Rheology and Processing of Paints, Plastic and Elastomer based Composites
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Lecture 37
Molding Techniques

Welcome to NPTEL online certification courses on Rheology and Processing of Paints, Plastic and Elastomer based composites. Today we are in on week 7 and lecture number 7.1. We will try to see the generalized concept of molding techniques and their concepts. So, concepts cover will be on molding and particularly initially we will emphasize on compression molding which is very common amongst all other molding technique, then gradually we will move on into the transfer molding and from transfer to the injection. And then about the injection we will elaborate little bit on the machine side, clamping units, injection unit and little bit on screw design roughly although we will elaborate while talking about extrusion in more details.

Again just in case you want to have a look through the literature these are the some of the keywords and most importantly here you can look into the flight, then pitch all these keywords to understand about the screw and in for the compression molding different types of daylight, single daylight, multi daylight, difference between ram and a plunger, thermal diffusibility as I told you in all this processing case thermal diffusivity plays very very important role, heat transfer part particularly. And about the injections about the screw as I mentioned already and also nozzles, runners and gates those are the places from which actually your you know polymer melt or polymer liquid is injected into the mold cavity. So, anyway let us first try to look into what is molding. So, molding is one of the five core processes involved in rubber and plastic manufacturing alongside with what are the other major casting, forming, machining and additive manufacturing.

So, the very primitive one is of course, in the solid state it is being done is a molding technique and extrusion comes into the forming that part itself. So, though they share some similarities that process are quite different. So, casting is altogether a different story compared to that of a molding. So, a molding process uses pressure and heat to fill the cavity of a mold and a rigid frame also known as the matrix. And the raw material typically pliable one like plastic, glass or ceramic is kept under pressure until solidifies or vulcanize solidifies I am talking about if you consider a plastic or thermoplastic, but if you consider a thermoset including rubber, epoxies others.

So, you have to really make sure that they cure before you release it. So, that is what it is called hardening process. So, for the epoxies or thermosetting resin for rubber it is well known as vulcanization. So, advantages of molding include greater accuracy, versatility and efficiency if I compare with the casting the one which is the counterpart of it ok. So, again the first question which I was trying to answer you what is the difference between the molding and casting ok.

The molding is different from casting and casting which is when the liquid or molten polymer is poured into a mold and solidifies to form a part. So, there is no question of pressure no pressure other than the gravity involved there ok. And the advantages of casting including the durability a greater complexity of the design ok and however, it may not be possible to cast a very large part while you can do it pretty well with the molding ok. So, this carton shows you a direct comparison between casting and molding. So, you can really you are making a bottle here by the process of molding.

So, there are 4 major types of molding I mean we are trying to make it generalized way ok. Although when you talk about rubber molding there are 3 different compression you know transfer and injection ok namely. So, in generalized way in the literature you will find it is rather categorized into 3 I mean 4 types. What is the compression molding? Where rubber is placed in a I mean heated mold and the mold is closed and held in pressure until the rubber takes it is safe actually it cures for the rubber that is the basic difference. See for the rubber vice versa plastic and let us take consideration into crystalline plastic semi crystalline plastic.

Semi crystalline plastic you just apply temperature and pressure it occupies the cavity ok. Then also your heat treatment plays very very important role because way it crystallizes way you cool it down that matters. But for the rubber what it matters that you have to complete the vulcanization finish the vulcanization. So, your molding time you will all decided by it is optimum cure charge or so. So, you have to take care of the thickness as well ok.

I mean if you make a thicker article want to mold it you have to obviously, allow more time than that you get it from ODR or MDR results ok. So, that is how a compression molding is accomplished by compression molding technique. More importantly for thermoplastic semi crystalline plastic heating rate or cooling rate plays very very important role because that is when it actually crystallizes under the pressurized condition after it takes the shape ok. So, that you have to under cooling part also you have to take it into consideration. So, actually some male molding is basically what I was emphasizing.

When when applied to thermoplastic material compression molding is referred to male molding. So, one hand you have compression molding of a thermoset rubber once it cures you do not mind whether it is a 200 degree centigrade you just quench it quickly also ok. No question of you know heat transfer slow slowly cool it down. But in the later case male molding case this plays very significant role until the time is perfectly allowed for perfect crystallization to come a equilibrium orientation of the molecules different domains is important. So, third one is actually transfer molding it is between compression and injection.

What it does you try to put it in between in terribly in a in a cavity where the belt gets heated up and in a flowable condition is established. Then you further ramp it down through a narrow clearance kind of a nozzle and it feeds into the final cavity that is what is the transfer. While for the injection it is all together you convey the mass molten mass you make it sufficiently soften or plasticized and try to inject it at a very fast rate through a very I mean a combination of say nozzles, sprue nozzles or nonnose and gate. It ultimately I mean depending on the intricacy of the design of the mold you have a multiple entry of that to to fill it uniformly the whole cavity and that is what makes it different in terms of that particular design was aspect also have to be taken into consideration. But as I told you compression transfer molding if you try to consider the quantum of shear rate involved in compression it is of the tune of some tens of second inverse.

Transfer while you are injecting it is of the tune of hundreds of second inverse while talking about injection molding is 10000 second inverse around that area. So, you can consider you can understand that rubber being taking it very very generalized fluid way is a pseudo plastic or shear thinning type. So, you can understand while dealing with injection which is 10 to the power 4 second inverse molten polymer behaves like a liquid simply like a liquid is viscosity goes down significantly. So, its flow inside the cavity will be much faster much accurate compared to our later earlier two techniques that way precision surface finish will be much better in a for the injection molding process. And also the molding time is also shorter because in course of you know filling the cavity I mean it gets heated up I mean that that also you have to take it into consideration.

So, in a nutshell if you just try to compare compression melt molding compression also melt molding also you can combine with the compression molding as well. And then transfer and injection all all this cross three major techniques if you tool take them transfer molding obviously, tooling geometries are a bit more complex mold design is bit complex and that complexity is further more further more expensive in terms of injection, but productivity wise this is number one followed by this is this is. So, you can understand one process to the other. Let me tell you one thing although injection is the molding process considered for the plastic items, but rubber it took little time ok. Rubber initially was banking on you know compression molding slowly slowly compression becomes semi automatic to automatic the compression molding then it went to transfer and some of the metal to rubber bonded cases where precision is at most important surface contact is more important its move towards the injection.

So, that transition for rubber you know shaping took little time it lagged behind little bit compared to that of you know plastics. Otherwise molded item made by injection will always have a much more precision over that of later two technique transfer as well as you can consider more first generation is compression transfer is the second generation third generation is your injection. So, once again in compression molding it is a it is a it consists of heavy metal base and which slide rods with which your two you know part actually one of the part can travel back and forth and apply the requisite pressure to the sliding rods basically ok. And a movement of a compression assembly and the force clamp against the base are usually provided by hydraulic presses ok. It can be hydraulic or other categories a mechanical one ok.

So, you can actually calculate the press gravity the force there involve the press gravity N area of the ramp multiplied by hydraulic pressure ok. So, the force to the mold a particular component depends on the material characteristics or part geometry and empirical relation used obviously, I mean if you consider take it into consideration the area and the dimension of it takes exactly this form that is the force involved. So, according to that you can calculate out through this empirical relation what exactly the pressure requirement. As far as design is concerned there are two types of compression molding machines one is down stroke compression press another is a up stroke one ok. Down stroke means it is upper plate end is coming down on the base ok which is quite common actually compared to that of the up stroke compression sort of a machines.

The first type compression assembly closes down onto the base of the machines and the advantage of this machine is the material is kept on a stationary platen and the ejection of the product can be effectively done from the bottom. And main disadvantage of this type of a machine that in case of hydraulic failure the operators handmade might get trapped between these two. Now, those accident risk are there otherwise I mean as I mentioned down stroke is taken by a large, but if you really would like to take care of that accident that accident is quite frequently happening then you have to go for the up stroke sort of a design. So, this is what roughly shows you I am not elaborating I mean this slides will be shared to you each and every components are written here you know I mean kind of a top platen bottom platen and mold hubs two part molds basically and then moving head ram how it actions and in the in this more precisely how the ram slides the pictorial it is depicted ok. But at this stage I will say I mean most of the commercial compression presses like special in the shoe industries you will find where they are making the sole part of it it is multi day light not a single day light.

So, in one go you are trying to have more productivity. So, as I mentioned earlier this compression presses used to be fully manual. So, then it move towards semi automatic and then automatic where your feed everything will be almost kind of automatic arm will be there it will take care of that ok. So, it is used for to improve the productivity of course, the automated one and hence all steps of the compression molding can be cycles are automated. And the widely used machine is a vertical type in which the platen moves up and down with a number of molds mounted that is a multiple day light kind of a structure.

And at the end of each cycle the molded pieces are stripped from the mold using a knock out pins or air blast ok. So, it makes it otherwise you have to open it then manually it has to be open and then that has to be you know whatever flash it has to be cut it out manually and then you have to machine it further to to give it a safe. So, those things are made quite automatic actually. So, automatic rotary paste which is quite common and these machines have large fixed and movable platteens on which respective molds ah mold hubs are fixed you can fix it even with automated robotic hand also it can be fixed there ok no issue. A movable arm goes around the platen to load the material and remove the molded parts and that is the basics of it ok.

Whether it is a 360 degree rotation or some rotation it depends on whether you make it semi or fully automated one. So, grossly if you look it at as I mentioned it to you in compression molding you can take care of all thermosets including phenolics, urea formaldehyde, melamine, epoxies, silicones like in thermosets, alkyd resins, unsaturated polyesters and most of the rubbers can be made by that process. And as I mentioned already to you for the thermosets particularly you need a curing agent you need a catalyst sometimes, silicon rubber say for example, if it is a platinum cured one you need to have a two part and then you have to go for the curing as I mentioned it to you. So, these are the major rubbers which can be compression molded and mind that mostly this for the rubber items are molded excepting certain gaskets or rubber bands mostly it is metal to rubber bonded products which are manufactured by molding techniques normally. So, you must understand one thing the flow and cure relationship that is very important for thermosets.

Press Capacity (N) = Area of Ram (m^2) x Hydraulic Pressure (Pa)

F =(A).[(L) + (k d)]

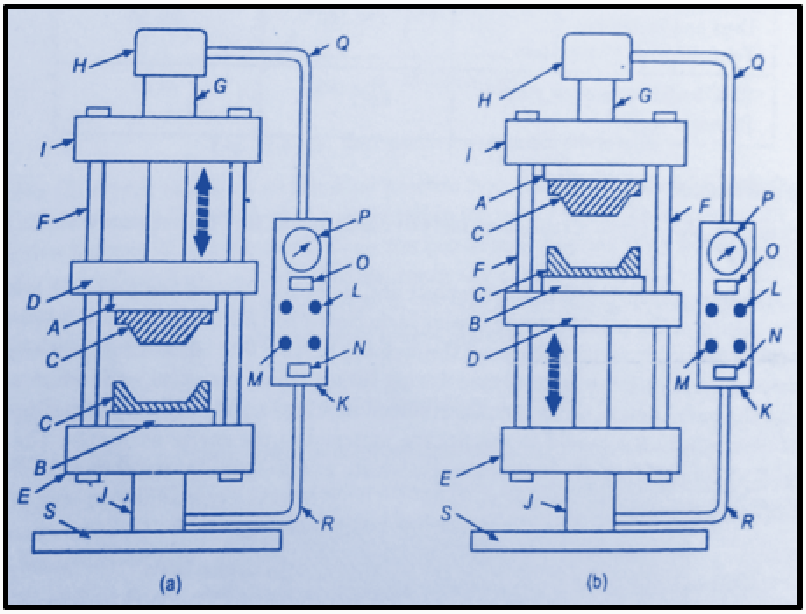
Where 'F' is force (N) required to mould the part.
'A' is the projected area (m^2) of the part,
'P' is the required cavity pressure (Pa) for a given material.
'k' is the additional pressure factor (Pa/m) accounting for the depth and 'd'(m) is the excess depth in excess of the minimum.

So, flow cure relationships. So, try to understand one thing the first part it has to be occupy the mold cavity without any interferences. So, it should not be scorching or pre cured. So, flow once it starts curing then flow will be arrested you will not be effectively there will be cavity there will be defects. So, there must be some induction time or safety time by which over which the material flows the cavity and then once it if it is a thermoset it has to be cured pretty fast.

So, next step is to release it. So, that is how you have a flow as well as cure relationship that you must understand while doing the curing of a thermosets. If it is a thermoplastic it does not matter for you you do not have to have a consideration your basic aim is it is a recyclable repeatable in thermal cycling. So, even if you allow little more time also less time also does not matter really only thing is that you lose in terms of you know electricity bill and cost of the molding basically. So, you can see here on your right side a table is given the molding material temperature pressure range roughly about. So, pressure also it is there is nothing like thermal although we take it like 6 to 10 for mostly for the rubber curing, but of course, for phenol formaldehyde urea melamine DMC you have a specified temperature as well as pressure range over which normally is molding is done.

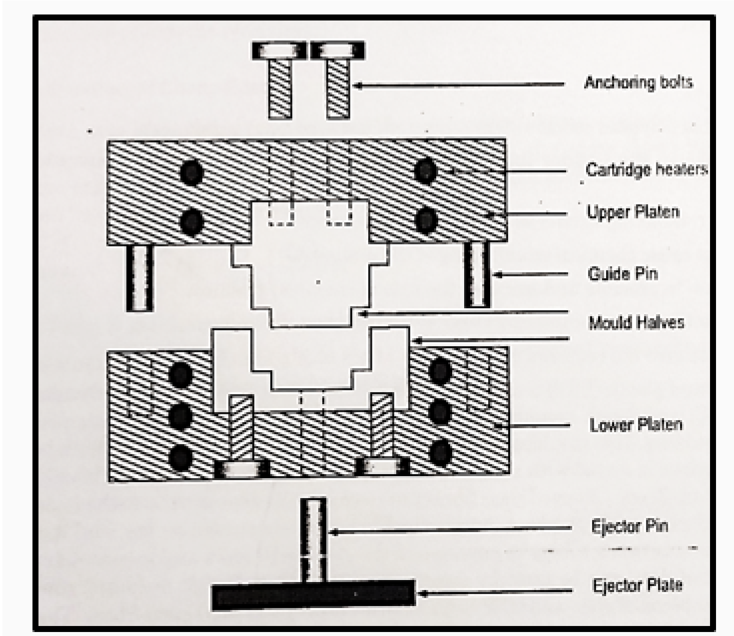
So, there are different types of molds of course, it can be like mainly there are 3 types flash molds positive mold and semi positive molds and those are elaborated here the positive mold then you know flash mold and then as well as the semi positive mold it is all about the for the flash mold through here you have a lot of wastage of material there will be a flash and the positive mold closer it has to have a precision by the way if geometry is not perfected then it will appear as a defect even though you do not have a flash loss here. So, semi positive is a little bit different you have a valve out here to separate the flash automatically. So, those are the things 3 different types to get rid of the flash to have the more precision of course, so if you have a semi positive or positive type of a mold semi positive is even further better. So, you have a you can separate flash very easily here. So, you can actually calculate this curtain source this picture source taking a cylindrical geometry.

Compression presses



A-top platen; B-bottom platen; C-mould halves; D-moving head; E-bottom stationary head; F-press pillars; G-top hydraulic ram; H-top hydraulic pressure head; I-top stationary head; J-bottom hydraulic ram; K-control panel; L-hydraulic ram operating switches; M-platen temp. indicators and control; N-switch to stop; O-switch to start; P-pressure gauge indicator; Q, R -hydraulic ram actuating lines; S-base.

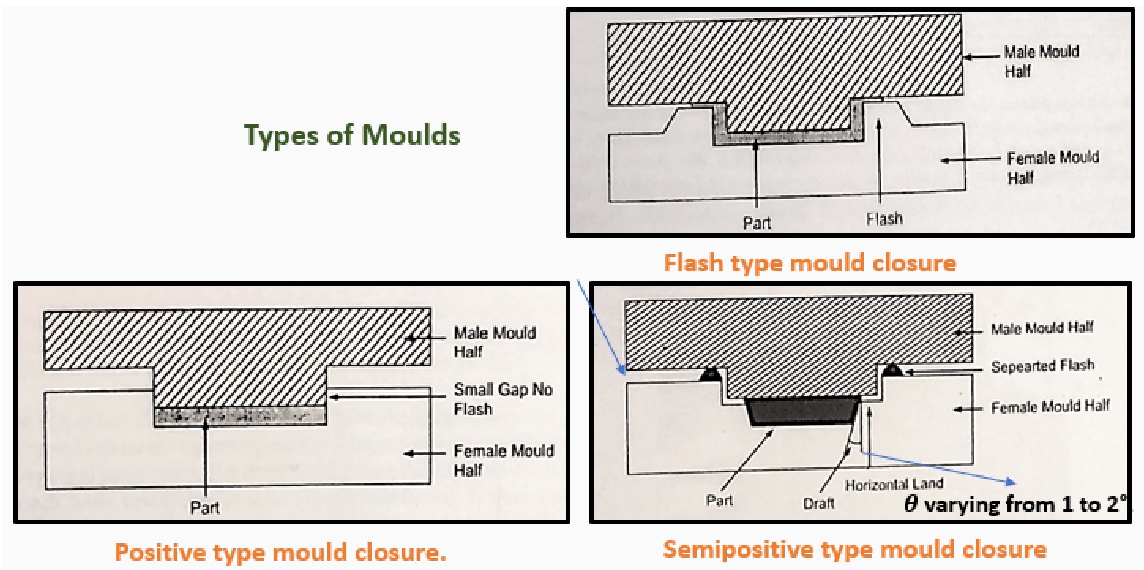
So, how the pressure is applied how the material is flowing this is the flow direction. So, if you consider that you can easily calculate the pressure flow part of it with this if you take a small volume element here and you can calculate out this is what is exactly with the geometry the flow is a t and h are the channel width and height respectively. And finally, for a cylindrical coordinate if you try to take the differential element you end up having Qp equals to 1 by 12 eta it is a viscosity obviously, and 2 pi r into h cube that is how you get it. So, if you integrate it over the volume you get f equals to 3 eta into v square by 8 pi into t h to the power 4 that is how you can you can actually calculate the total force that is requiring for a given sort of a you know flow of the material there inside the cavity. So, terms associated with the compression molding is the clamping force, clamp stroke, mold platen and delights, surtight, guide pins, knock out and performs.



Side ram type machine Compression mould platens

So, these are the parameters you must have to taken into consideration designing the pressure of course, I have not talked about the mold design part of it is also a different ball game basically. Although in this particular course we are not taking into consideration particularly the mold design of compression transfer or injection. Let us see if we can upgrade this course later on after certain times those component will be added on I mean how you effectively do it in a basic engineering design as well as the advanced tooling technique including with the fluid may help of fluid mechanics and computational fluid dynamics how you can take care of that part. So, that is not by the way included here I just intention is to make you familiar with the intricacies of this three molding techniques precisely. Let us move our attention to transfer let us see as I told you have a compression molding you have a plunger and that gives you a upper platen and then you have a lower platen in between there mold cavity mold will sit on in the bottom plate you fill the material and then try to press it take out the flash and then your molding is in a specified time I mean as required by whether it is a thermoset or thermoplastic you decide upon your molding cycles.

But here on the contrary, it goes through a intermediate pot basically where is a you can consider it is a reservoir where you give a thermal plasticization part of it and then through a sprue and a runner channel it tries to fill the cavity of the mold and you see there are parallel two molds molding is happening through a singular entry of the material inside the channel. So, this is what exactly you are doing and transfer molding in compression press yes you can do it in this case the plunger portion of the mold is clamped to the top platen and of the of course, we are talking about down stroke you know press for this for the timing the force required for the transfer of the materials developed on the hydraulic ramp. So, that also need to be calculated exactly how much force is needed for a particular volumetric flow rate through the you know sprue and runner and that within a specified time it will try to fill out the cavity of the molds that is required. So, these are also have to be taken into account while designing this type of a molds basically and the area of the pot should be 10 to 15 percent more than the area of the cavity and the runner. So, that is also one of the thumb rule that is required ok.



Flash type mould closure

Positive type mould closure.

Semipositive type mould closure

So, without going into the details, details rest of the part you please read through it will be provided to you. But you try to see plunger transfer molding here in this type an auxiliary ram is used to exert the force ok and the auxiliary ram forces the preheated material into the pot through the runner into the cavities and a two plate mold is used here ok. So, as you can see from a b c here how it is finally, being performed from the pot to transferring into the mold and finally, ejection out with the ejection pins basically ok. So, systematically that is how you achieve the from filling to the ejection basically. So, of course, this what I showed you a plunger type transfer mold can be little bit upgraded ok.

It can be made to like a screw based conveying system because screw based conveying system is giving you a automatic you know plasticization effect that you would not get it in a runner although with a ram or plunger you can go for a high pressure injection of course, So I agreed, ok? What you cannot apparently do with the screw because of screw is leave a gap between the barrel and the screw. So, that way taking into that advantage by the conveying process from the feed itself it will be heavily plasticized before it reaches to the you know pot and then the second phase is of course, is a plunger will takes care of the next part of it. So, the transfer ram lifts up while charge is transferred through the screw and then it comes down. So, that is how the exactly the mechanism happens for a screw type transfer molding techniques ok. It is something in between transfer and injection the transition is you better understand once we go into the injection process.

Molding materials and temperature and pressure range

Material	*Temperature (°C)*	*Pressure (MPa)*
Phenol Formaldehyde Compounds	150-200	14-40(20 typical)
Urea and Melamine Formaldehyde Compounds	120-160	20-40
DMC based on General purpose Polyester resin	120-165	6-10

So, advantages and disadvantages of transfer molding of course, as I mentioned flash is minimum because you are after the pot it is going to a precise you know mold cavity ok no question of flash there. But at the same time it has since higher shear rate the performance is being done I mean molding is being done. So, flow is much better compared to that of compression. So, these are the two major advantages, but disadvantages are the wastage of material in the form of sprue, curl and runner is higher because you have a additional components there before it transfers there. And I mean one molding to the other if you move on you have to really have some loss there of course, you cannot negate that and tool costs are higher in than the compression molding.

So, as I told you it need much precision of the design and there itself is cost more as far as I mean as comparison to your injection molding techniques. Again coming to the injection by by now you might have understood that it is going to perform we are going to perform the operation at much higher shear rate. So, the precision will be much higher. So, the finish will be much higher without any flash. So, the texture and characteristics will be much much much better texture is the surface finish of it I am talking about.

So, this process can be used for all thermoplastics and it is taken over nowadays by thermosets including rubber as I mentioned it to you. So, an injection molding machine is basically a tool for raising the temperature of the polymer to a point where it will show under the pressure into a clamped mold the mold is clamped. And in fact, and all if you have a single injection point. So, there should be some sort of a mechanism which can rotate and each point there will be fitted with the cavity clamped cavity. So, each and every time the one clamp comes gets fit in it comes this rotates and the next will come and by the time it comes over here the pins will automatically eject it.

$$Q_p = \frac{1}{12\eta}\left(\frac{dp}{dz}\right)TH^3$$

where 'T' and 'H' are channel width and height respectively.

$$Q_p = \frac{1}{12\eta}\left(\frac{dp}{dr}\right)(2\pi r)H^3$$

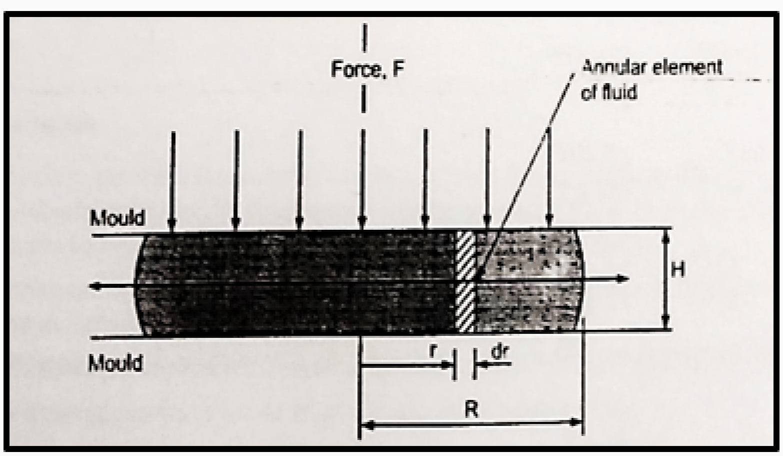
By integrating across the platen surface As a result the compaction (clamp) force F is given by-

$$F = \frac{3\eta V^2}{8\pi t H^4}$$

where H is the platen separation at time t, V is the melt volume and H_0, is the initial separation.

So, it will be a continuous process that way. So, injection unit and clamping unit those are the two major you know backbone of injection molding machines. So, there are four types of injection molding machines. So, we will elaborate on single stage plunger. So, that gives you more or less the basic conceptions. So, from that you have a injection ram here injection plunger here injection sieve here and from here you feed in the feed tube here.

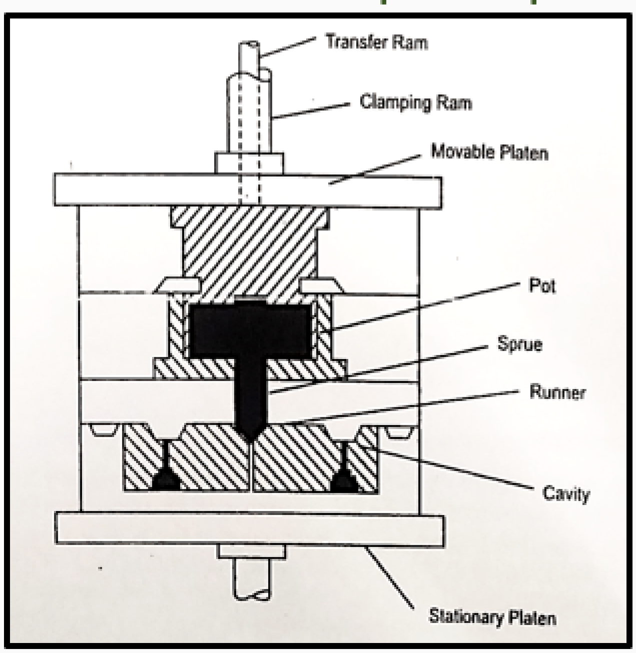
Clamp force on an annular element



And then finally, this is the place you have a heated torpedo that takes care of heat uniformity heat transfer part of it. And then finally, through the nozzle it gets injected. I mean in a nutshell in a bird's eye view you go through each and every component it is well depicted from the feed towards the to the it goes to the clamped mold part of it injection part of it. So, the heat is supplied by resistance heaters quite common in extruders also and the materials is heated by convection and conduction mechanism of heat transfer.

So, pressure losses are of course, very high in this case. There are certain two stage machines also available in a single stage plunger to plasticize the material and the second force is second just to inject. So, the two stage screw plunger is essentially similar to that of the plunger-plunger machines. See one thing you keep in mind if it is a plunger type of ram time sometimes it is called your precision in terms of pressure is much higher that of screw. Screw on the contrary has an advantage of plasticization. So, in many cases there are certain machines which are called reciprocating screw.

Transfer mould in compression press



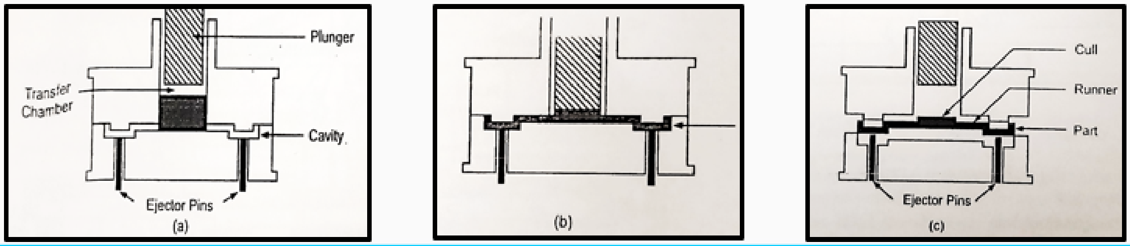
So, screw conveys like in transfer I talked about and ram or plunger actually finally, injects. So, that is what is called reciprocating screw type of machine here. So, without going into the details you can see from this complexity I mean if you have a two stage injection I mean two stage plunger machine or screw and plunger combination the complexity is more, but precision of course, is much higher for obvious reasons. Again you have to consider the thermal diffusivity is important part of it. The residence time we can give you some numerical problem related to thermal diffusivity by the way.

So, try reading it I mean outside however I am not teaching here, but you can expect some something on thermal diffusivity. The ratio of the surface area of the heated section of the cylinder to the volume of the plastic the larger the surface area more material can be plasticized. So, these are the some of the consideration you have to take it into consideration into your design basically how the screw will be designed how things will be obviously, you have to make your design very compact otherwise it will try to you know occupy more space working space there in the production floor basically. So, that that is how the design is ultimately have to be made. For the basic preliminary calculation you can calculate out the clamping part because that plays very important role.

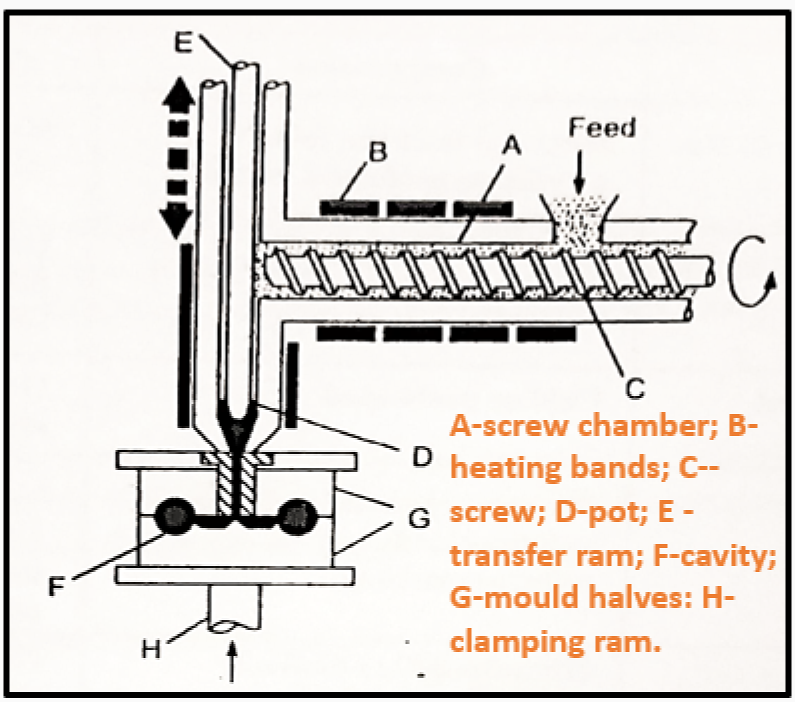
So, it can be straight hydraulic clamping system like it is hold here, but it can be mechanical also it can be single point toggle clamp or multipoint toggle clamp by which your clamping is done I mean it is arrested. So, then you can you can take it out once your you know injection is over your molding is over. So, type of clamping has a long term reliability excellent control of low pressure and molding protection it is as far as hydraulic is concerned, but nonetheless you can go for mechanical for a for a little low pressure sort of a injection systems. So, a toggle is a pair of mechanical the toggle that I am talking about earlier to I mean let me go back this 2 ok is the little depiction of it is there at in in terms of tooling a toggle is a pair of mechanical arms that are rotated about a pivot point. So, that they can be opened or locked into the ah position to hold the pressure.

So, simply as simple as that ok the main disadvantage of this system is the wear of the bushing and pins of the because it is a multiple cycles you have to do it it is not a single times you lock it you lock it close it I mean open it lock it open it. So, by that process your it can get pins may get damaged long run injection unit is also important ok ah just try to see for a reciprocating screw because that is one of the better design and mostly practiced one rather than a plunger design. So, you can see it as I mentioned it to you it is a reciprocating means any motion reciprocation means it is rotation as well as translational motion this combination. So, when it conveys the material it is a screw action it is a rotation, but once it reaches to that you know reservoir then it has a this sort of a translational sort of an action.

Plunger Transfer Moulding



So, this combination is called reciprocating action. So, bring the nozzle into the contact with the screw bushing of the mold everything is sitting out the rest part of it is clamped basically. Generate contact pressure between the nozzle and screw bushing I showed you earlier what is screw what is nozzle and the enables the rotation of the screw during the refilling ok and ah see it is a kind of a cycle ok. You have a reservoir it is conveys it comes screw comes here ok then the valve closes it is filled then it pushes goes back and forth by that time it starts the reservoir to be filled. So, it should be a continuous process otherwise again you have to wait for the filling for the next mold you make it.



Screw transfer moulding

So, that is what I was talking about the automation is necessary. So, this kind of a valves are there and injection end of the screw a non-retained valve is present which allows the material to flow only in the direction of the flow remember that it is filled non-retained valve will set set up is action it would not come back and then by that time you all set and go for the next level of filling of the reservoir and this pushes and by the time by the rotational g I told you the next mold comes fits into the the gate right in the position. So, that is how it is being done. So, little bit depiction about the generalized depiction of a screw see a screw generally have three places one is a feed section generally it is wide open you have more volume can be feed second is the compression and unmelting section ok. So, the screw pitches or height either way it can go down.

So, the volume will be reduced. So, it will compact it you may have a venting unit there and then finally, before it goes, there should be a laminar flow, which is what is called metering zone. So, generalized way your you have a helical structure and you have to define what type of a l by d ratio I going to do as I mentioned is a thumb rule is that for rubber injection or you know extrusion l by d ratio has to be lower than the plastics ok. So, that is the important thing and helical angle also plays very important role we will try to solve a numerical problems also on that later on when I will depict about the extrusion, but nonetheless meanwhile try to look into this you know particular figure that I am giving you an essential you know this is very important compression ratio for an extruder ok. Compression ratio actually says how much your material is getting compacted that depends on your material characteristics also ok. So, that is also important and try to see what is the flight clearance what is called pitch what is flight depth ok.

So, what is helical angle that you try to go through and try to go through this figure those who have not tried you know extrusion or design of a screw ok. So, effective output through a screw always is a difference between you know three different types of flow one is a drag flow what is drag flow your material in contact with the screw is rotating. So, with that rotation something is adhering to the surface is going to the forward direction as the screw rotates. Second thing you have a that is called drag flow you have a pressure ok pressure high pressure just before the injection just before the output low pressure at the feed. So, there will be a back flow of the everything tries to in the world tries to be less pressurized.

So, it will try to go to the opposite direction and of course, the leakage flow in between a screw you know there will be some gap and the barrel otherwise screw will not rotate. So, through which it can goes, but importantly like this cartoon says. So, how the material if you feed it in the granular form by that time it enters the plasticization or metering zone it has to be in the molten state. So, each granule has to be molten perfectly it goes to a transition zone and goes to the you know ah circulatory melt plastic zone basically. So, then only your your it it will be a perfect you know otherwise think about if your granule half molten it goes to the cavity it is going to be a disaster ok.

So, that is what the melt forms a pool of circulator you know circulates and more unmelted material is drawn into the pool to complete the melting process. So, exactly that is what it it should be happen during the melting mechanism ok as far as plastics are concerned ok. But, rather no question I mean you need to have a optimum you know temperature. So, that it is optimally softened ok and it is ready for the injection say. So, types of nozzles you can see from the design there can be open nozzles there can be shut off nozzles there can be little wall.

So, by the way in this particular context again I will reemphasize I am not going into the detail design of the you know nozzles through gate, but for your ah you know clarity I am showing some of the examples you please go through go back if you want to learn more about the ah entire design of injection mold or transfer mold. Let you go through understand what is the need for whether see through the main nozzle area there can be distribution as I mentioned depending on the complexity of the mold. There can be it can be divided into 4 sub divided channels ok. So, the all that depends on the how optimally you can feed how fast you can feel how efficiently you can feel otherwise one part or the other will start. Obviously, when it it it goes through a single channel centrally one if you consider a rectangular geometry of it ok.

It has to be enter and it has to be you know evenly fill out ah this part of it all 4 corners and including the rest part of it considering a rectangular sort of a design ok. So, I am not going into that complexity right away if the provision is there if ah this course becomes little bit popular before you then I will try to add on another 4 weeks later on. So, we will try to make the course like a 12 week courses then the entire mold design component and screw design component whatever applicable we will go into that we will take into consideration the interlink between the flow and the design interlink between the you know heat transfer component of it and scaling up component of it. So, that is again based on your feedback we have to we have to decide in the long run, but not this in this semester this particularly course context. So, that that is what again I will emphasize mold and mold design that part will be taken up in the long run that is what how we envisage here.

So, again the runner types also are different see let us let me give you a very very ah ground level example you you you can have a runner of different shapes it can be ah fully rounded trapezoidal it can be modified trapezoidal then you have to consider the flow across ok some of the flow things I already have depicted before you, but if it is a half rounded runner if it is a rectangular runner with a parting line you can having a some some poor results in terms of the precision. So, I am not going into that details right away. So, and gate also gate means where it fills actually through which it fills the gate must be located in such a way that rapid and uniform filling is there that is what I was talking about whether a single gate or multiple gates and the shape of the gate also matters and the gate location plays an important role in avoiding problems like weld lines parting lines jetting burn marks etcetera etcetera. So, these are the some of the consideration ok. So, here actually what we showed you I I showed you other part later part of it now I am showing you the along with the clamping part inside the mold ah I mean we are considering up to which the the material has reached already and then later part how it is getting injected that component of it ok.

So, again I will say I am not going into the detail part of it ok. So, you try to read through the literatures ok some of the things are not given here, but to conclude we try to give you a bird's eye view I will say bird's eye view because this particular subject is very very white ok. I just try to make you familiar with part of the part of it specially the depiction part of it the compression molding it types different varieties and then I went into the transfer molding and injection molding and you must have realized the complexities ah going to be more more more and more if you if you go for rudimentary you know compression molding machine then automatic and semi automatic part of it then transfer molding and then to ah injection and that to injection with the state of the art reciprocating screw ah some sort of a design ok. So, with that we will see you next time. Thank you very much.