Lecture 31 - Injection Moulding-01

Hello, friends! Welcome to Part 1 of the Injection Molding segment, exploring the nuances of polymer process engineering. In this session, our focus lies on injection molding, a fundamental aspect of polymer processing that yields a diverse array of products. Let's delve into the key topics slated for discussion in this lecture, including the historical background of injection molding, an overview of its basic principles, and the classification of injection molding machines.

The injection molding process stands as a cornerstone within polymer processing, contributing significantly to the production of various products. To better understand its intricacies, we'll explore the historical evolution of injection molding and delve into the fundamental principles governing this manufacturing method. Additionally, we'll shed light on the different types of injection molding machines, emphasizing how their variations cater to diverse product requirements and operational parameters.

Advancing our discussion, it is crucial to evaluate the advantages and disadvantages associated with injection molding machines. By scrutinizing these aspects, we can gain a comprehensive understanding of the machine's efficiency, limitations, and its overall impact on the manufacturing process.

Given that injection molding is a cyclic process, we will proceed to dissect the various stages encompassing the injection molding cycle. Understanding the breakdown of this cycle is essential for optimizing production efficiency and addressing potential challenges that may arise during the manufacturing process.

Our exploration extends to tooling aspects and essential terminologies pertinent to injection molding. Key concepts such as L/D ratio, compression ratio, back pressure, injection speed, and cushions will be elucidated, providing a nuanced understanding of the technical intricacies involved in injection molding.

Our exploration into the world of injection molding begins with a historical perspective, tracing back to its inception in 1872 by the Hayek brothers in the USA. The crucial element of this innovative process lies in the design and patenting of injection molding, a milestone recognized in a patent granted to Adam Gastron in 1932. This design introduced the heating cylinder, a pivotal component ensuring the transformation of polymers into the desired shape. The heating cycle, integral to this process, involves melting or heating polymers to facilitate the molding process, emphasizing the indispensability of the heating cylinder.

Notable advancements in injection molding machinery design unfolded in Germany during the late 1950s. The German expertise in machinery played a significant role in shaping the development of injection molding machines into the sophisticated devices we are familiar with today. This pivotal period marked the evolution of injection molding into a global sector, contributing substantially to the employment of approximately 0.5 million individuals in the United States alone.

The expansion of the plastic sector gained momentum as a direct result of technological advancements, the introduction of novel products, and the continuous development of new polymers. This dynamic landscape has led to a steady increase in the number of operational plastic sector facilities. As a testament to the industry's growth, these facilities continue to multiply, responding to the demand generated by both emerging products and the evolving landscape of polymer development. The injection molding sector, thus, stands as a testament to the continuous innovation and growth within the realm of polymer processing.

Within Europe, the injection molding industry finds its stronghold in Germany, standing out as the most significant player across all European countries. Meanwhile, India has emerged as a notable contender in the injection molding arena, boasting a substantial presence of injection molding machines nationwide. The globalization of the market has played a pivotal role in shaping the dynamics of the injection molding sector. Countries like India, China, and Eastern Europe have become hotspots for the manufacturing of plastic injection moldings, capitalizing on cost-effective facilities.

India, in particular, has embraced this trend with gusto, notably in the state of Gujarat and certain regions of the southern states. These areas have become manufacturing hubs for a myriad of injection molding machines, aligning with the Make in India mission, further fueling the growth of the injection molding industry on a global scale.

Transitioning into an introduction to the injection molding process, it stands out as the predominant method for producing a diverse array of plastic parts, including commodity materials such as chairs and buckets. The versatility of injection molding is evident as it accommodates the manufacturing of various commodities, showcasing its applicability across industries. Operating in a cyclical fashion, the process initiates with the swift fitting of a mold and concludes with the essential steps of cooling and ejection. This cyclic nature underscores the efficiency and systematic progression inherent in injection molding, making it a cornerstone in the production of a wide array of plastic products.

Examining the injection molding process in greater detail, we identify four integral components that play a crucial role in shaping the final product. The process commences with the introduction of polymer, a pivotal raw material that undergoes heating before passing through the mold. Mold design, the second key element, holds paramount importance as it determines the eventual shape of the product, making it an essential consideration in managing the heating aspect of the process. Following this, the incorporation of cooling channels becomes imperative to solidify the molded material. Finally, the cyclic nature of the process is completed with the ejection of the prepared parts or commodity materials from the injection molding machine.

Considering the raw materials, a diverse array of substances, encompassing both plastics and non-plastics, can be utilized in the injection molding process. The design of the machine is tailored to accommodate the specific material being used, allowing for flexibility in machine types and mold configurations based on unique requirements. Raw materials, often in the form of grains or powder, undergo plasticization in the injection unit before being injected under high pressure into a clamp mold, with typical pressures ranging from 500 to 1500 bars.

Central to the injection molding process is the plasticizing area, a critical zone where the raw material is melted or heated to achieve the desired consistency for molding. Separation between the plasticizing area and the molds is maintained, emphasizing the importance of managing the heating aspect to achieve optimal shaping and form. As we delve further into our discussion, we will explore each of these components in more detail to gain a comprehensive understanding of the injection molding process.

In the injection molding process, maintaining the temperature of the plasticizing cylinder or the plasticizing area is crucial, and it is typically sustained at the same level as the processing temperature. Simultaneously, careful attention is given to the mold temperature, ensuring it is either warm enough to facilitate cross-linking or cold enough for the demolding process, especially relevant for thermoset materials.

Moving to the injection molding machine's configuration, it commonly features an integrated clamping unit that houses both the mold and the injection unit. The injection unit comprises a cylinder and piston assembly, responsible for pumping the polymeric material through various channels into the mold. The mold, often referred to as a dye, is designed to produce the desired parts for the injection molding process.

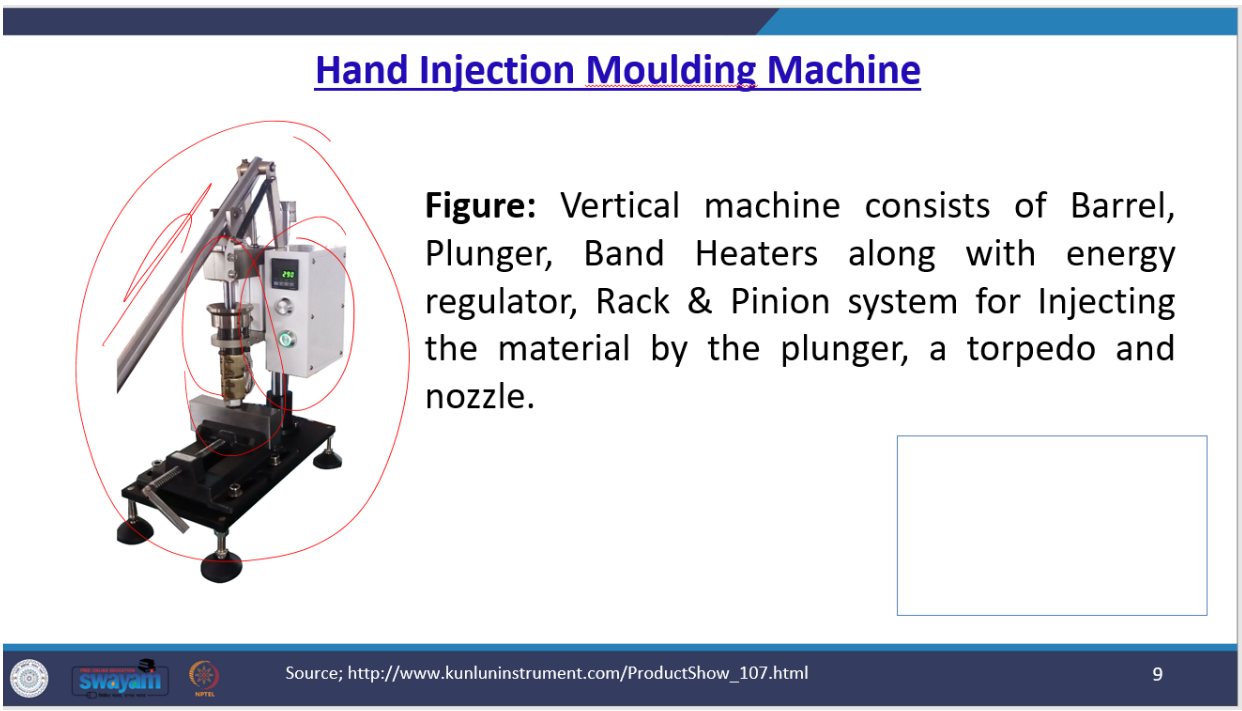
Notably, thermoplastics are commonly processed using injection molding equipment, yielding diverse products such as solid white necks, flat items like buckets and cabinets, and various industrial parts used in the automotive sector. The injection molding machine injects molten thermoplastic material into a closed mold, typically maintained at a relatively cool temperature.

Before delving into specific details, let's introduce the three main types of injection molding machines commonly utilized in the industry. This classification sets the stage for a more in-depth exploration of their individual characteristics and applications within the injection molding process.

Among the various types of injection molding machines, three primary classifications are commonly employed: hand injection molding, plunger-type injection molding, and reciprocating screw-type injection molding. Let's begin by exploring the hand injection molding machine.

The hand injection molding machine is characterized by its vertical structure, comprising essential components such as the barrel, plunger, band heater, energy regulator, rack and pinion system for material injection by the plunger, a torpedo, and a nozzle. The machine incorporates control units to regulate the entire process. Pressure is applied to the system, facilitating the insertion of molten polymer into the mold. This manual method provides a hands-on approach to the injection molding process, allowing for precise control over the material injection and molding stages.

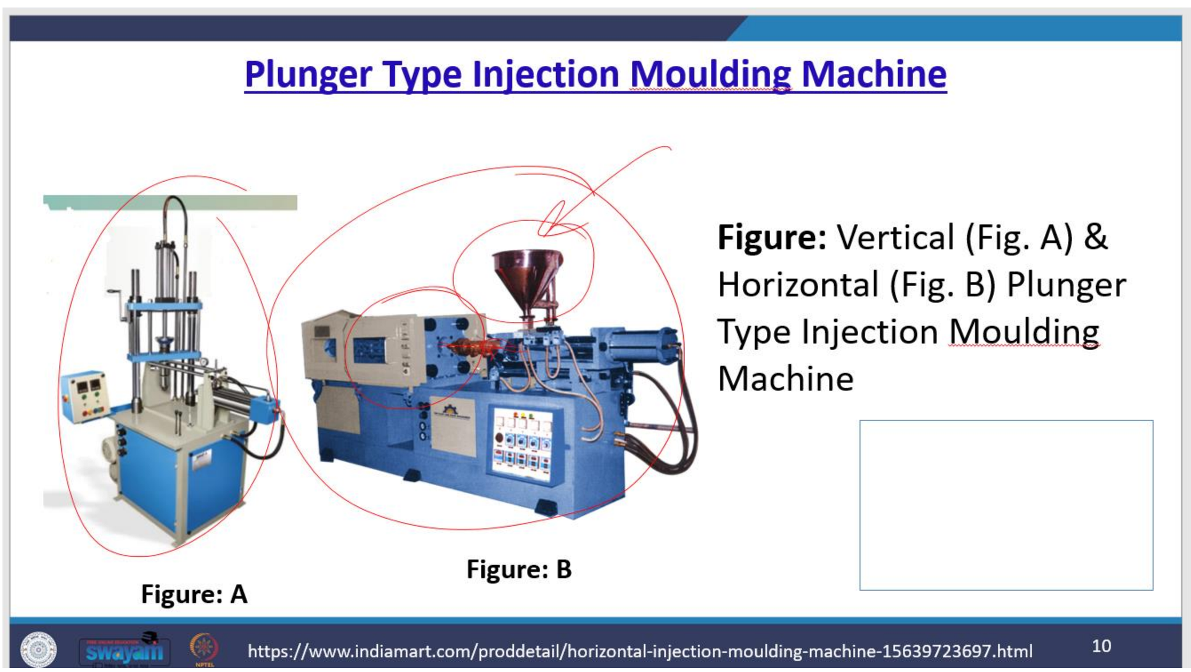
Moving on to the plunger-type injection molding machine, it involves a distinct mechanism for material injection. The details of this type will be explored further, shedding light on its unique features and applications within the broader injection molding landscape.



In the realm of plunger-type injection molding machines, two main configurations exist: the vertical and horizontal plunger types. Let's begin by examining the structure of the horizontal plunger type injection molding machine.

The horizontal plunger-type machine features a hopper where the polymeric material is introduced. Adjacent to this, the mold is housed, accommodating the desired product dye. Through heating units, the polymer undergoes the melting process, transforming into a molten state before being injected into the mold. This basic anatomy of the horizontal plunger-type injection molding machine outlines the key components responsible for the effective execution of the injection molding process.

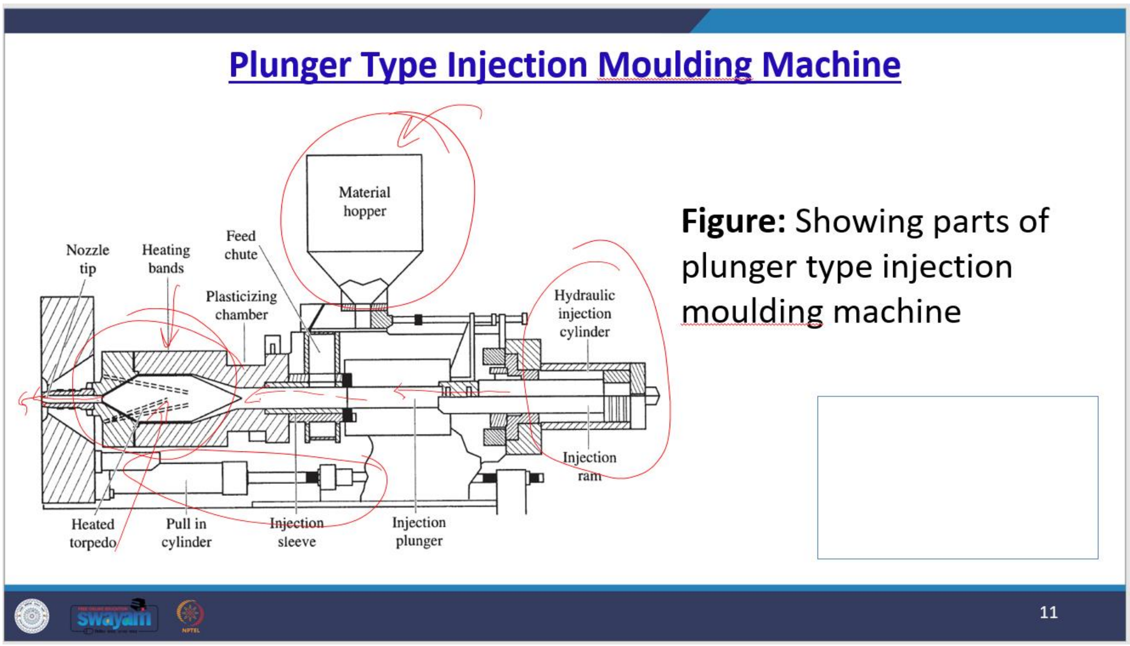
In comparison, the vertical plunger-type machine showcases a similar setup, with a material hopper serving as the point of entry for pallets, powder, or polymer in various forms. Additionally, provisions are made for the inclusion of dyes to introduce coloring materials into the process. This flexibility in material handling allows for a diverse range of applications and end products, contributing to the versatility of the vertical plunger-type injection molding machine. The subsequent discussion will delve deeper into the intricacies and applications of both the horizontal and vertical plunger-type machines within the injection molding domain.



In the injection molding process, versatility is achieved by incorporating additives when necessary. This addition takes place in the material hopper, offering the flexibility to introduce various additives along with polymers, pallets, or powders. To facilitate the heating of the injected materials, a dedicated heating chamber is integrated. This chamber contains different heating bands, ensuring that the polymers or other materials in pallet or powder form undergo the necessary heating process.

The hydraulic injection cylinder plays a pivotal role in the system by applying pressure, facilitating the smooth passage of the heated material. This pressurized, molten material is then directed through a nozzle tip for injection into the mold. The injection process is further supported by the presence of heating torpedoes and specific plunger-type systems, contributing to the efficient and controlled injection of the material into the mold.

The combination of these elements in the plunger-type injection molding machine underscores the intricacies involved in creating a controlled and effective process for molding a diverse range of products. The discussion will continue to explore the nuances of this injection molding machinery, shedding light on its various applications and advantages within the manufacturing landscape.

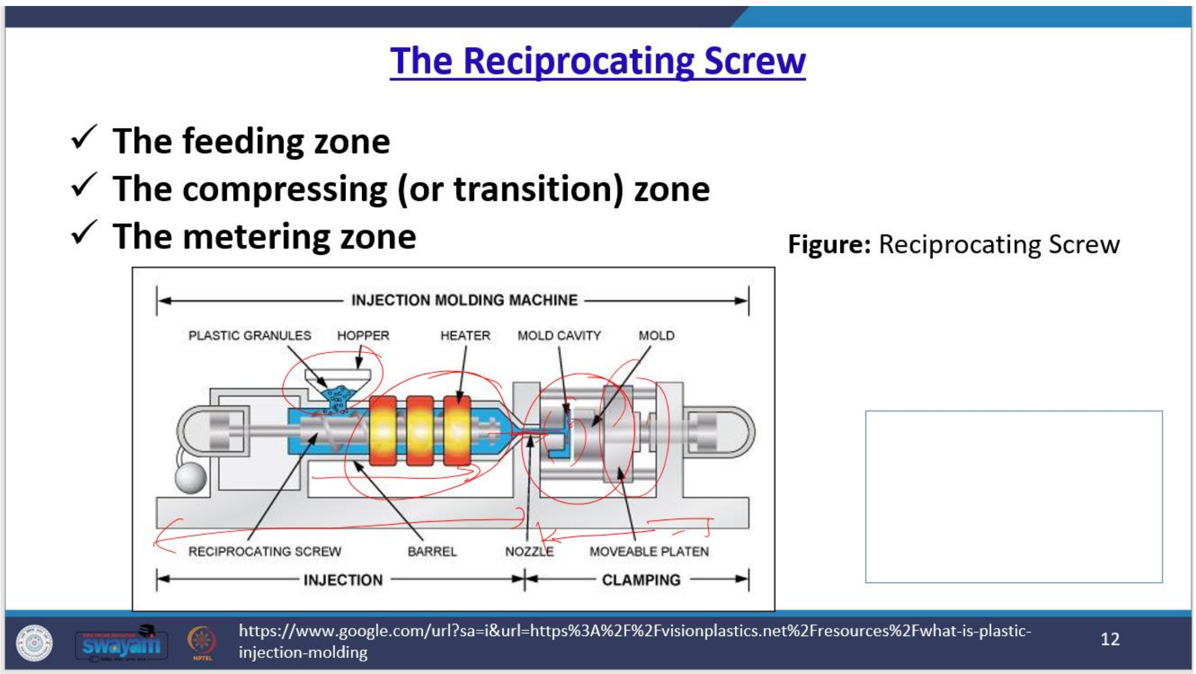


Now, let's shift our focus to the reciprocating screw-type injection molding machine, which is characterized by three major components: the feeding zone, the compression zone, and the metering zone. This design enhances the efficiency and control of the injection molding process.

Beginning with the feeding zone, the machine features a hopper where plastic granules or powder can be introduced. From there, the material progresses through the heating assembly, where it undergoes the crucial melting or heating process, acquiring the necessary properties for molding. The molten material is then injected through a nozzle into the mold cavity, which defines the desired shape for the final product.

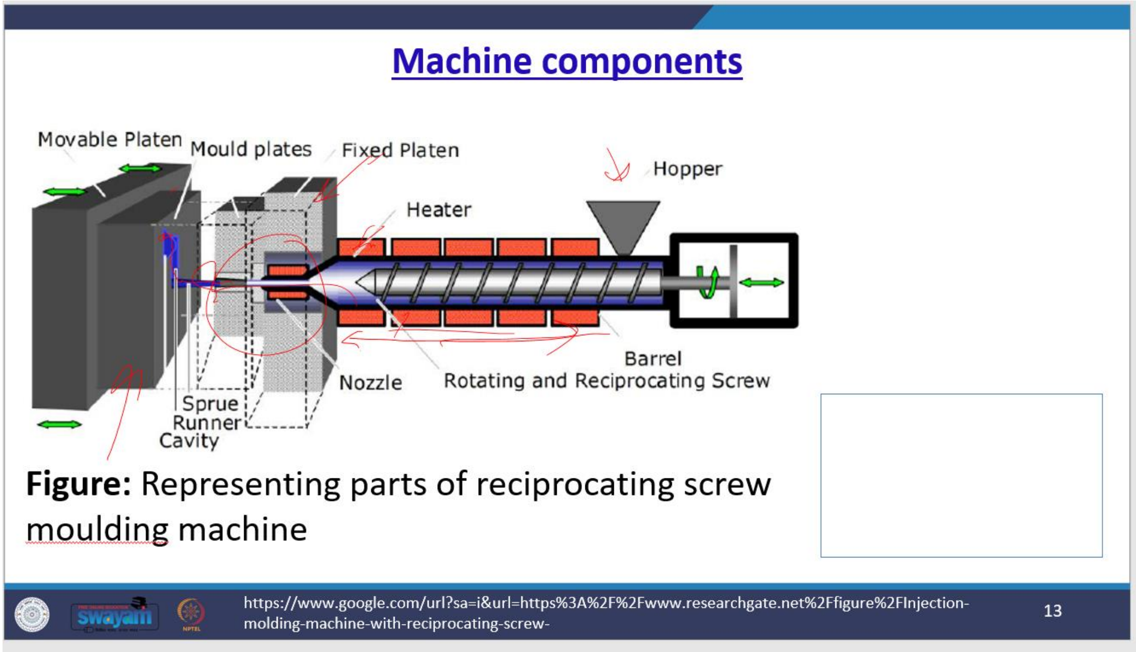
The reciprocating screw-type machine incorporates movable platens, both male and female, within the mold cavity. These platens play a crucial role in giving the molten polymer its desired shape. The barrel, injection segment, and clamping segment collectively contribute to the functioning of the machine. The injection segment encompasses the feeding hopper, the pushing system, and the heating system, while the clamping segment is dedicated to the mold section.

This segmented design allows for a more detailed control of the injection molding process, ensuring precision in material feeding, compression, and metering. As we delve deeper into this discussion, we will explore the specific advantages and applications of the reciprocating screw-type injection molding machine within the broader context of polymer processing.



Now if you see that the integral part, another integral part of the reciprocating screw molding machine, this is the nozzle, here you can have a more clear picture and through this the polymeric material inserted into the mold, these are the mold plates. So usually it is the male and female type of a system and through the runners the molten material can pass through these molds. Now here you see the heaters and this one is the fixed plate, here you see the hopper. So by rotating motion, this rotating or reciprocal motion the material is passed through this heating zone to this nozzle zone and to this the mold zone. So all these things they are the integral part of this reciprocating screw injection molding machine.

Now because these machines are sometimes they are referred as a very simple type of a machine, then and sometimes they are very complex in nature. So this injection process, injection heating and mold these three are the integral processes. So let us discuss about the injection process. Now here this plasticizes the material by the reciprocating screw. Here you see that this is the plasticizing section.



Now this injects the molten material to a closed mold. Here you see that this is the closed mold. There are various channels through which it can go inside the mold with the gates and runners. Then it cools the mold because it is a heat and plasticized material. So obviously you need to cool the mold otherwise once you remove the part then definitely it may deform over the shape.

Then refill the material for the next cycle. So once it over the prepared part come out and then it machine is ready for another cycle. Ejection of the product is again very important at appropriate time because overheating or cooling this may create a problem and the part may get deformed. And then the closing the mold for the further cycle is again very essential part. So all these are a cyclic process.

Now these are some of the commodity items which can be injection molded like buckets and different type of packaging materials. All these things are injection molded. Now there are various advantages associated with the injection molding process. One is the high production rate because it is a cyclic process. Once the material is in then definitely once the part prepared then automatically the machine ready for the next cycle.

You can have a large volume production because of the cyclic process and a relatively low labor cost per unit. So cyclic machines are available nowadays so that the labor cost or manhandling cost is very low over the period of time. And higher susceptible for automation section because these machine nowadays completely automated machines are available. There is not any requirement for finishing and different surfaces, colors, finishings are available and you can prepare the good decorative items from these injection molding machines. We have discussed some of the things over here and the process because the low labor cost because of the large volume production and because of the high production rate these machines and this process are most economical.

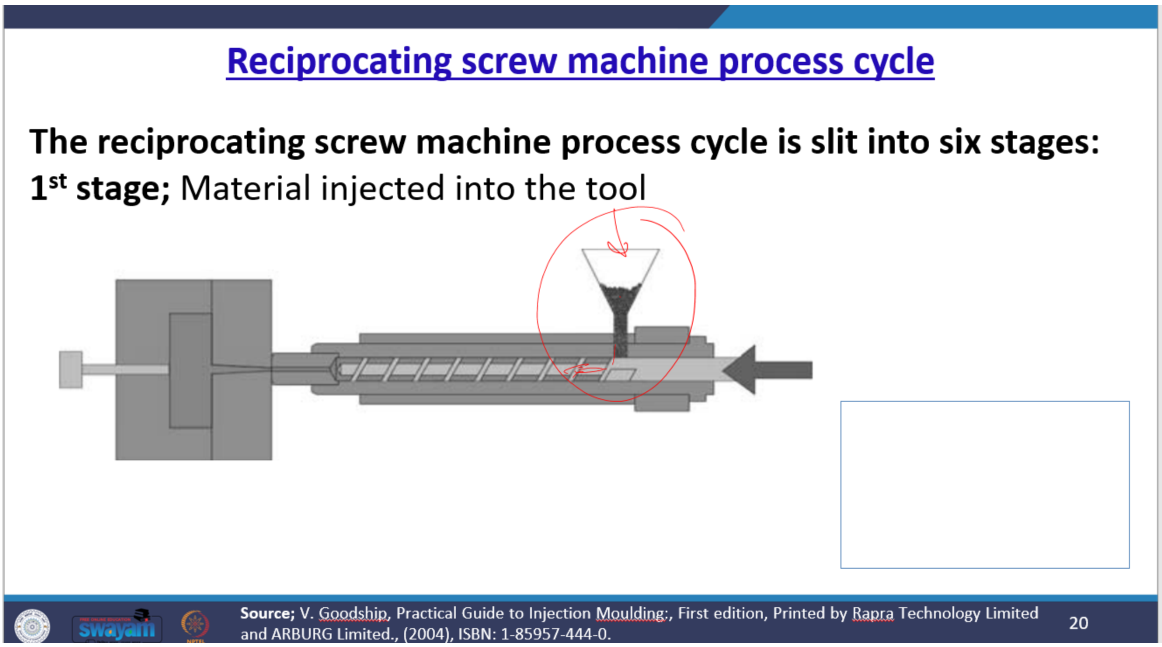
Similarly there are some you can say the some advantages or disadvantages associated small parts they are impossible to fabricate in the quantity in comparison to other methods. These are another advantages because some small parts as you can see here these parts can be fabricated from the injection molding machine very easily which are very difficult for other methods to produce. The wastage or the scrap loss usually results from the runner gates jets can be reground and reused. So usually there are certain wastage material may be the because of the runners and some sort of the material may come out this can be recycled back in that particular machine only and different materials can be used to produce the same type without changing the mold or machine.

So these are the case sensitive things. Now it is possible to preserve the tight dimension tolerance this is a very important thing in the injection molding process. The metallic and non-metallic inserts this can be molded into different into the parts as we can see in the figures. The glass, asbestos, tarp, carbon they are just of the few example of the filler that can be molded with the plastic to create the part only thing is that you need to put all these things into the hopper. The materials inherent qualities this provide the numerous benefits like excellent strength to weight ratio, corrosion resistance, strength and clarity all these things are the plus point of this injection molding process. But simultaneously there are so many limitations of these injection molding machines or rather you can say the disadvantage of these injection molding machine.

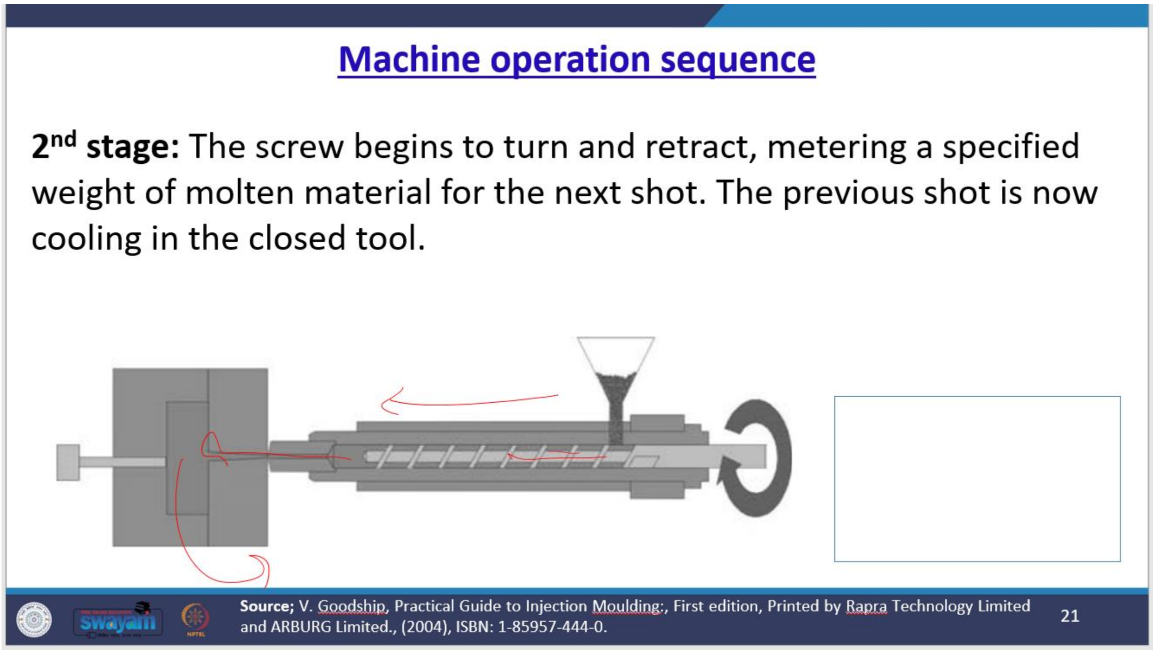
Sometimes the low profit margin which is frequently the outcome of intense industry competitiveness and you see that the mold prices are high and even in Indian context sometime with specialized mold we need to import from Korea or China. So, this add-on to their pricing and ultimately it Is add-on to the per unit volume of the part being produced to the injection molding. Now the cost of molding machine and supporting equipments are relatively high as on date. Now problem arise from a lack of understanding of the basic of the process. Now this is very crucial because you need to keep an eye about the properties of the polymer being used as a raw material.

You need to keep an eye over the affinity of the dyes and other additives being inserted in the upper section. So, you need to see of different type of problem that may arise because of the process. Then long term failures that could come from a lack of understanding of the materials and a long term characteristics. So, that is why we discussed that this particular characterization of the material is extremely important and this characterization need to be tuned as per the basics of the injection molding machine. Now the reciprocating screw type of a screw machine process cycle.

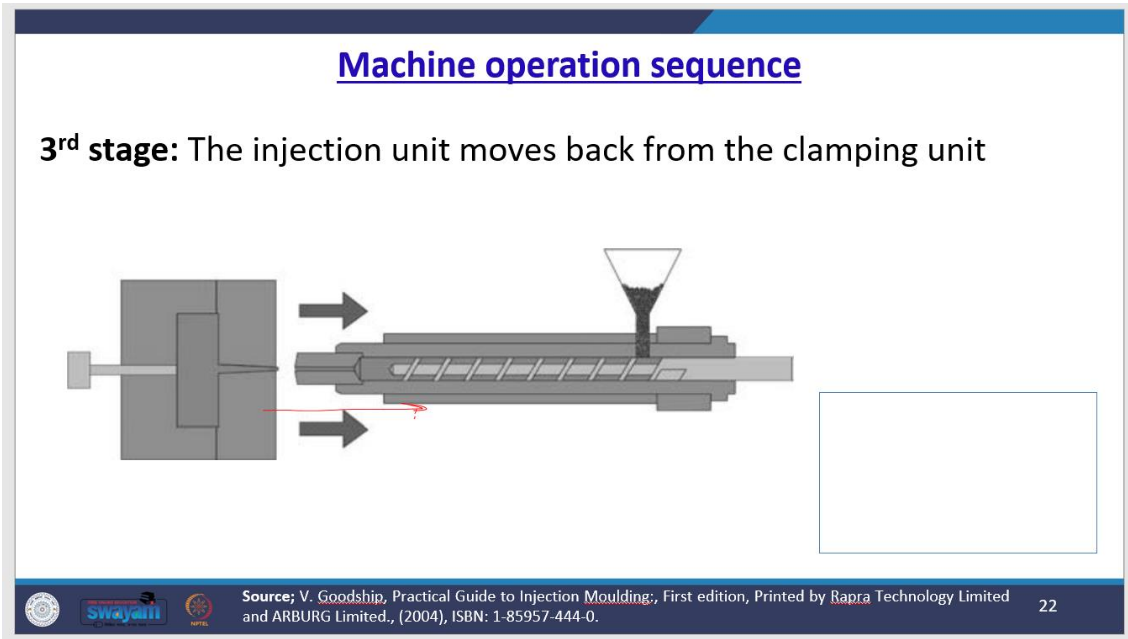
This process cycle is slit into the 6 stage. Now one is first stage 1 which briefly we discussed in the couple of slides ago that the material injected into the tool. So, this is the hopper and this material being injected into the tool. Now this twin screw serves both purpose. One is that it moves forward the material. Then second aspect is a properly mixed the things of a dye and other additives being added.

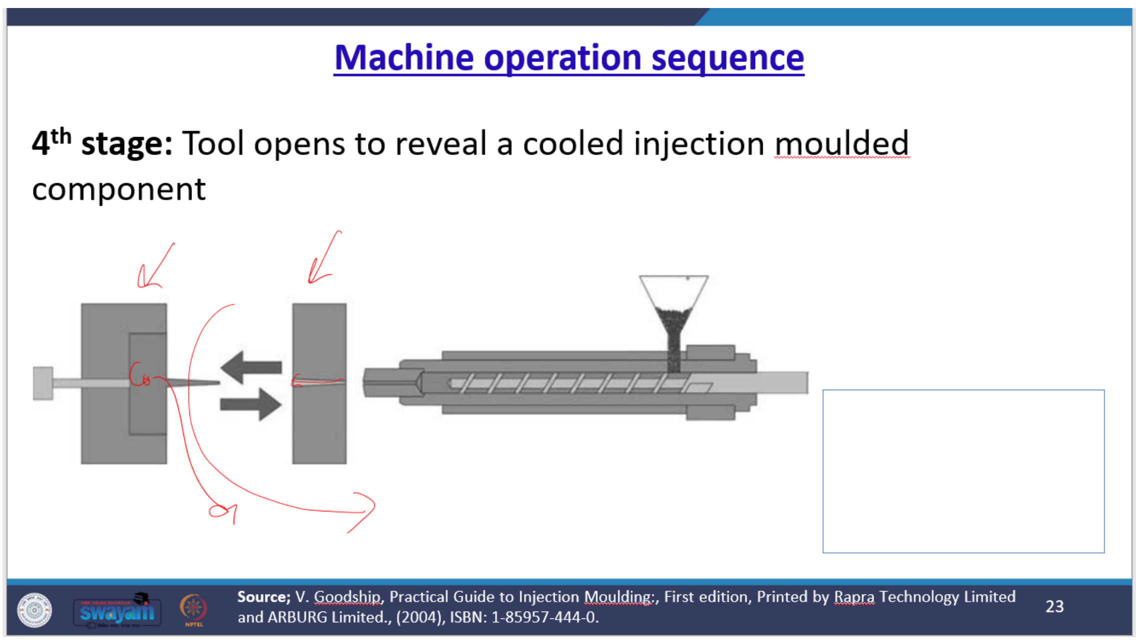


So, the second stage this screw begins to turn and retract the metering a specified weight of molten material for the next shot and the previous shot which is being inserted is now cooling and in the closed tool. So, this can be come out. The third stage the injection molding unit moves back from the clamping unit. So, this movement is like this. So, the machine is preparing itself for the next shot.

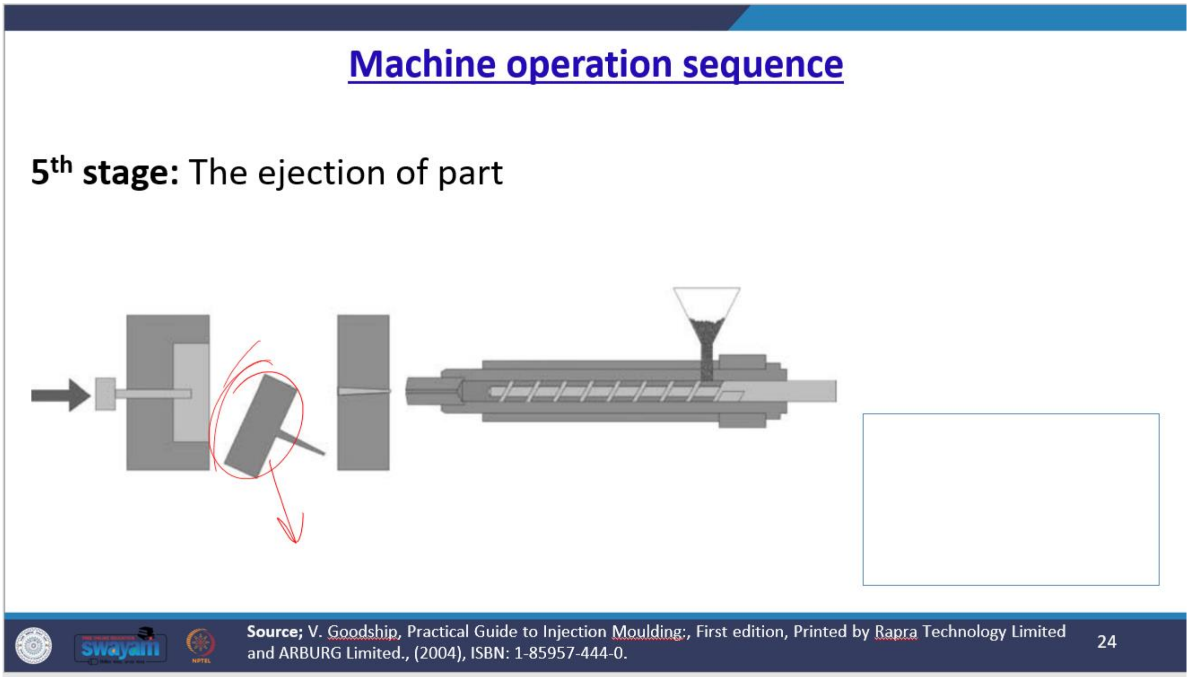


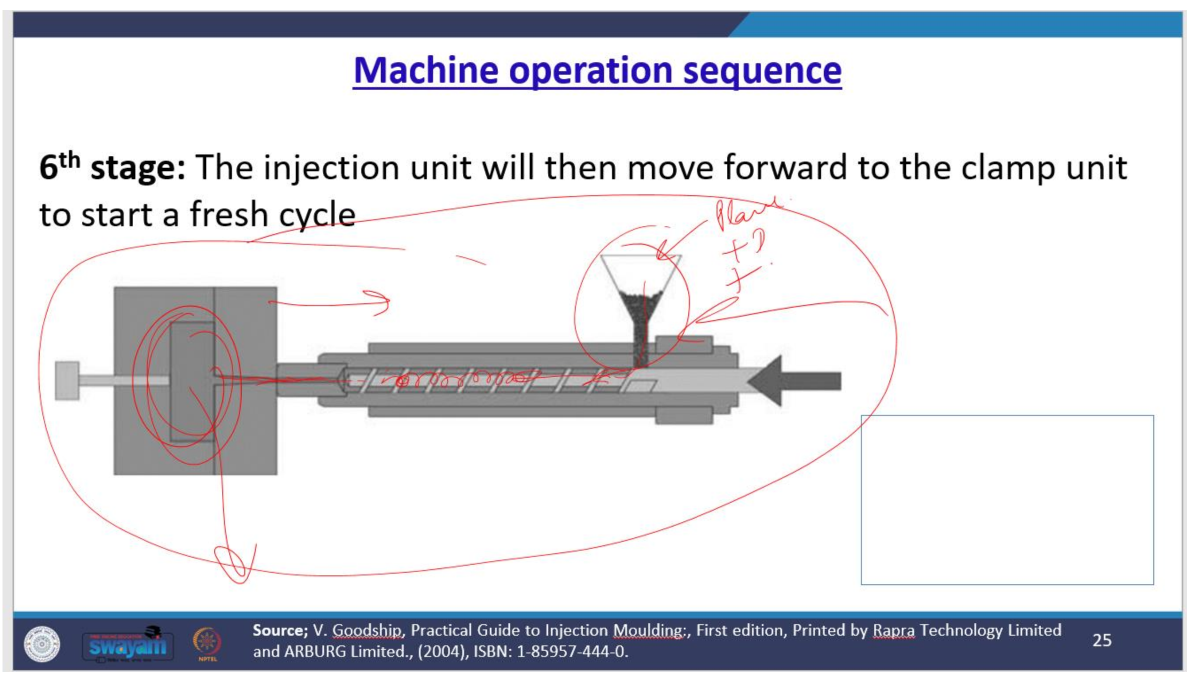
The fourth stage this tool opens and reveal the cooled injection molding component and this component can be come out. So, this is some sort this is a male and a female type of a part or vice versa. Now this is through this runner the material is being injected. Now this is the component which we need to come it out. This is the cooled one because see if the cooling process is performed at the atmospheric temperature then there may be a chance the part may get deformed.





Then this is you see that the injection part is the ejection part is there. So, the prepared part is come out from the machine and the last stage is that the injection unit then move forward for the next round of cycle or a start a fresh cycle. So, in a nutshell you see that this is the hopper from here you are the plastic material either granule in a or in a powder form plus dye plus other additives if required and these all these thing inserted and the mixing process plus heating process performed over here and then the molten mixed material is inserted into this through this runner to this mold where the this mold is filled with the molten plastic material and once this it acquires the shape then the cooling cooling starts and this section will come out and the prepared part may come out from this mold assembly. So, by this way the cooled product come out and then machine is again ready for next sort of the cycle. Now, let us discuss about the breaking down aspect of injection molding cycle.





The injection molding cycle this can be broken down into 3 distinct stages one is plastication, second one is the mold filling and third one is the cooling with solidification. So, proper optimization in all the aspect is quite essential in injection molding machine at what time you need to come out with the material at what time what temperature is required what pressure need to apply how the cooling process takes place what should be the cycle time. So, all these things are quite essential and you must have some optimization in this aspect. So, let us discuss about the plastication this is carried out in the injection unit and the polymer flow rate which is quite essential to be monitored the polymer flow rate is governed by the material processing condition of the plastication state. A combination of material you need to have a proper knowledge of rheology the barrel temperature shear back pressure screw speed mixing speed heating zones all these things you need to be very careful and you need to optimize these things.

Now, the aim is to produce the homogeneous melt because otherwise there may be some segmental things and the quality of the product will not be there. So, the basic objective is that you must have the homogeneous melt for the next stage and this has to be done when the material enters to the mold. The parameters which are usually controlling the plastication we have already discussed that the cylinder temperature screw back temperature back pressure etcetera and then what is the size and other things so that proper homogenization should be there. Next is the filling this section the injection unit delivers the preset amount of a molten polymer to the mold tool. So, excess material is always undesirable because it may not only lead to the pressure to the injection molding system but also it may create the future problem and we need to recycle the excess material which unnecessary enhance the cost of your product.

So, the mold filling parameters they are crucial to the outcome particularly whenever taking into account things like var patch this is sometimes referred as a orientation effect surface finish skin formation all those things. So, the level of the residual stress are also assumed to be primarily influenced by filling dynamics. Now, the reproducible injection speed these are again crucial since even little alteration can result in the valencies in the final product this may create some air voids this may create the weakness of the this may further weaken the final parts. So, this is again a very crucial too high injection speed can result the jetting and deterioration which can alter the mechanical properties apart from this if you are having the too high injection speed sometimes the mold runners can get choked and this may ultimately destroy your mold and which is very costly affair. Now, due to the thicker frozen layer the brief shots in complete filling of the mold low speed may increase the pressure needs.

So, again this is a very important and this is the engineering perspective. Then let us have a discussion about the packing and solidification. So, once a material is in the tool filling tool packing cooling and eventually the ejection of the component are required. The packing stage goal is to add more material to make up shrinkage brought on by the solidifying polymer decrease the density. So, this is again very crucial and you need to optimize because once the material is cooled there may be certain effects may take place this may ultimately deform the outcome of the product.

The component would shrink deform as a result of uneven cooling if additional polymer went supplied. So, this type of a thing need to be addressed because ultimately the additional polymer put a pressure so that the final part or product acquires the desired shape upon cooling because shrinkage may occur. So, the polymeric chain may get entangled so the deformation may take place. So, that is why to overcome such kind of a thing you need to have some additional polymer to be injected. Now in a perfect scenario the packing and cooling processes would keep the final dimension as near as possible feasible to the design tolerance.

Now variables during the stage are packing pressures, packing time and the mold temperature. So, mold temperature and the injection temperature these need to be sink in different ways. So, the once material is cooled sufficiently the component can be injected and injection cycle continues. Now here you see the breakdown of injection molding process cooling different aspects like mold closes, cycle starts, injection, packing stage, screw backs, cooling and then mold opens. So, this represents the complete cycle of injection molding process.

Now you see that the heart of the injection molding process is mold because this gives the proper shape of the product you desire. Apart from this, this also having a triggering factor for the proper shape, proper quality and all those things which is needed. So, that is why the mold is said to be the heart of the process. Now here different type of molds are there.

The injection mold tool has two major purpose. One is that it is the cavity into which the molten plastic is injected and the surface of the tool acts as the heat exchanger because you need to cool down or you need to heat all those things carried out in the mold operation. The injection mold designs may differ depending on the type of the material and component being molded. One is the two plate mold. It is the simplest one, the male and female type and this the mold cavities are formed in one plate with the stationary half of the mold blank. Now the central screw brushing can be placed into the stationary half of the mold or it is possible to have a direct runner system into a multi-impletion mold and the moving half of the mold contains the ejection mechanism so that the pins can inserted and the material can out come out.

Now here you see the two plate injection mold. Now here this is the ejector pin and you see that these are the ejector system and these are the cavities which we are discussing over the period of time and this is the sprue and this one is the stationary plate. So this one is the moving plate and this one is the stationary plate. So this moves as per the injection or the plunger type of a system moves in and out so that once and one segment is fixed.

So this moves like this. Now here is the stripper type of a mold. This it is similar to the standard two plate mold except the ejection system. It has a stripper plate for ejection whereas the standard one has the pins and a sleeve as ejector. The advantage of a stripper plate is that increased surface area for ejection. Now here you see that the stripper plate. Now here this is the moving plate as discussed and this one is the stripper plate and this is the cavity you see and this one is the parting line and this is the sprue and this one is the stationary plate.

Now stationary plate is fixed with the stationary part of injection molding machine and this one is the moving which moves as the barrel moves in and out. Now slide molds it also has a two plate mold. It has a slides and campings for additional lateral movement and it is suitable for producing part with undercuts or external threads like this.

This is the slide mold. Now here you see this is the ejector system. This is the camping so that it can ease out the finished product and as usual these are the cavities, these are the slides and this one is the sprue. So again this is a stationary plate and this is the moving plate. Another is the three plate mold. This is used when multi cavities are involved and a semi or fully automatic working is required. It has an extra plate and extra plate usually continues the gate on one of its sides with the complete runner system preferably trapezoidal.

Now this is a more obviously when there are more parts then it is more expensive and slower in production than the two plates. Now here you see the three mold system. Now here this is again as usual our ejection system. This one is the stripper bolt and this cavity and this one is the runner and the sprue is here. So this is the stationary plate and this one is as usual our moving plate connected with the barrels.

Now there are various screws being used in the injection molding machine. Now there are screws with three distinct reasons, feed zone, melting transition reason and the metering section. Now here you see that the injection screws, this is the passive screw and this is the standard screw. I told you that the purpose of screw is to move the material as well as the mixing of the material and sort of this because of the friction the material is again some sort heating. Now screw usually they have been three zones with the ring plunger assembly. One is the feed zone where the plastic is carried along a fixed root diameter after initially entered into the screw.

Then the transition zone where the plastics is moved in the forward direction and squeezed and the melted along the tapering route with an increasing root diameter so that when it is melting then it can easily pass through the nozzle. Then the metering zone where the plastic is finished melting and is being transported forward to the constant root diameter to a temperature and viscosity where parts can be formed through nozzle. L by D ratio is again very important. L by D ratio is the ratio of the flagged length effective length of the screw to outside its outside diameter. For thermoplastic it is usually minimum 20 is to 1 and for thermoset elastomer it is made approximately 14 point 14 is to 1.

For extended plasticizing screw the L by D maybe 24 is to 1. This is usually used for the thermoplastic with the color additives especially with the polypropylene and polyethylene. So effect of if we are having the high L by D ratio then the plastic can create more shear heat uniformly without degrading the high homogeneity of the metal is produced by increasing the mixing opportunities. The longer the plastics residence period in the barrel might allow for greater short cycle to happen more quickly. Compression ratio is again very important. This is the ratio of the first flight depth of feed zone to the last flight depth of metering zone or first channel volume of the feed zone to the last channel volume of the metering zone.

So basically it ranges from 1.5 is to 1 to 4.5 is to 1 for the most thermoplastic materials. Now most injection screws classify as a general purpose and have a compression ratio of 2.5 is to 1 to 3 is to 1 and thermoset screw have a 1 is to 1 ratio. Now question arises that what will happen if we are having the high compression ratio.

So effect of high compression ratio is again very important. Now it will provide the greater shear heat imparted to the resin, greater heat uniformity to the melt, high potential for creating stresses in some resin and high energy consumption. Back pressure it is again very important. Now it is the amount of the pressure exerted by the material head of the screw as the screw is pushed back in preparation for the next shot and it has the unit of kilogram per centimetre square or bar. The effect of back pressure, the more homogeneous mixture, you may have the proper melting, you may have a more compact material and sometimes it leads to degradation.

Now this is showing the pressure profile in injection molding machine. So you see that if this is the one cycle, one mold closes, then material, then plunger machine it fills, then it goes forward direction, the pressure or plunger adds the material to compensate for the shrinkage as a material, then injection and then clamp hold and mold goes and part removed. So you see the pressure versus time cycle. So this type of a plot is essential when you are performing any kind of injection molding operation. Injection speed is again very crucial, important. This is the forward speed of the screw during its injection operation and it is having the unit of centimetre per second.

Now this, the effect of injection speed is attributed to the easy injection of material. This avoids the short shots and sometimes lead to the more orientation and burn marks. Now the screw rotation speed is again important. It is, you see that represented in RPM and rate at which this plasticizing screw rotates. Now the faster screw rotation can cause the faster material is compressed by screw flights. It may increase the amount of shear heating, it may create the low residence time and some less melting.

Cushioning. The cushioning is the difference between the screws actual forward in position and the maximum permitted forward position. So the more cushion results, more residence time, sometimes degrades the material. Now the cushion would be 0 if the screw were permitted to complete its whole stroke before coming to the mechanical stop against the nozzle. Now 0 cushion has no hold over works and usually 3 to 6 mm cushion is employed in that particular aspect. Now here you see that the cushioning aspect, 4 to 6 mm for smaller machines and 10 to 15 mm for the larger machines.

So at the outset in this particular segment we discussed about the various integral part of injection molding machines and what are the different zones, how we can optimize and what are the integral part of these injection molding machines. Now ultimately the basic aim is to have a brief outlook about these injection molding machines so that once performed it can provide a good product as desired. For your convenience we have enlisted couple of references, you can utilize these references as and when needed. Thank you very much.