Processing of Non- Metals

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Module - 4
Plastics: Properties and Processing
Lecture - 3
Extrusion of plastics

A warm welcome to all of you, in this lecture of on extrusion of plastics. We are covering a series of lectures on processing of plastics in module number 4 for our course on processing of non metals. We have already discussed two important aspects related to plastics in lecture number 1. We have seen what are thermostats and thermoplastics, we have seen the advantages and the little imitations of plastics, we have seen what are the various applications areas of thermostats, what are the various application areas of thermoplastics and we have tried to understand the basic difference between the two categories of plastics that is thermo sets and thermoplastics.

In lecture number 2, if you remember we have seen that we have seen what are the various mechanical properties that are important in case of plastics, we have seen the stress and behavior of a thermoplastic, we have seen how a plastic fails under the affect of loading. We have discussed one of the important processes, these are one of the simplest processes for making plastic products and the process was casting. We have also seen in our previous lecture, that there are three important words we should always keep in mind when we are discussing the processing of plastics, that is the heating, forming and cooling. I have given them H, F and C words or H, F and C alphabets.

So, H, F and C is heating forming and cooling. If you remember in casting we had only two infrastructural requirements that was to melt the plastic and to pour the molten plastic into a mold. So, there were two requirements; one was an equipment requirement to melt the plastic, and the other one was a mold, that was exactly duplicate of a exactly replicable of the final product that we want to make. So, basically in case of casting we need temperature, the forming is being, the heating is being done of the plastic that is H and then we are forming it that is giving it shape with the help of a mold that is forming.

Finally, when the plastic is there in the mold we allow it to cool, that is cooling process. So, all the processing techniques that we would be discussing for processing of plastics, would be having all these three types of steps, all these three steps one after the other. So, today our topic is a extrusion and extrusion word most of you might of you have already heard. In case of metals also extrusion is done. What are the different types of extrusions that is a forward or the direct extrusion, backward or the indirect extrusion, hydrostatic extrusion, impact extrusion. So, extrusion is not an new word but, extrusion of plastics is done in a slightly different way as compared to the extrusion of metals.

We have already we can say discuss that, we have two heat the plastic we have to form the plastic into the desired shape and finally, we have to cool it. So, these three steps would be similar in case of extrusion of plastics also, but also a process would be different from that that is done for the metals. So, in today's lecture we would be focusing on the extrusion process. Then extrusion has got some variants also, that is depending upon the specific requirement we may go for co extrusion or sometime it may be used for jacketing a plastic material over the wire.

So, we will see and try to understand with the help of diagrams, that what are the various process variants of extrusion specifically in case of plastic materials? We would not be discussing or highlighting the issues and challenges that are there in extrusion of metals because our course is focusing on extrusion of non metals. Now, right now right now we are focusing on module number 4; that is processing of plastics. So, today we would be covering the extrusion process specifically in context of the plastic materials. So, let us start our discussion with this introduction.

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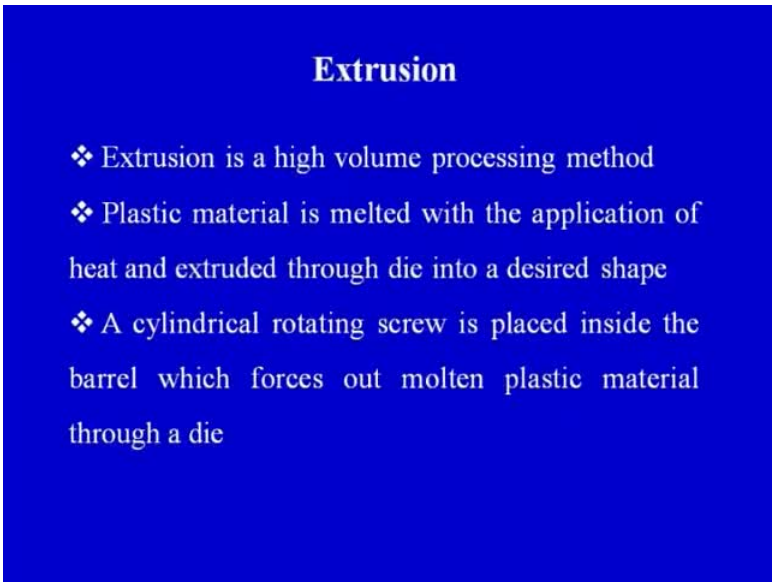

Now, it is extrusion? Although we will try to understand it with the help of diagram also but, what is extrusion? Extrusion is a high volume processing method. If you remember the last lecture on processing of plastics there were two important points that were highlighted related to the processing. That is that the processing technique for a plastic can be a continuous step technique, in which the product is coming out continuously or it can be a repeated cyclic type of processing, in which we may say 100 components per hour or 500 components in a day.

So, that is a discrete type of production, in which number of parts are being produced to processing of each part basically means one cycle. So, there are 500 cycles of processing in a day or else 5000 cycles processing in a day. But extrusion process is a high volume processing method it is a continuous processing method. Once the process has been started the raw material can be fed continuously and the output would also be a continuous output. Depending upon the rent or the size of the final job required or the final product required, we may have a cutting arrangement, which vary automatically cutting the final product into the desired lengths.

So, extrusion process is a high volume processing method here production rates are very, very high. Plastic material is melted with the application of heat and extruded through die into a desired shape. So, that extrusion process with we will see the diagram also, but here also the raw material is in the form of a plastic. It is melted and it is

extruded means it is pushed through the die. The final product would be depending upon or the shape of the final shape of the final product would be depending upon the shape of the die.

For example, that if we want a circular section final product, the opening in the die would also be circular. So, whatever is the shape of the die opening similar type of product or the cross production we would be getting. Just to give you an example of extrusion, whenever we press a tooth paste through the opening, the paste comes out. So, what basically we are doing we have a raw material, inside the tooth paste and we are applying the pressure on the tube and through round opening the tooth paste is coming out.

Similarly, here also in the barrel we will be having the raw material which will be in the molten state and we would be applying pressure and the molten plastic would be coming out of the die opening depending upon the cross section of the die. So, the important point to note here is that extrusion we are applying certain pressure also, but if you remember the previous process that we are covered in the last class that was on casting. In casting the material was or the plastic was being melted and it was poured into the mold cavity and no pressure was being applied the material was allowed to cool to take the desired shape of the mould, but here in case of extrusion we are applying the pressure also.

The second point onwards clearly identify is the difference that here is the pressure is also applied. That plastic material is melted with the help of the application of heat and extruded through the die into the desired shape. Extrusion need there is a pressure which is also being applied, a cylindrical rotating screw is placed inside the barrel, which forces out molten plastic material through a die. So, this pressure is being applied with the help of a rotating screw.

So, it is a screw type of extrusion process, with we can have other types of extrusion processes also in which, we can use a piston and a cylinder type of arrangement to exercise or to a subject pressure on the molten plastics. So, that the plastic comes out of the die opening, but here on your screen one of the common types of the extruders are the screw screw extruders, in which the rotating screw is placed inside the barrel.

The screw is rotated which forces out the molten plastic material through the die opening. Again I am emphasizing the shape of the final product would be depending would be dependent on the or would be depending on the cross section of the die opening. Now, on your screen we see a very, very simple diagram of the extrusion process.

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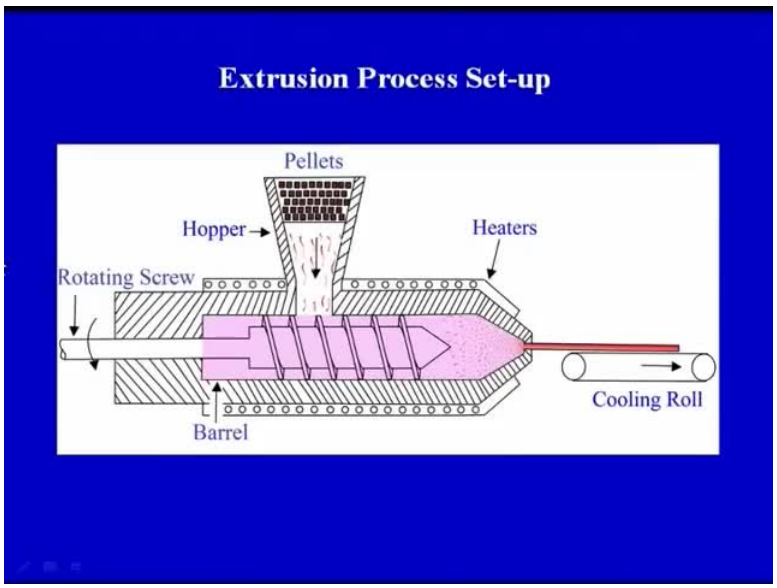

We can see, let us first see what are the important elements in this diagram? We have the heaters these are the heating arrangements or the heating elements all around the periphery of the barrel. These are the heating arrangement, this is the barrel. Hashed portion is the barrel and then this is the rotating screw, the direction of rotation is also shown. It is marked by an arrow rotating screw this is the rotating screw.

We has a heating arrangement, we have the barrel or the rotating screw and these are the cooling rolls, which are used to cool the final product. The final product is the red portion on your screen it is coming out continuously this is the die opening. On your screen you can see this is the die opening from where the molten plastic is coming out. Taking the shape depending across section of the die opening and this is the hopper.

This small, small, small, small particles we can say the raw materials are in the form of pallets. So, this is the raw material this is the hopper through which the raw material is entering the barrel and inside the barrel the temperature is high, why? Because of these

heating elements or heating arrangement. So, in this diagram we have seen what are the various elements and now we can try to understand the role. The raw material is placed in the hopper, the raw material enters the barrel through the hopper continuously.

This rotating screw is rotating, it the raw material are after entering the barrel will heated because of the heating elements and these heating elements will melt the plastic material. This molten plastic would be pushed by the this rotating screw or this is the example of a screw type of a feeders, this would be feeding the molten plastic to the die opening. This die opening will correspond to the final shape of the product and the final product on your screen is coming out.

Now, since the molten plastic would be at an elevated temperature, we would be requiring a cooling roll to cool the molten plastic. So, basically here also the three stages are common; stage number one is the heating in which the raw material which is coming from the pallets is entering into the barrel, because of the heating elements the raw material will get heated up and melted. So, first stage is heating and melting. Second stage is forming this is been pushed by the screw feeder into the die, and the forming of the final product is taking place in the die.

The shape of the final product will depend upon the shape of the die opening. So, that is the forming process. Finally, the cooling is taking place with the help of cooling rules. The heated plastic is getting the final shape and the cooling process is taking place after that. So, three stages step by step of heating of the molten plastic sorry, heating of the plastic pallets of the raw material pallets are available in the solid form, so heating of the solid pallets melting of the pallets, third stage is the forming of the plastic into the desired shape at the die opening.

Finally, cooling of the final product, which has been made or processed by the screw type of extrusion process, which is shown on the screen. Now, whatever diagram we have seen we will try to see the various steps involved. Although I have explained twice that how the process is actually takes place, but again we will try to read and understand what are the final points in this extrusion process in which a plastic in the form of a pallet form is getting converted into a final product. The final product is coming out through continuously through out of the die opening.

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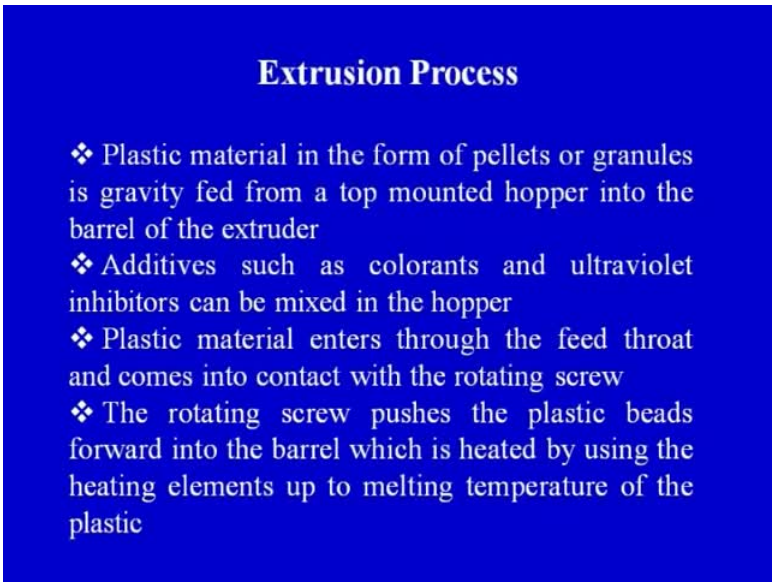

So, the plastic material in the form of pallets or granules pallets are granules means the raw material is in the solid form. So, plastic material in the form of the pallets or granules is gravity fed from a top mounted hopper into the barrel of the extruder. So, there are three four important terms which, if you have no idea about the extrusion process, again I am emphasizing. Pallets are granules is the raw material which is available in the market, so the raw material is in the form pallets or granules. This is gravity fed which means there is no pushing of the raw material.

The raw material is fed under gravity from the vertical hopper in the hopper the raw material is put and from there it comes down by gravity into the barrel. Now, barrel is the part which is heated because of the heating elements provided on the circumference or the periphery of the barrel. So, barrel is the heated zone where the temperatures are high, because the plastics are been entered under the pallets are being entered from the hopper into the barrel, the pallets would melt and they would form a molten plastic material.

Then this molten plastic material is fed towards the die with the help of a rotating type of screw in case of screw extruders or screw extruders. So, the barrel of the extruder is fed by the pallets from the hopper, that is the summary of the point number one. Additives such as colorants and ultraviolet inhibitors, can be mixed in the hopper. Now, we want the final product as in our diagram we have seen the final product that was

coming out of the extrusion or extrusion process or the extruder was red in color. Now, suppose we want to give the different color to final product, the colorants would be added in the hopper stage only or in the raw material only.

Sometimes the final product may be required to operate under specific set of operating environments. Therefore, in those case is also we may need to add certain additives into the raw material. So that the final product exhibit those properties for which the raw material has been blended. So, basically additives such as colorants and ultraviolet inhibiters, these are some examples ultraviolet inhibiters. There can be as type of regents or other type of additives which may be blended with the basic raw material or basic raw plastics. These are mixed with the raw plastic in the form of pallets in the hopper only. So, additives such as colorants and ultraviolet inhibiters can be mixed in the hopper.

Point number three, plastic material enters through the feed throat and comes into contact with the rotating screw. So, this is another time is coming into this particular point, that is the feed throat. It is the point through which the raw material in the form of pallets would be entering the barrel, so through the feed throat the pallets would be entering to the barrel and would be coming direct contact with the rotating screw. Now, what is the rule of the rotating screw? The role of the rotating screw is to perform the uniform melting under the uniform feeding of the raw material towards the die.

So, the heating is been done by elements which are provided all around the barrel. Now, plastic material enters through the feed throat and comes into the direct contact with the rotating screw. So, the raw material has entered into the system. Now, the rotating screw pushes the plastic beads forward into the barrel. So, the barrel has got a definite length and the place where the raw material is entering the rotating screw pushes this material forward towards the die. So, the rotating screw pushes the plastic beads forward into the barrel, which is heated by using the heating elements.

Probably the barrel is already heated with the help of heating elements up to the melting temperature of the plastic. So, we are heating it to a particular level and the level is higher, then the melting temperature of the plastic. Now, the plastic which we are entered in the form of a solid in the which is further in the form of a pallet, so the raw material that is entering into which is pallet solid. Now, this pallet and number of pallets

and thousands of pallets lets have melting because of the high temperature generated inside the barrel because of the heating elements. So, the melting of the plastic takes place or the plastic pallets takes place.

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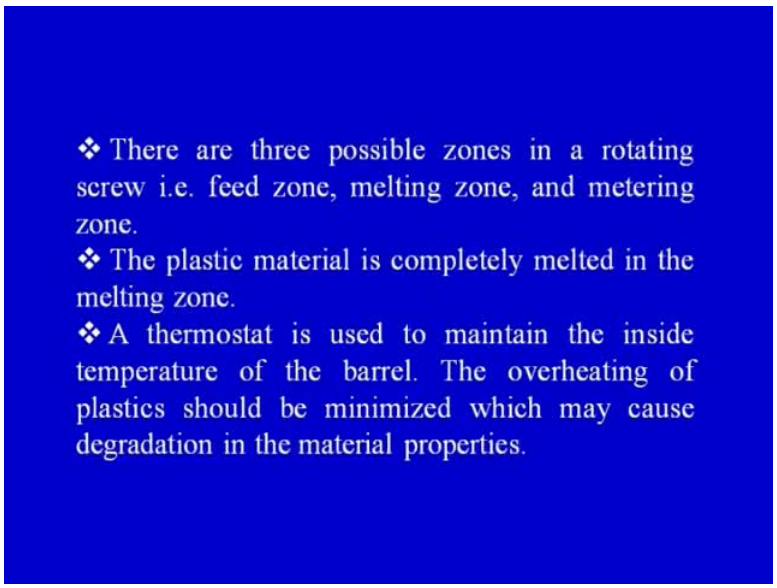

There are three possible zones in the rotating screw, that is… Now, there are rotating screw will also have got its length. Now, in that particular length we can have different zones like the fee zone, the melting zone and the metering zone. So, basically feed zone the role of the a screw and the feed zone is to feed the material to in the barrel towards the die. Second is the melting zone of the during in this particular zone, the actual melting of the plastic would take or the plastic or the pallets would take because of the heat generated because of the presence of the heating elements around the periphery of the barrel.

Finally, the metering zone means that a definite amount of material would be meted which would be coming out of the die. So, the three important zones are there; feed zone rolling feeding the material, melting zone where the actual melting of the pallets is taking place because of the heat generated due to the heating elements outside the barrel, present outside the barrel.

And finally, the metering zone were the we are predetermining what are the amount of material should come out in one particular, although it is a continuous process, but still the metering to be done. So, that exact amount of the molten plastic flows towards the die, the plastic material is completely melted in the melting zone which is very, very important in order to make products by extrusion process. A thermostat is used to maintain the inside temperature of the barrel, the overheating of the plastics should be minimized, which may cause degradation in the material properties which is very, very obvious.

If we raise the temperature beyond the particular level the properties of the material that is the material in our lecture today is a plastic material, so the properties of the plastics will get the degraded because of the high temperature to which they are subjected to. So, we have to describe side that up to what temperature the heating process should take place or what is the melting part or the melting temperature for that particular plastic at which it will melt and be formed into the desired shape.

So, for that purpose to exactly know that what is the temperature inside the barrel thermostatic used to maintain the inside temperature of the barrel. And we have to avoid the overheating in any case because it would affect the final properties of the extruded product, which is being made by the extrusion process. Now, at the front of the barrel then molten plastic.

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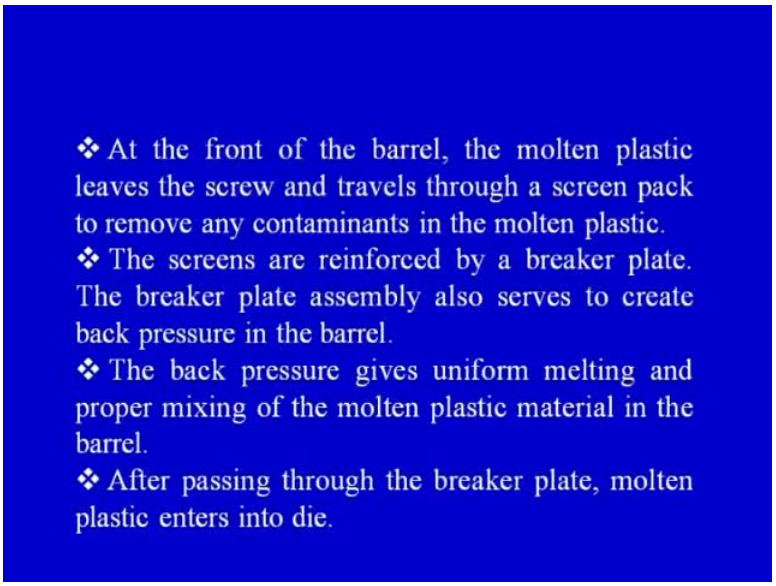

Now, these are some additional features which are provided the extrusion process or although the basic mechanism or the basic process is divided can be divided into three stages, in which initially the raw material is being fed from the hopper into the barrel. The barrel has high temperature because of the heating elements, in the barrel the material or the plastic the material melts and because of this melting action, it is pushed by the rotating screw towards the die.

The molten plastic comes out of the die and takes the shape of the die to the at the desired final product in the continuous scalar in a continuous manner. But there are few additional attachments also which are provided in order to further improve the effectiveness and the efficiency of the process, which are mentioned on your screen now. At the front of the barrel there is another we can say thing, which is present that is the molten plastic leaves the screw and travel through a screen pack to remove any containments in the molten plastic.

So, we are manipulating our raw material, so that there are no containment present in the raw material, which would subsequently affect the properties of the final product. Therefore, a screen pack is used to arrest all those impurities or containments the screens are reinforced by a breaker plate what is the role of the beaker plate. The beaker plate assembly also serves to create back pressure in the barrel. So, we need to create a back pressure in the barrel, why the back pressure is important that we would be seeing in the subsequent point.

The molt, the back pressure gives uniform melting and proper mixing of the molten plastic material in the barrel. Now, if you see in the previous slide we have seen that sometime colorants and some ultraviolet inhibiters or some other types of additives additives have to be added with plastic pallets, so that we are able to improve properties are able to define the properties of the final product depending upon the specific requirements. But where will this mixing taking place?

Because in the hopper the all the colorants the pigments and the pallets are present in the solid form, so this mixing up of as to be taking place in the barrel. So, this back pressure providing by the beaker plate that is there in part number two, helps in the uniform melting and the proper mixing of the molten plastic material. That is the this particular

melting is being taking place inside the barrel. No back pressure will help or it would further catalyze the unit for mixing and the heating process.

So, uniform heating and uniform mixing of the various constituents that have to go into the final properties is better if you are able to generate back pressure. Now, the screens are rein forced by a beaker plate. The beaker plate assembly also serves to create the back pressure in the barrel. The back pressure gives uniform melting and proper mixing of the molten plastic material in the barrel, after passing through the beaker plate molten plastic enters into die.

Now, the final stage is where the material has to be formed? Till now whatever we have discussed our focus was primarily on the melting of the plastic and raising the temperature of the pallets to a temperature higher than the melting point of the particular plastic. So, the raw material has come from the hopper it is gravity fed into the barrel and inside the barrel there is a feed inside the barrel there is a feeding zone, there can be there is another zone which for the melting and finally, the metering zone.

So, in the melting zone the actual melting of the plastic is taking place and the uniform mixing of the various constituents is taking place during the melting process. Now, once the plastic has melted it would be pushed towards the die from where it would be coming out depending upon the cross section of the die opening.

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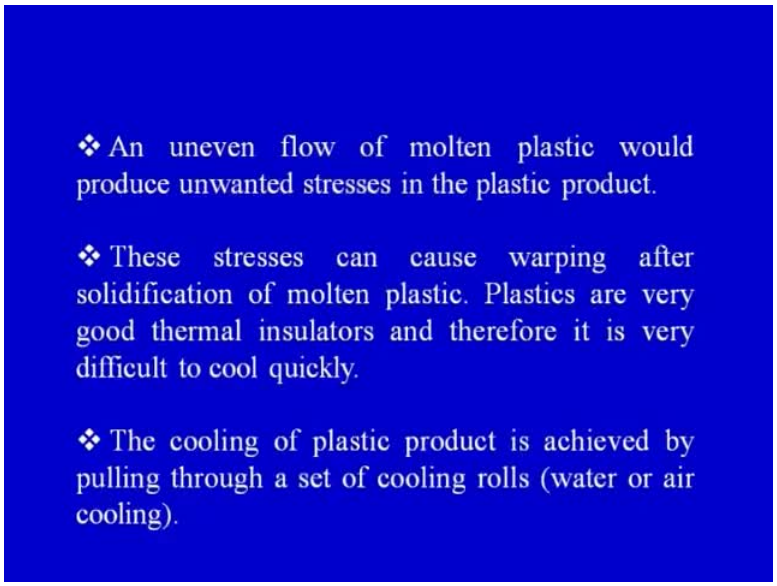

An even flow of molten plastic would produce unwanted stresses in the plastic product. So, we have to ensure that the molten flow or the flow of the plastic in a molten stage should be very, very uniform. So, an un even flow as is very clearly mentioned on your screen an un even flow of molten plastic would result in certain stresses, which are completely unwanted. These stresses are present in the product after sometime the product may fail because of these developed residual stresses. So, these stresses have to be avoided in any case.

So, this stress can cause warping after the solidification of molten plastics, some of the effects are given that if these stresses are present. Theses, stresses are present because of the un even flow of the molten material in the plastic product. So, these stresses can cause warping after solidification of molten plastic. Plastics are very, very good very good, good thermal insulators, therefore it is very difficult to cool quickly. So, that is another issue that is involved if you remember the diagram that we have seen for extrusion.

We have a separate cooling arrangement after the final product is coming out of die opening. Now, why that cooling arrangement has provided? It has been provided because of the point it is mentioned on your screen, that is plastics are very good thermal insulators. So, when there thermal insulators therefore, the cooling may take a long time. Therefore, we can say additional cooling arrangements are provided to cool the plastics products once they are formed. So, we have to avoid the stresses we have to cool the plastic products after they are formed, so that we can avoid the problems or the difficulties later on.

So, the cooling of the plastic product is achieved by pulling through a set of cooling rolls, water or air cooling which, we have seen in the diagrams that there are cooling rolls available after the extrusion process is done, after the product comes out of the die opening. We have arranged cooling rolls arrangement which cools the final product and the final product is now ready to be shift to be put into the warehouse. So, basically important point to note here is that there are certain additional attachments in the process or certain additional equipment in the process, which helps us to achieve a better quality product.

Now, a contaminants can be arrested the cooling can be done and there can be other attachments, which may further improve the efficiency of the process. But the basic process is that we would be melting the plastic inside the barrel and then pushing that molten plastic through the die opening to get the final product.

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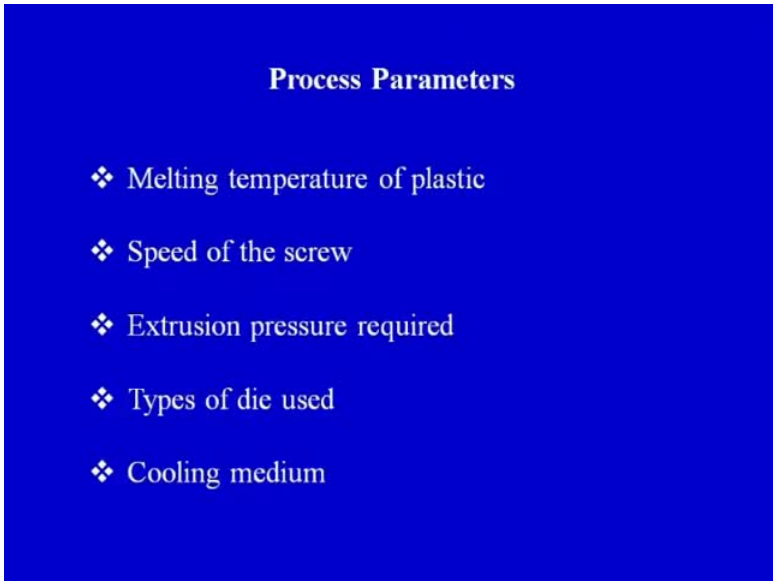

So, we will see the some of the other important details related to the extrusion process like on your screen you can see the process parameters. Now, what are important process parameters that have to be taken into account specifically in case of extrusion of plastics, that that we can see. Melting temperature of the plastic, why? Because we have to design the heating elements around the barrel in such a way, so that we are able to generate the specific temperature required to melt a particular plastic material.

Now, suppose a plastic material does not melt properly, the feeding through the rotating screw would also be problematic. We will not be able to get the desired viscosity. Sometimes some un molten or un melted solid palettes may be formed in the final product, which may act as concentration points where the failure may take place. So, important point is that is one of the important process parameters in case of extrusion process is a melting temperature of the plastic.

So, before subjecting any plastic material to the extrusion process we should definitely understand the melting characteristics of that particular plastic. Second important point

is the speed of the screw, now the speed of the screw should not be very fast and it should not be very slow. So, an optimal speed of the screw has to be adjusted, so that the general behavior of the polymer melt is such it is able to come out of the die in the best possible or in a good quality product.

If we do it very fast there can be certain types of defects that may be present or prevalent in the products being made out of the extrusion process. Specifically in case of plastics and if it is very slow there also other may be certain problems related to the quality of the final product. So, two important process parameters are the melting temperature of the plastic and the speed of the screw third important point is the extrusion pressure required no I have already told.

In case of a extrusion screw type of extruders are very common in which are rotating screws is used to feed the molten plastic towards the metering zone into the die and from the die we get the final product. Now, this screw feeder, how much pressure should the screw feeder apply on the molten plastic is very, very important. So, the extrusion pressure required to form the shape of the final product is also very important.

Now, the types of the die used is also equally important. Last is the cooling medium. In the total extrusion process once the final product comes out of the die it has to be cooled, which is very which was very clearly explained in the previous also, that the cooling is definitely the coating phase processing of plastics. Therefore, the design and design and type of the cooling medium also has to be understood in case of extrusion process.

Now, what are the important points that are to be taken care of specifically in case of the extrusion process are or what are the important process parameters that have to be accounted for in the, we can say good quality, high manufacturing or high production rate extrusion process are; we should be able to control or monitor the melting temperature of the plastic. We should have the information about the optimal speed of the screw, we should know what is the extrusion pressure for the particular plastic we should know what type of die has to be used if we want to get a particular shape.

Finally, we should also understand that what would be the type of cooling medium that would be used when the product would be coming out of the extrusion and would

finally be cooled. So, it is easier said than done that the extrusion is a very simple process, because an exact control of all this process parameters is very important. And if this process parameters are not controlled properly then the product that we are going to get out of the extrusion process will not be a very good quality.

There can be different types of defects that may be found in the final product which is coming out of the extrusion process. So, again I would like to revise or read what is already written on the screen that is the process parameter or the important or the critical process parameters in case of the extrusion process. Now, the important parameters are the melting temperature of the plastic, the speed of the screw, extrusion pressure required, types of die used and the cooling medium. Now, these are the important points that are to be taken into account.

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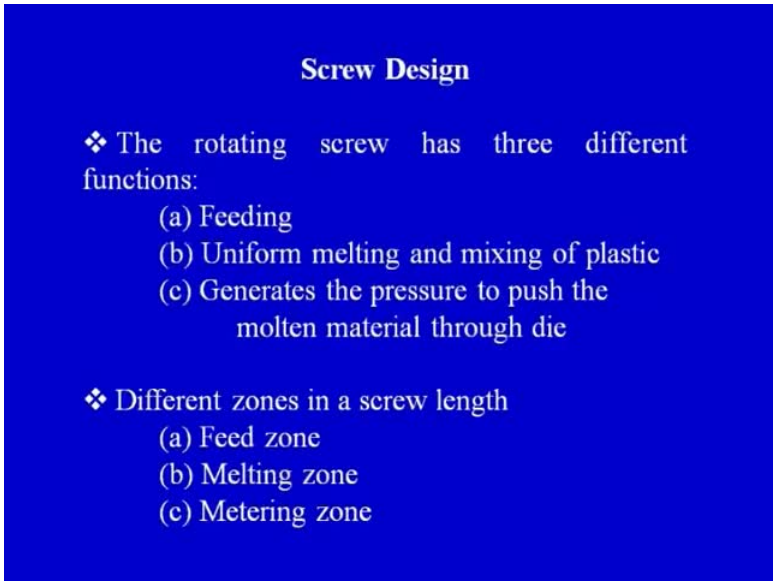

Now, the screw design is also very, very important, why? Because it is the element which is applying or which is exercising pressure over molten plastic and feeding it into the die so that it takes the shape of the die and gives us the final product. Now, the screw design rotating screw has three different functions. Now, what are the functions of the rotating screw that have been highlighted on this particular slide.

Feeding, it has to feed the material when the falling in the under the influence of gravity from the hopper into the barrel and it comes in contact with the rotating screw. What is

the first function of the rotating screw, the first function of the rotating screw is to feed the raw material, that is the palettes towards the melting zone. So, first important point is the feeding of the raw material, second important point or the function of the rotating screw is to ensure uniform melting and mixing of the plastic.

So, the second important function which are particular rotating screw in case of rotating process, process has to satisfy is that it should ensure uniform melting and the mixing of the plastic. That is the second zone that is the melting zone. Finally, it generates the pressure to push molten material through the die. So, it has ensure feeding, it has ensure melting and it has to further ensure it has the pressure to push the molten material or it generates the pressure to push molten material towards the die from the die finally, a product comes out.

So, the rotating screw has three important functions, which I would again revise. It can be used it is used for feeding it ensures uniform melting and mixing of the plastic and finally, it generates the adequate pressure to push the molten material through the die into the final product. Different zones in the screw length because if you remember the diagram, there was a definite length of the screw. Now, these particular lengths can have different zones, where there can be a feed zone there can be a melting zone and there can be metering which we have already discussed.

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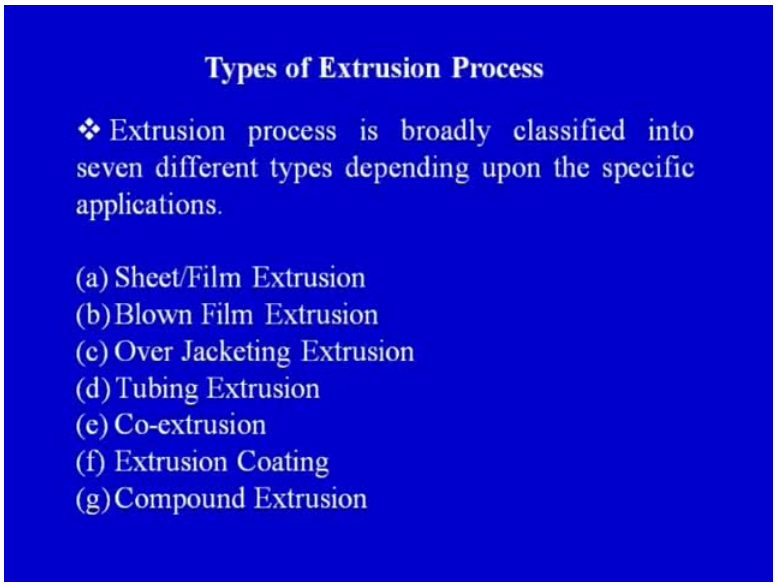

Now, we come on to the types of extrusion process. So, there are different types of extrusion process, one by one we will try to understand at least one or two of these processes. Different types of extrusion process are; it can be broadly classified into the following types, that is sheet film extrusion, blow film extrusion, blown film extrusion, over jacketing extrusion, tubing extrusion, co extrusion, extrusion coating and compound extrusion.

So, different types different names have been given, but the basic principle is same that the molten plastic is formed into a given shape as it passes through the die. Now, some of this we try to understand with the help of some text and some diagrams, but important point to note is that name of names itself is very, very clear that these processes have been developed for specific application requirements.

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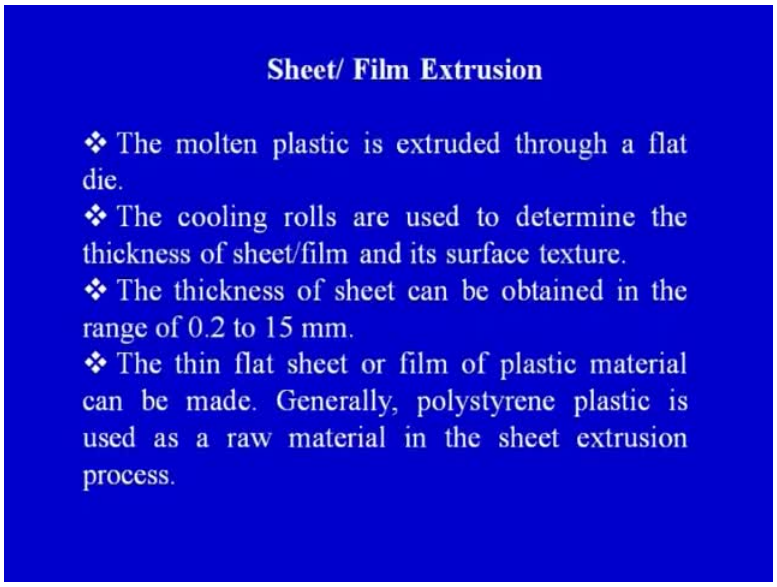

As the first process on your screen you can see, sheet film extrusion. Sheet film extrusion that the final product, would be in the form of a film or a sheet. So, we can read what is there on the slide the molten plastic is extruded through a flat die. So, as I have already told the final product or the shape of the final product or the cross section of the final product would be dependent upon the shape of the die. So, in case of sheet film extrusion the die would be a flat die.

So, the molten plastic is extruded through a flat die, the cooling rolls are used to determine the thickness of sheet film and its surface texture. Now, we if we want a specific surface texture or a specific surface finish on the sheet the rolls can be or the cooling rolls adequately or judiciously selected. So, the cooling will depend will dictate the thickness and the surface texture of the fill. As it is very clearly mentioned in point number two, I am reading that point for you.

The cooling rolls are used to determine the thickness of sheet film and its surface texture. Where are these cooling rolls? These are at the end of the barrel, outside the barrel, once the product comes out of the die it is taken by the cooling rolls. So, the thickness of sheet can be obtained some typical range has been given, that is it range from 0.2 to 15 milli meter. So, a fairly thick sheet can also be made by a sheet films. A thin flat sheet film of plastic material can be made. So, this is the application film area of the sheet film extrusion.

Generally polystyrene plastic is used as a raw material in the sheet extrusion process. Now, one type of material is given which can be used for sheet film extrusion, the typical thickness range is also given and the final shape that we get out of sheet film extrusion is mentioned on this particular slide.

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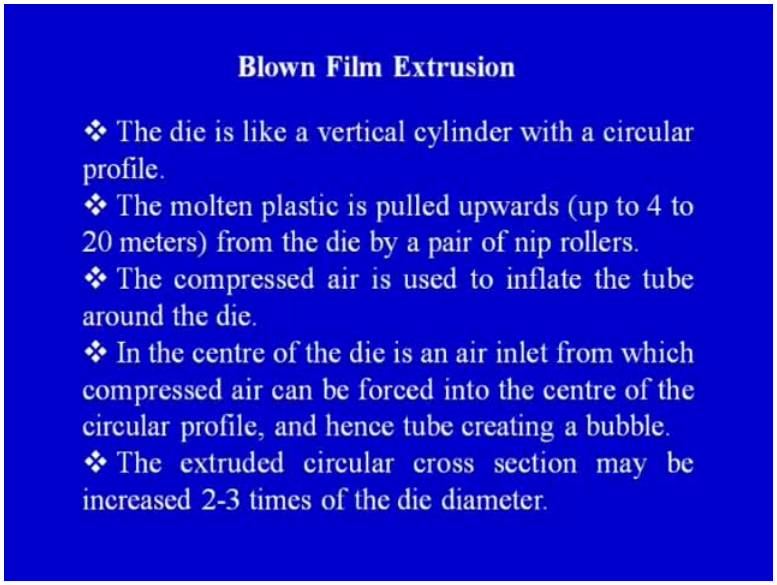

Second one is the blown film extrusion, we will try to understand with the help of a diagram also. The die is like a vertical cylinder with a circular profile. So, the die in this case is like vertical cylinder and it has got a circular cross section. So, a vertical cylinder circular cross section the molten plastic is pulled upward. So, it is a vertical forming process in which shape will be given in a vertical manner.

So, the molten plastic is pulled upward 4 to 20 meters, 20 meters is a considerable height. So, the molten plastic is pulled upward and the die, how it is pulled upward from the die? With the help of nip rollers. Now, what are nip roller? We will see with the help of a diagram, so the molten plastic is pulled upward through this die with the help of the nip rollers. The compressed is used to inflate the tube around the die, so it would the tube would be inflating around the die as in the case of blow molding which we would be seeing at the later stage.

Now, this compressed area is used to inflate tube tube through the around the die so we have a die and this tube would be plastic tube would be inflated. In the center of the die

is an air inlet from which the compressed air can be forced into the center of the circular profile and hence tube creating a bubble. So, here we will see how that will be formed with the help of diagram. Finally, the extruders circular cross section may be increased two to three times of the die diameter. So, this circular cross section is increased up to two to three times. Now, let us try to understand this with the help of a diagram.

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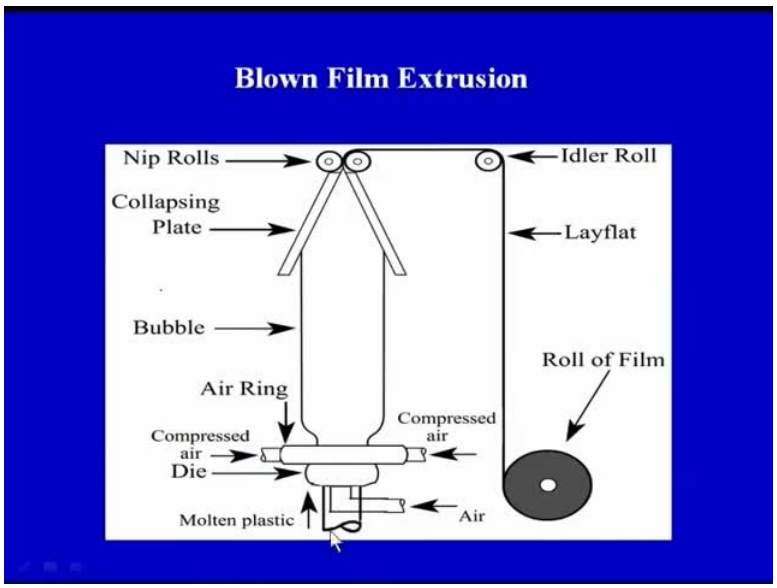

In this particular diagram, we can see that we have a molten plastic coming out in the vertical fashion like this. The air is entering from here this is the die vertical die, with circular cross section molten plastic is entering the die. The air is blown out the molten plastic, this is the air ring compressed air is entering from here and from this side also. This is the bubble, which we are talking about this is the bubble, which is formed and this is pulled up with the help of this nip rolls.

So, this plastic is been pulled up because of this movement of this nip rolls and this bubble will go or move up and at the collapsing plate it would collapse. Finally, this is the sheet that we are generating or the film that we are generating that is blown film. This is the film this is the idler roll, this is the lay flat final product is called lay flat. This is the lay flat, which is coming and getting round over the roll. So, this is the roll of the film, so basically we can see the plastic is entering that there are two important points to note here that we have a molten plastic.

We have a compressed air and a air supply, now the air will blow out the plastic it will give it form of a bubble shape. This bubble would be collapsing at the collapsing plate. Finally, we will get a sheet of, which we may call as a lay flat and which is called as a blown film.

So, this is a blown mess from the blown word is coming from the air because air is been used to blown blow out the molten plastic. So, basically we have a molten plastic, we have a supply of air that air is blowing out the molten plastic into a forming kind of bubble. This bubble is collapsing at the collapsing plates and it is forming a film and the film is getting collected on the roll.

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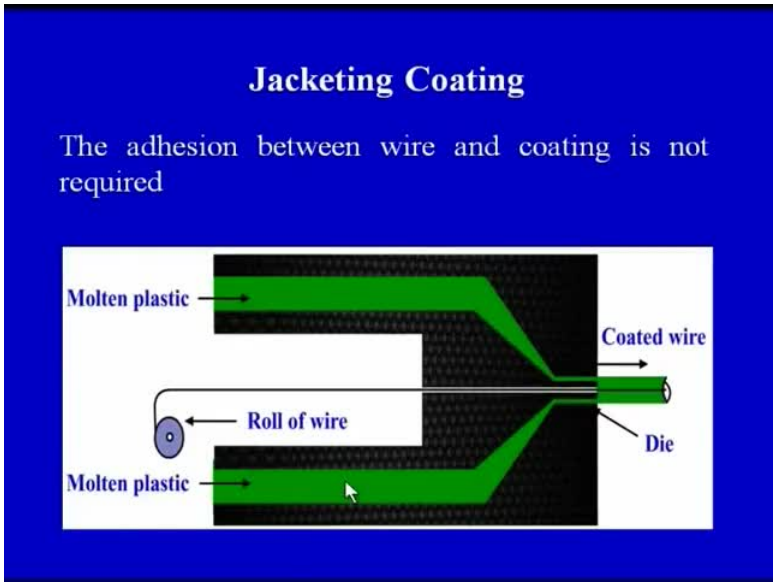

So, this is the process of blown film extrusion then we have a jacketing coating in which we see the adhesion between the wire and coating is not required on a screen a very simple diagram. You can see the green color. Represents the molten plastic and this is the role of wire jacketing. Wire jacketing means we are jacketing the wire with the plastic. So, here we can see this is the role of wire from where the wire is coming and this wire we want to jacket around by the plastic, why?

Because plastics are thermal insulators and many of the plastics are electrical insulators also. In case of electrical wires we can coat them or a we would we may like to jacket the wire with the coating of plastic material. How it can be done? We can see the molten plastic is coming from two sides, the wire is coming from this side and the wire is moving out. The adhesion between the wire and coating is not required because this jacketing is taking place outside the die. This is our setup, outside the setup the jacketing process taking place.

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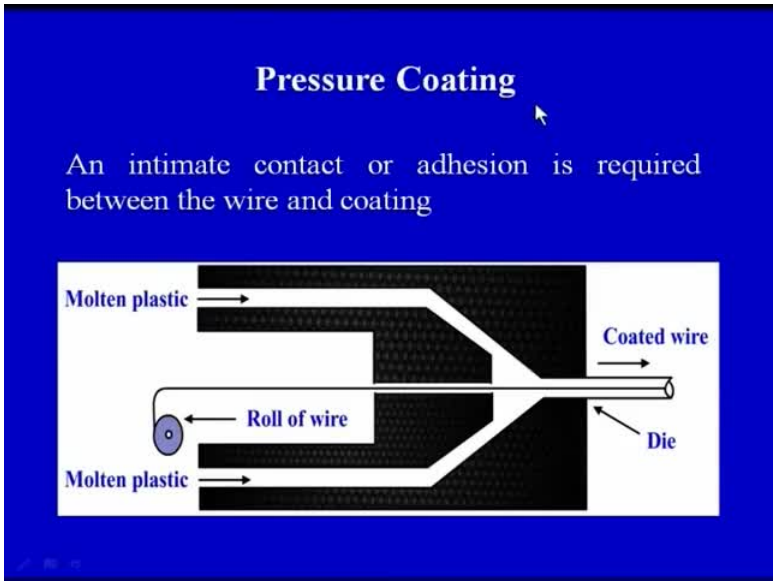

In a different case that is pressure coating, we can see an intimate contact or adhesion is required between the wire and coating, why? Because the coating is taking place within the setup only. The roll of, from the roll of wire the wire is coming. If you see this is the movement of wire wire is coming from this direction it is moving in this direction.

The molten plastic is again from a this is the point, where the jacketing or the coating is taking place and finally, we get the coated wire outside. So, this is also a kind of extrusion process in which we are coating the molten plastic outside the wire or we are jacketing the wire with the coating of a plastic material, why it is required that I have already told.

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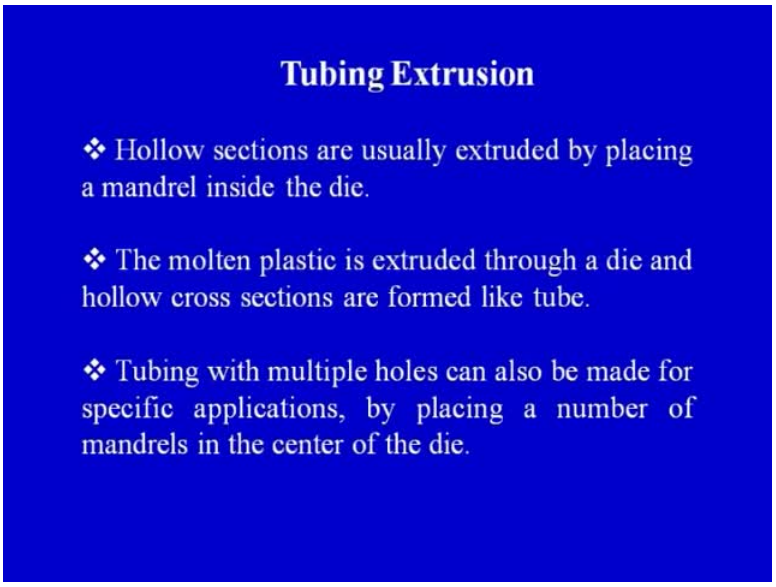

Then we can go for tubing extrusion. Hollow sections are usually extruded by placing a mandrel inside the die. So, if we want make a tube instead of solid rod, we need to have mandrel that all of us know, that is very common case of tube drawing also. Hollow sections are usually extruded by placing a mandrel inside the die, the molten plastic is extruded through a die and hollow cross sections are formed like the tube. So, we can get hollow plastic tubes also by using a mandrel, tubing with multiple holes can also be made for specific application.

Now, if we want to make different holes, number of holes are different, different mandrels can be used for specific for specific applications. So, here by placing a number of mandrels in the center of the die, we can make a specific design also, in which number of hollow sections can be there. So, tubes can also made by the plastics by the process of extrusion.

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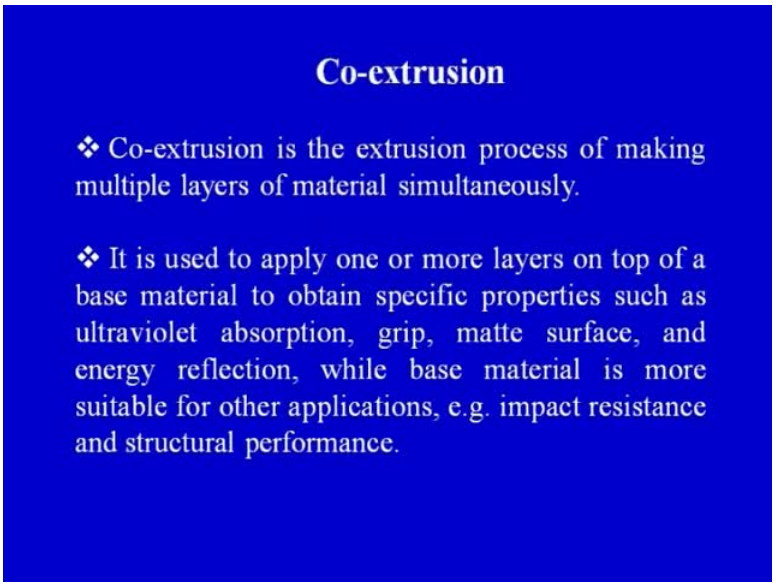

Now, what is co extrusion? Co extrusion is the extrusion process of making multiple layers of material. Simultaneously like we have seen in one of the process that is in which film of plastic is coming out of the extrusion machine or extrusion process. This film can have different layers why because we require certain specific properties. So, in co extrusion we can blend different types of films to gather to get the desired properties out of the final product.

So, extrusion, co extrusion is the extrusion process of making multiple layers of material simultaneously. So, it is used to apply one or more layers on top of the base material to obtain specific properties. Now, what are the specific properties that are desired. These specific properties desired are such as ultra violet absorption grip, sometimes we want to have a matte surface and sometimes we need require energy reflection. So, the base material is more suitable for some specific application like impact resistance and structural performance.

The top coating or the top we can be having certain ultra violet resistant or a resistance to ultra violet radiation or may be providing a matte surface or may be some cases only to have good surface finish also. In co extrusion the base material will have different properties different functions and different material may be chosen further and on top of that we have others layers, which are co extruded on the base layer. So, that the

properties of the top layers are entirely different depending upon the specific requirements for which, the extrusion process or the extrusion product is being made.

Now, it may be on any of the process such as blown film as we have seen in blown film. We are making only one film we can use this different type in which we can have two or three different layers in the blown film or in which we are making the plate, in one of the processes that we have today. We can make a plate up to a thickness of 0.2 milli meter to 15 milli meter. So, we can have two or three different layers, co extruded, so that the total thickness has got gradient properties or we can say the properties are varying in the thickness of the plate. So, it may be used on the any of the process.

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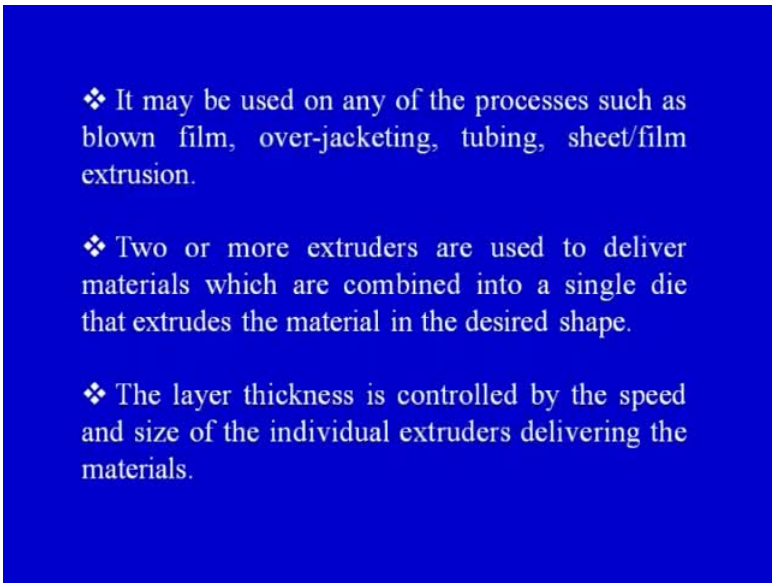

Now, co extrusion can be done with different processes like, blown film over jacketing, tubing or sheet film extrusion, as we already discussed in sheet film one sheet is coming we can make two three different sheets with the help of co extrusion process. So, two three different sheets would be coming out to gather in a single form. The final product would be single, but it would have gradient properties in through the thickness of the final product.

So, two or more extruders are used to deliver materials which are combined into a single die that extrudes the material in the desired form. The layer thickness is controlled by the speed and size of the individual extruders, delivering the materials. So, basically

different types of extrusion process is can be there. Although we have discussed only two or three important variants of extrusion, but there can be other variants extrusion process also. Although we have seen two or three important points related to the process variants that is we have seen over jacketing, we have seen sheet film extrusion, we have briefly outlined the tube tubing extrusion and blown film extrusion.

So, with we come to the end of today's lecture, in which we have seen that what is the extrusion or what are the important points to be taken care in extrusion of plastics? What is the extrusion process specifically in contexts of plastics? We have seen that basically three steps are involved, which means heating, forming with the help of the screw feeder with the help of the die and finally, cooling the final product. We have seen some of the process variants of the extrusion process, to name a few we have seen sheet film extrusion, blown film extrusion, we have jacketing extrusion and finally, in the last we have seen co extrusion.

So, different types of extrusion process can also be there, but in today's lecture we confined our discussion to these processes only. These process variants of the extrusion process only. In our sub sequent lecture we would be discussing other techniques which are used for processing of plastics.

Thank you.