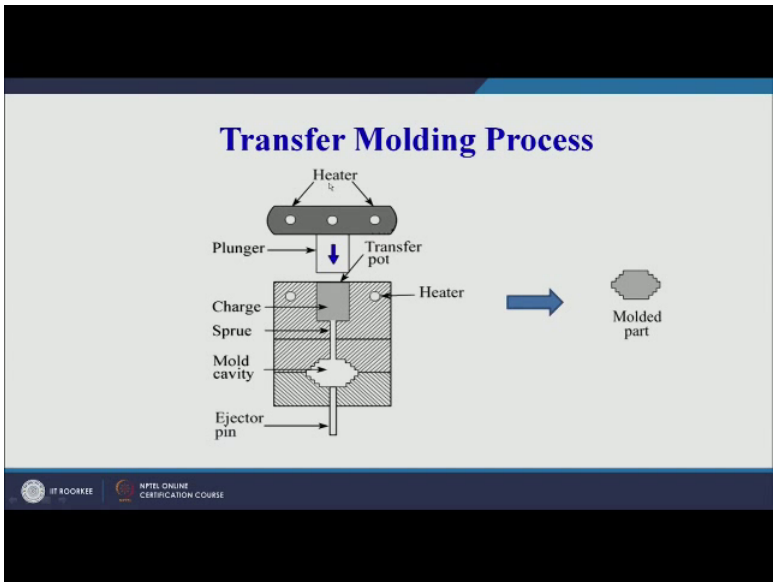

On these are the heaters here, these are the heaters this is a plunger, here we have the transfer pot and the raw material in the polymer melt form will be available here or we will put the raw material here and we will heat it so that it attains the desired viscosity that is desirable to push it through the sprue into the mold cavity. So, this is the place where we are keeping our raw material this transfer pot, there are heaters here because in every plastic molding process we have to supply heat in order to heat it to its a desired temperature.

So, the raw material is stored, heating arrangement is there and then this plunger comes down. This on your screen you can see this is the plunger that will come down this plunger will move in this direction and once this comes down this charge or the plastic molten plastic that is available here will you push down through this sprue into the mold cavity. Now here you can see the mold cavity is again into two halves; the bottom half and the top half. So, that is in two halves bottom and the top and how the product will be taken out. Once the process is over the top half will move up, and the bottom half there is a ejector pin here the product will be in the bottom half only and the ejector pin will give a slight tap on the molded part and the molded part will be pushed out and here you can see this is the molded part, this is the molded part that has been produced by the process of transfer molding process.

So, there are maybe three or four important steps in the transfer molding process on your screen, first step is the raw material is put in the transfer pot this is the transfer pot on your screen the raw material is put on the transfer pot it is heated with the help of heating arrangement, once it has attained the temperature for transferring it into the mold cavity as well as it is attained viscosity, it is pushed naturally by the using the plunger through the sprue into the mold cavity.

Now the two halves of the mold will remain closed until the complete curing of the product has taken place, once the complete curing has taken place the two mold halves will open the upper half will move away and the product or the molded part will stick to the lower half of the mold and finally, pneumatically or hydraulically we may use the ejector pin, to give a slide tap on the molded part and we will get our final product. So, this is the basic working principle of transfer molding processes now let us read it step by step.

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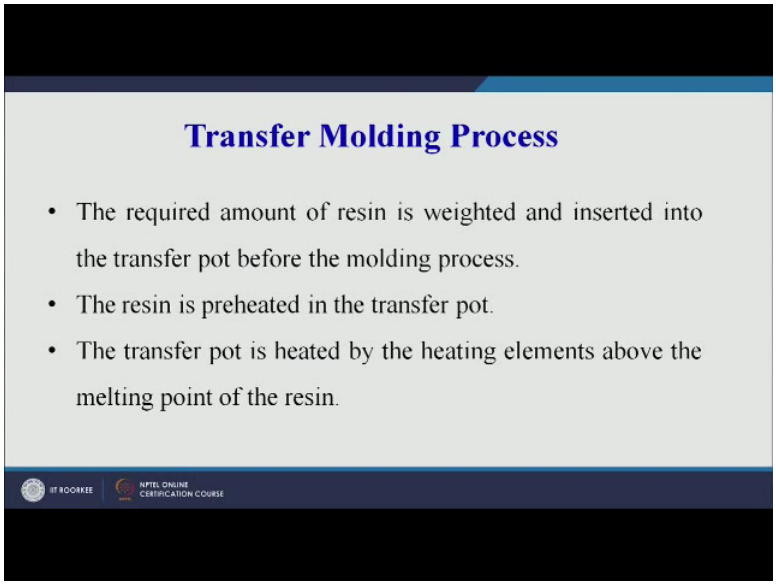

The required amount of resin or the polymer is wade and inserted into the transfer pot before the molding process.

So, we have to first introduce our raw material into the setup, the resin is preheated in the transfer pot, there up there is heating arrangement all around the transfer pot. The transfer pot is heated by the heating elements above the melting point of the resin. So, we have to heat the resin above the melting point of the polymer.

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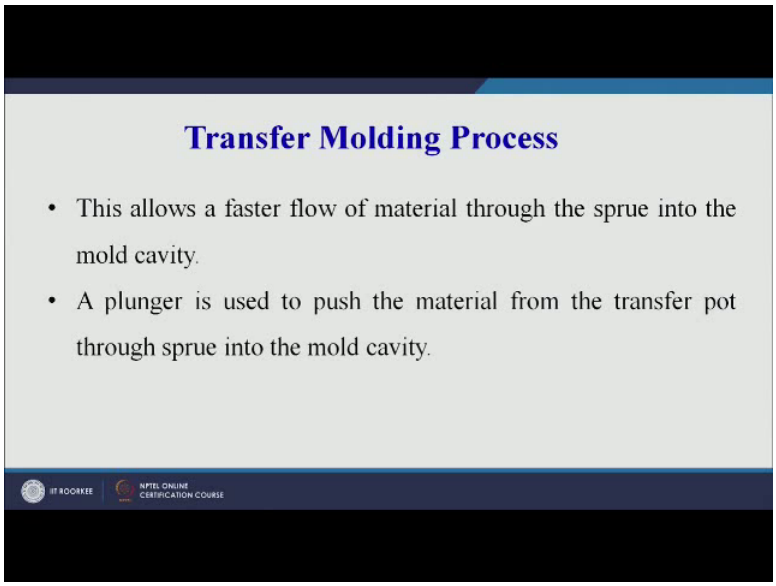

This allows a faster flow of material through the sprue into the mold cavity.

So, if we heat it above its melting temperature. So, it will allow for a smooth flow of the material into the mold cavity, a plunger is used to push the material from the transfer pot through sprue into the mold cavity as there is natural transfer of material. We are not applying any additional pressure. So, the plunger will only force this molten plastic material through the sprue into the mold cavity.

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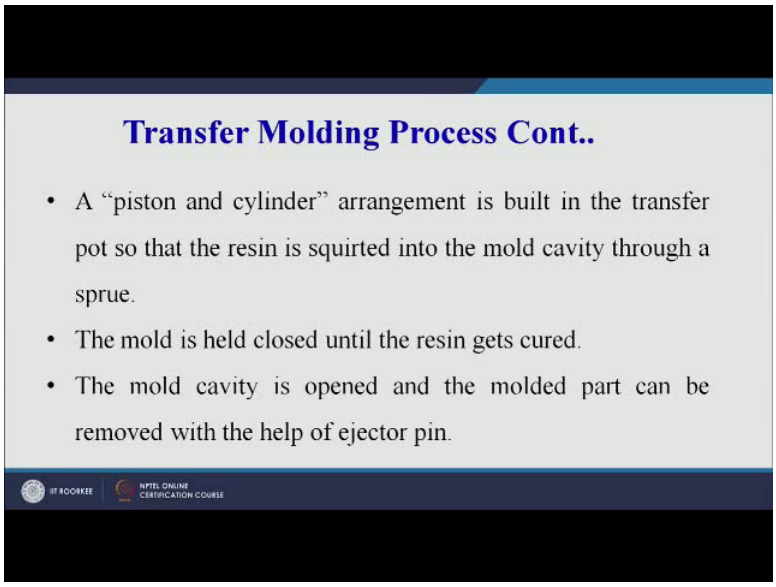

Piston and cylinder arrangement is built in the transfer pot. So, that the resin is quoted into the mold cavity through the sprue. In some cases we may have a piston cylinder arrangement also to transfer the molten plastic or the polymer melt into the mold cavity, certainly the plastic will travel through the sprue and before it enters into the mold cavity.

The mold is held closed until the resin gets cured, these I have already explained the two halves of the mold will remain closed until the complete curing of the molten plastic has taken place and it has solidified in to the final form of the product that is as per our design. Once the final curing has taken place the two mold halves will open, the mold cavity is opened and the molded part can be removed with help of the ejector pin the ejector pin will slightly give a tap on the product and it will be pushed out from the bottom half of the mold cavity. So, these are the steps involved or this is the basic working principle of the transfer molding process.

Now, let us us try to see or understand the process with the help of a animation that how the process operates the source of the video is also given it is again YouTube.

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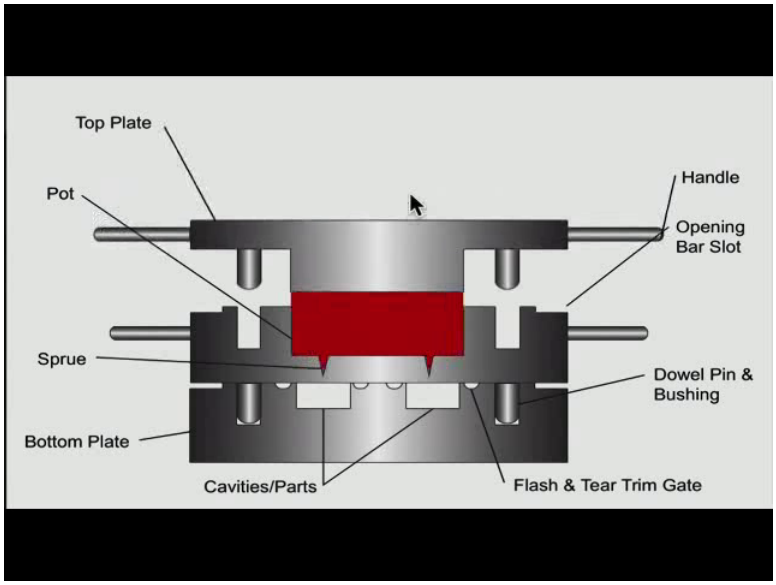

So, on your screen you can see again this is the movement of the plunger, then through the sprue the red color defects the charge or the raw material heating arrangement is also there and it is pushed through again it is maybe we can see it is pushed through and it

fills may be these are the cavity parts, these two are the cavity parts and the red color product is being made in this process.

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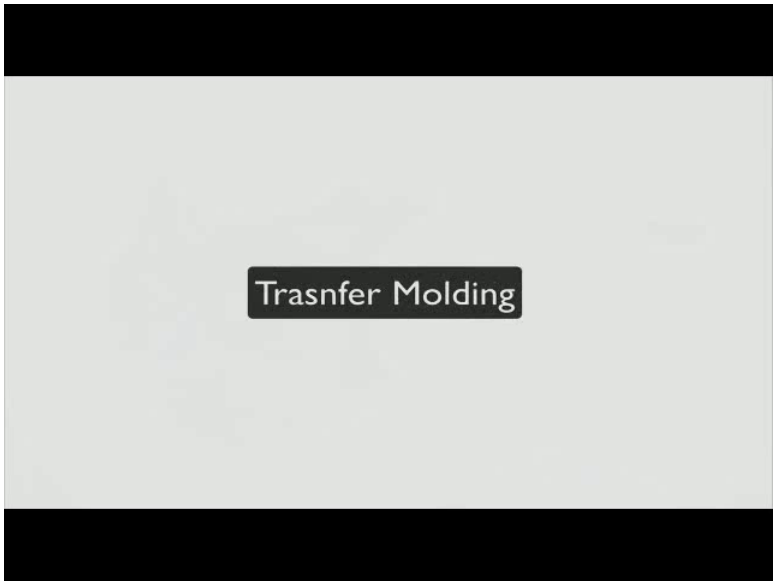

So, this is the basic working principle of our ejection molding sorry not ejection molding transfer molding process.

Now, as per our previous discussion, I think it is clear that how the transfer molding process will take place, the raw material will be in the transfer pot it will be heated the plunger will push this material through the sprue into the mold cavity, we have to keep the two halves of the mold cavity closed until the complete curing of the process takes place and once the curing process is complete we will open the mold, than the final part will be taken out with the help of ejector pin.

So, these are the four five basic sentence related to the working principle of the transfer molding process. Now what do we need to understand further a related to our process. In our previous techniques or processing methods that we have seen we also try to understand stand that this process is used for which specific type of material, we have tried to understand what are the advantageous of this process, we have try to understand what are the limitations of this process, we have tried to understand what are the application areas of this process.

Now once the fundamental working principle is known or understood we can then go forward and see that; what are the various process parameters that we can control.

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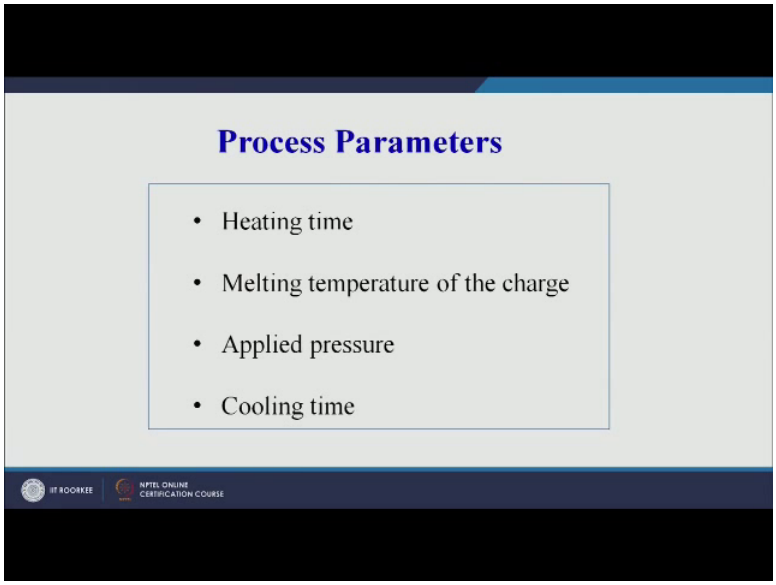

Now, in this case the important process parameters that we can control are the heating time, melting temperature of the charge, applied pressure and cooling time. Now applied pressure we have we have seen here is through the plunger and we can control the weight of the plunger and we can slightly very the applied pressure. We can control the heating time with the help of the heaters that we have supplied or we have applied all around the transfer pot, we can also control the melting temperature of the charge. So, these are the process parameter that we have to select judiciously intelligently so that our final product is made as for the requirement.

Now, what are the material for which the transfer molding process is successful on your screen, you have generally thermo plastics sorry generally thermo sets are processed by the transfer molding process.

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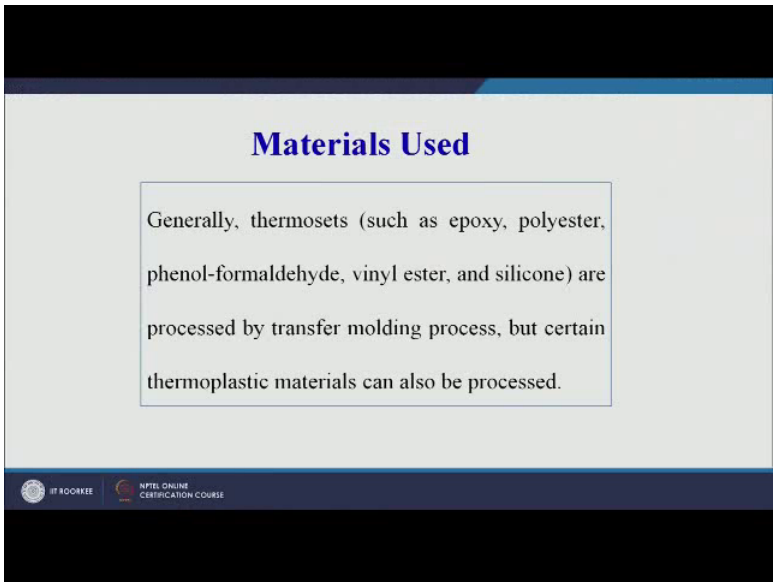

So, thermo sets such as epoxy, polyester, phenol-formaldehyde, vinyl ester and silicon are processed by the transfer molding process, but certain thermal plastic materials can also be processed. So, majorly this process is applicable for thermo sets and the applications can range from a different or a variety of products. That we will see in our subsequent slides that what can be the application areas for transfer molding process, but the raw material or the material of the products that we will make by transfer molding process is given on your screen, majorly epoxy polyester phenol formaldehyde are used as the raw material for making the product using transfer molding process.

Now, what can be the application area? So, let us look at the application areas of the transfer molding process.

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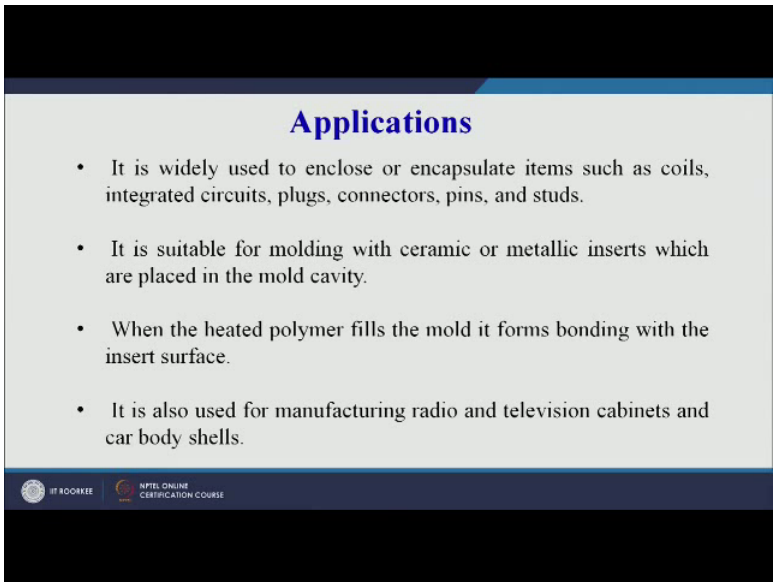

It is widely used enclose or encapsulate items such as coils, integrated circuits, plugs connectors pins and studs. Now some of you will wondering what is this encapsulation now encapsulation is that you have a part inside now for example, this is my part and I want to encapsulate it, I will I want to coat it or cover it with a plastic we can say boundary or a plastic surface what I can do I can melt my plastic and I can force that plastic all around the product whenever we travel by air at the airports many a time you wont to your suit case to be robbed by a plastic film so that it is safe during the journey. So, there also we put our baggage on platform and then it will rotates and raise a plastic films film all around the baggage. So, that is also we can say encapsulation of our baggage with the plastic film. So, that is basically the fundamental process of encapsulation.

Now, transfer molding is useful here in the contest, that we have a mold cavity. Now whatever we want encapsulate we can keep it inside the mold cavity, we have our polymer or plastic in the transfer pot and from there with the pressure being applied by the plunger we can push the plastic it will enter into the mold cavity, where the part that we want to encapsulate is already placed or already fixed now the plastic will only go to the space that is vacant the initial part that we want encapsulate is already lying there are as already been placed clear as per the requirement.

Now, the plastic will take the vacant space all around the part that we want to encapsulate and finally, we will get a product in which centrally there is a product centrally there is part which requires encapsulation and all around we have a plastic covering and specifically if you see integrated circuits plugs connectors spins electrical equipment usually we require insulation in terms of electrical insulation and all of us know that polymers are a poor conductors are bad conductors of electricity. So, for those kind of insulation we can use the transfer molding process, and this particular plastic will encapsulate all these may be electrical circuitry or may be electrical component for making them electrical shock proof. So, this process can be used for similar applications.

So, applications again I am reading the first point again, it is widely used and closed encapsulate items such as coils integrative circuits plugs connectors pins and studs. Similarly it is suitable for molding with ceramic or metallic inserts which are placed in the mold cavity. So, this metallic or ceramic insets can be pre placed inside the mold cavity located at strategy positions in the mold cavity and then we can force the plastic through the sprue into the mold cavity plastic will occupy all the vacant place or open spacing and will encapsulate these metallic or ceramic inserts.

Similar to the first point where we can encapsulate coils or integrated circuits when the heated polymer fills the mold it forms bonding with the insert surface or there can be a bonding between the insert and the plastic that we have inject that we have transferred from the pot transfer port through the sprue into the mold cavity. It is also used for manufacturing radio and televisions cabinets and car body shells. These are another applications of transfer molding process. Here you can see the applications of transfer molding process different types of parts can be made some may be spherical parts can be made, oval shaped parts can be made, cylindrical parts can be made.

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Now, the shape of the final product will definitely depend upon the type of or type or the shape of the mold cavity and encapsulation process can also be done maybe some metallic parts can be encapsulated with the polymer using the transfer molding process. So, this particular application of encapsulation can be used in our composite materials also. When we will make use when we will be discussing our resin transfer molding process we will see that we pre place or we will place our reinforcements in the mold before transferring the polymer through the sprue into the mold cavity.

So, our raw material will be a combination of two things that is a fiber that are already there in the mold cavity, the polymer that is there in the transfer pot after heating it after melting it we will push that polymer and it will go and it will be used as a matrix material in the composite our reinforcement is already placed in our mold cavity. So, the resin transfer molding process, then we lead to a composite part in which we a reinforcement in the term towing the form a fibers and the matrix in the form of the polymer, which we have transferred from the transfer pot. So, here also now maybe these are the important application and similar type of thing we have already studied in our exclusion process also, where we have seen the jacketing type of exclusion process in which of coil is coming from may be one direction and then the polymer is flowing and then they are catting combine and finally, we get a covered wire or a covered rod which we can use for our thermal insulation or can use for our electrical insulation purpose is over jacketing extrusion process also, can lead to in encapsulate encapsulation of the rods or the wires with the plastic layer on top of that.

So, here also depending upon the shape, because there we have seen the wire as a raw material only, but here different types, maybe if it is a flat surface we want to encapsulate it with the plastic cover that can be done in case of transfer molding process.

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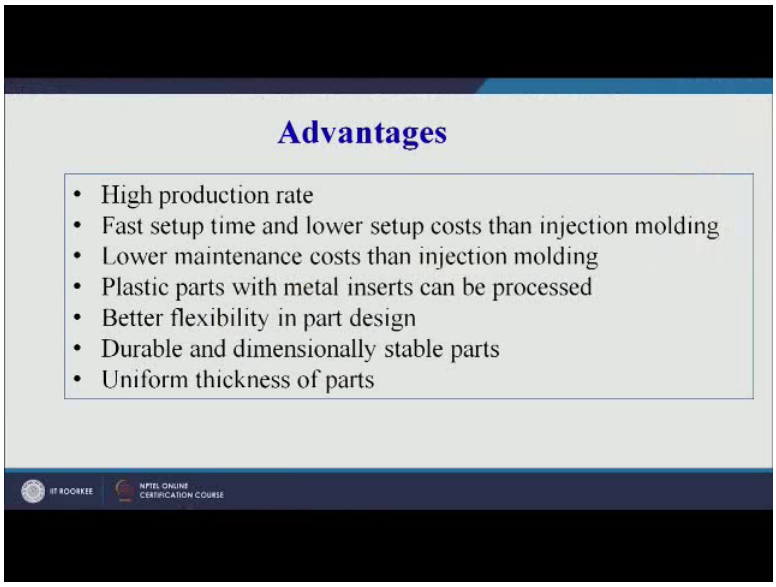

Now, let us quickly look at the advantages and limitations of transfer molding process; advantages on your screen high production rate as compared to the normal compression molding process, faster setup time and lower setup costs than injection molding. So, the machines or the transfer molding machines are relatively cheaper as compared to the injection molding machines, lower maintenance cost than injection molding. So, the running cost is also low plastic parts with metal inserts can be processed as we have seen the metallic inserts can be placed in the mold and then you can transfer the polymer form the transfer pots through the sprue to the mold cavity, and the they will be covered by layer of polymer or the plastic.

So, better flexibility in part design that is possible that will depend upon the mold cavity or the design of the mold durable and dimensionally stable parts can be made and uniform thickness of parts can be ensured using the transfer molding process.

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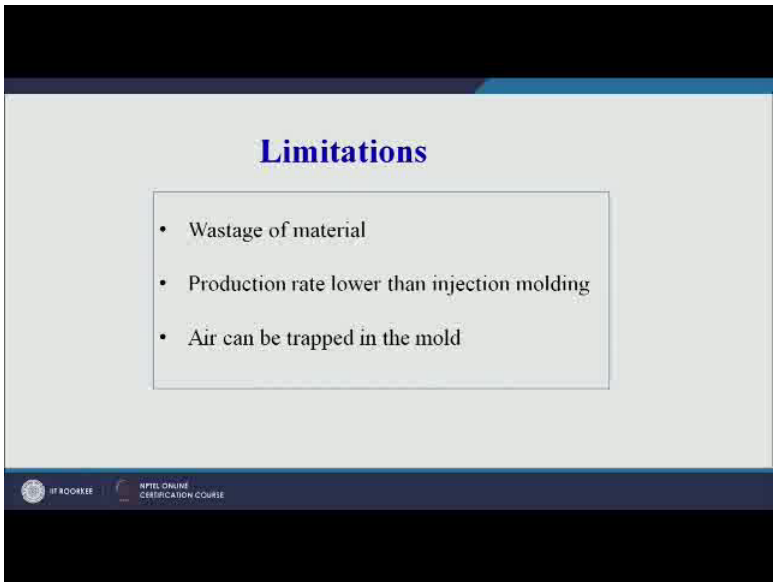

What are the limitations? Many times it may lead to wastage of material production rate lower than the injection molding, because injection molding is a commercial industrial scale process and even fully optimized you can get number of parts in the previous section on injection molding we have seen that cycle time may vary from two seconds to 60 second which means injection molding we can get a product every two second that is the capability of injection molding process, but this process may not be that fast moreover we have seen that this process is useful for thermo sets and thermo sets have a adequate range of curing time. So, therefore, this process will not be as fast as the injection molding process, because injection molding process is majorly used for thermoplastics which have to be cooled for making them solid. So, if you remember we have cooling coils all around the mold cavity we have to force the cooling of the part inside the mold so that our process cycle becomes quicker and faster.

So, it we cannot compare transfer molding in terms of the cycle time, as in comparison to injection .Injection molding of injection of the very fast process and transfer molding is a relatively slower process. So, the production rate in case of transfer molding will be less more over in case of transfer molding there are chances of air that gets trapped in the mold. So, these are the limitations of the transfer molding process.

With this we come to the end of our session on transfer molding. I think whatever discussion we have done today at least the fundamental working principle of the process

is clear to all the learners. We have try to understand it with the help of a video also as well as we have try to understand the advantage is limitations and application areas of the transfer molding process. In our subsequent session we will try to address another process that is used for processing of polymers.

Thank you.