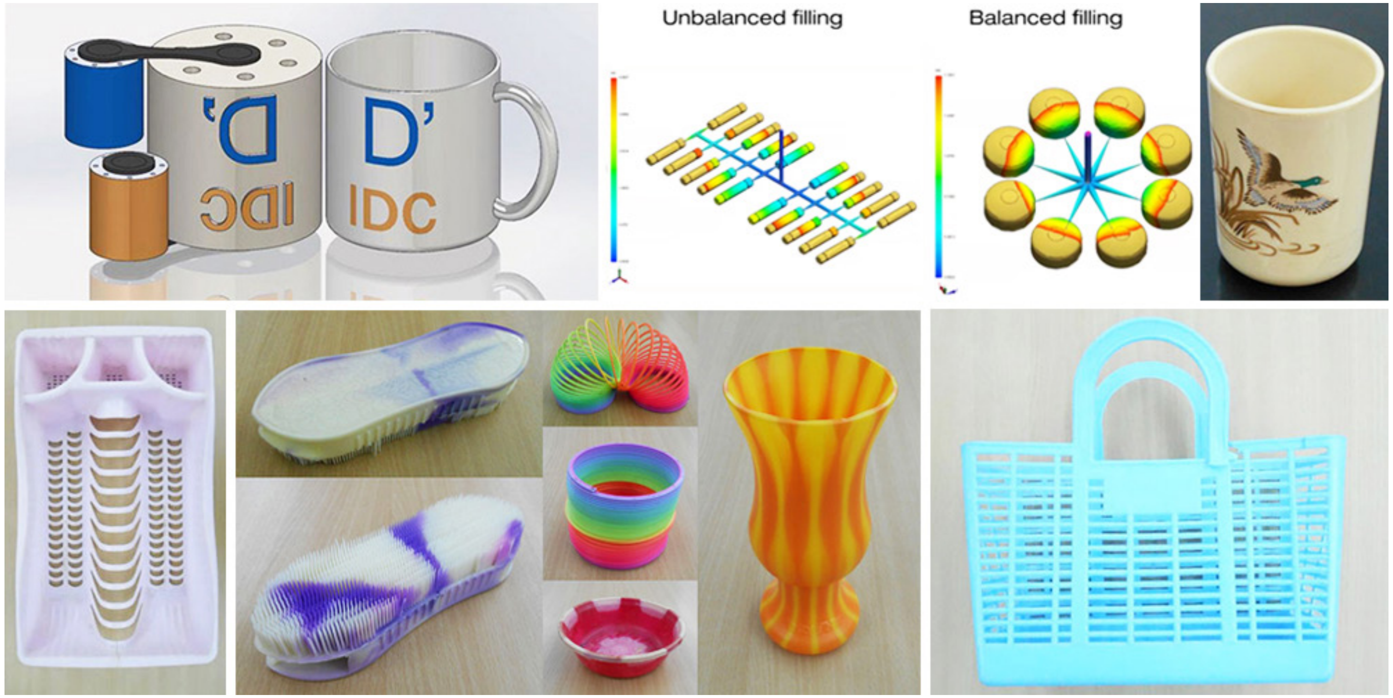
Design Course

Designing of Plastic Products for Injection Moulding

Manufacturing Methods and Technologies

by
Prof. Vijay. P. Bapat and Shiv Kumar Verma
IDC, IIT Bombay



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Design Considerations

The proper knowledge of materials and its manufacturing process helps a designer to select the best material as per its application. This knowledge plays most important role when a designer uses the materials in an innovative way to solve a design problem. A good designer always consider the limitations and constraints of the materials in design phase since materials not only affects the aesthetics of a product but also decides its manufacturing cost.

This course will focus on PLASTICS. They are organic polymers of high molecular mass. Because of their properties like ease of manufacturing, versatility and imperviousness to water they have a wide range of applications from toy industries to space explorations. Plastics are more varied and complicated compared to other materials like metals. As time passes they shrink and creep. They change their properties with change in temperature.

Types of plastics

Plastics can be classified as thermoplastics and thermosets. Further thermoplastics are classified as semi-crystalline, Amorphous and elastomeric.

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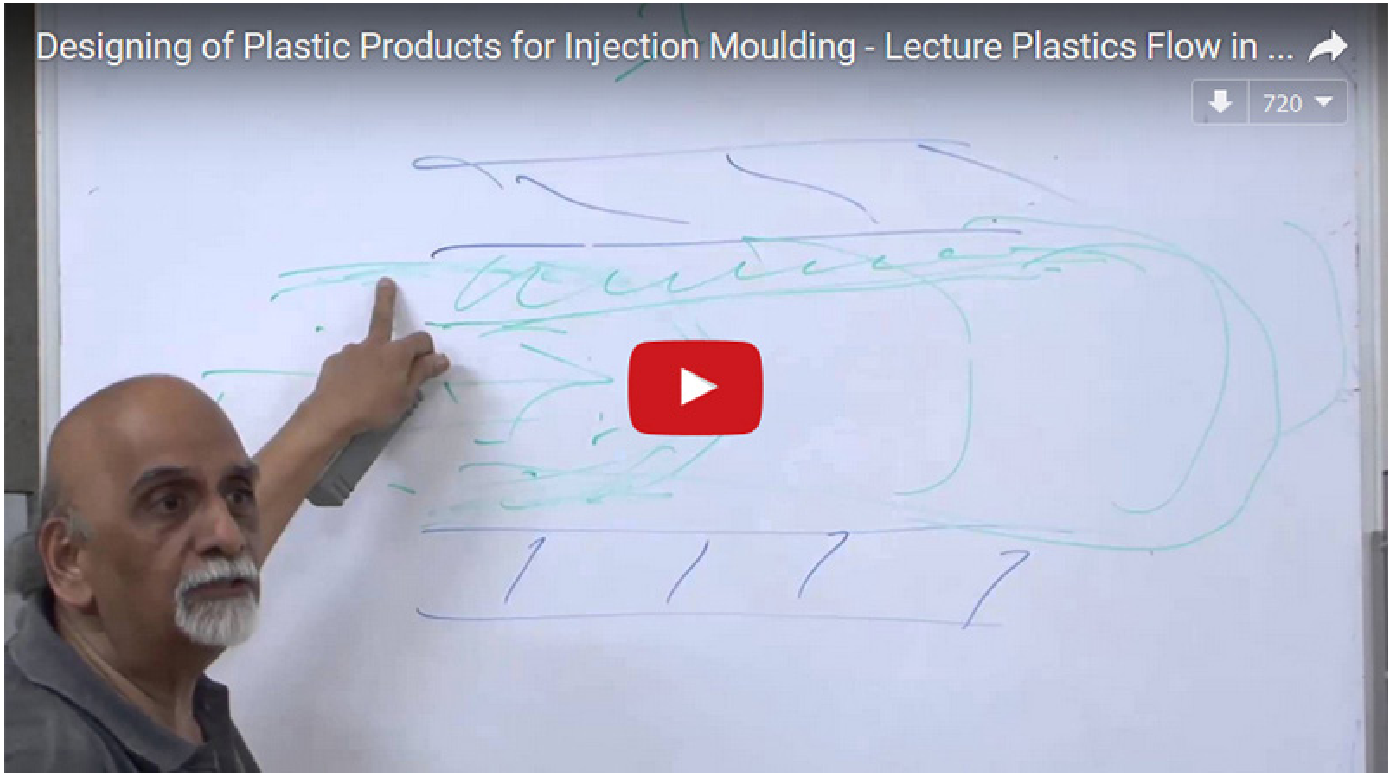
Flow of Plastics in Mold



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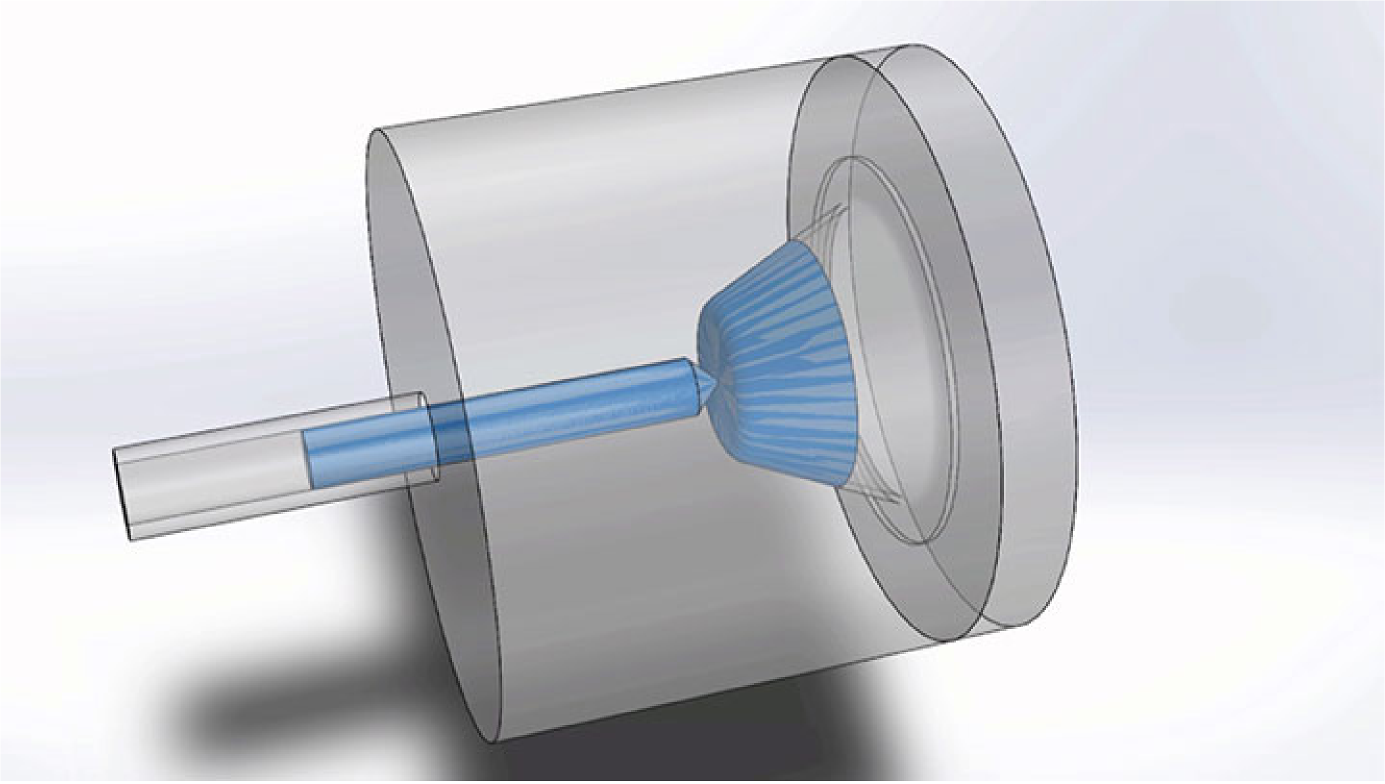
Injection Molding

Injection molding is a process of injecting hot molten plastic into the cold mold and forming the part. It consists of a hopper that hold raw plastic and feeds barrel. Plastic is melted in barrel and injected into the mold cavity through a screw. The plastic rapidly cools and solidifies due to the lower temperature of the mold. The part is then ejected after opening the mold.



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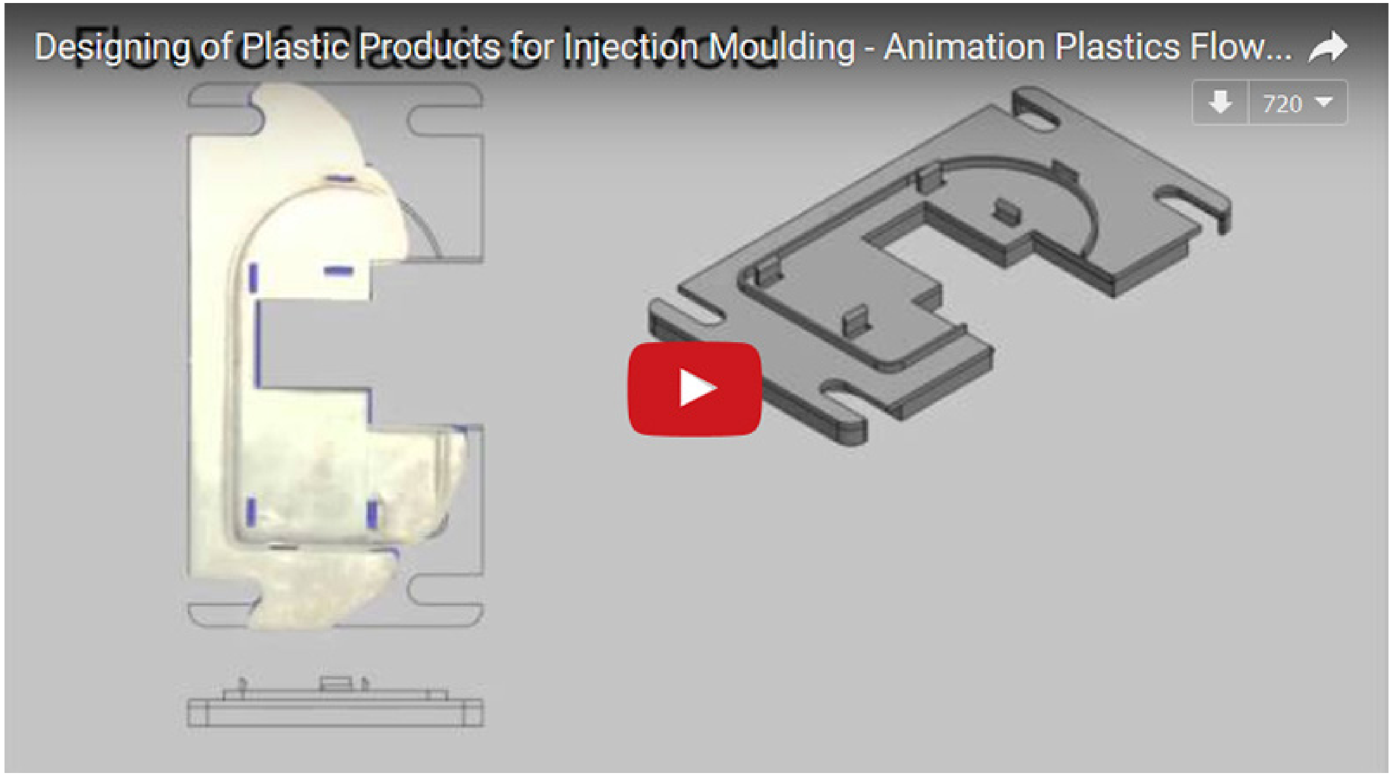
Flow of Plastic in Mold

Hot plastic is a viscous fluid termed as 'Melt' and ease of flow of melt is measured by Melt Flow Index (MFI). The flow of plastic is demonstrated in an animation below. The melt is forced to flow inside the mold cavity under high pressure. Plastic at the center will flow faster than plastic near the wall because flow speed of the plastic gets reduced due to the friction with wall and due to solidification of plastic near the wall.



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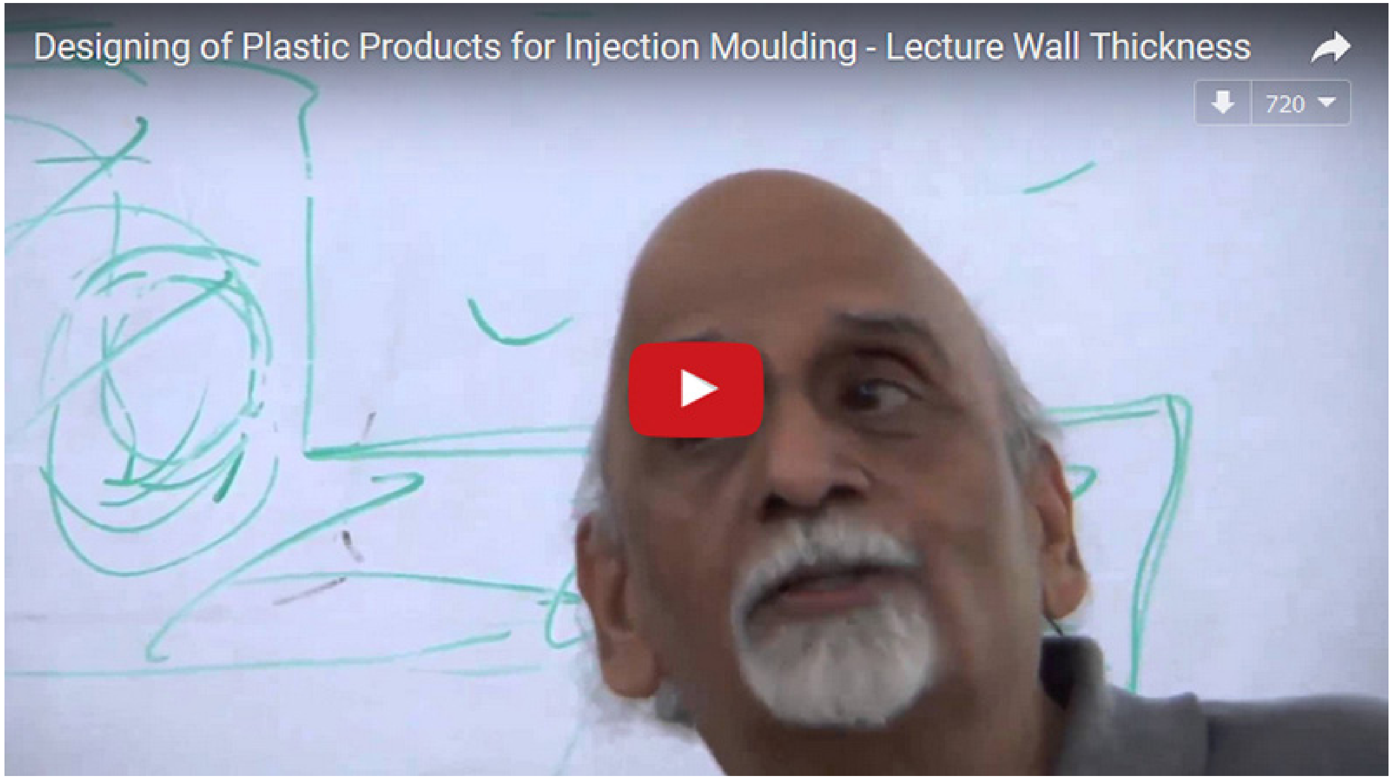
Wall Thickness



Wall thickness is referred to the thickness of the part produced. Wall thickness depends upon the strength required. Plastics are poor conductor of heat and thicker section take time to cool and are costly to manufacture. Since there is a temperature gradient with in the part which led to development of thermal stresses which causes shrinkage, warpage etc. so wall thickness should be optimized considering these factors. Two parts with similar geometry but different wall thickness have different filling and cooling time since the minimum cooling time (Tc) is directly proportional to the square of the wall thickness (t) of the part.

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Minimum Cooling Time (T_c)

$$T_c = \frac{t^2}{\alpha \pi^2} \ln \left| \frac{4}{\pi} \left(\frac{T_m - T_w}{T_e - T_w} \right) \right|$$

t = Wall thickness

α = Thermal diffusivity

T_m = Melt temperature

T_w = Mold wall temperature

T_e = Ejection Temperature

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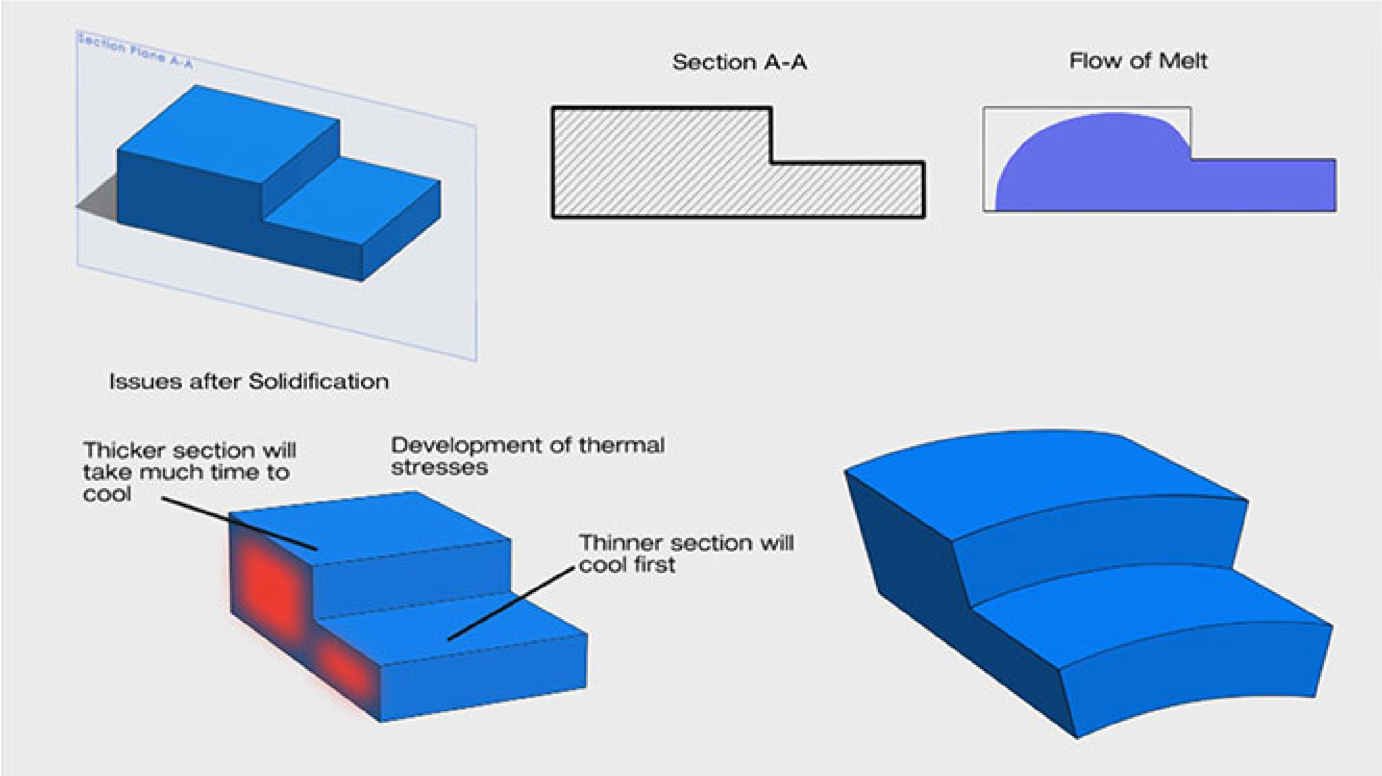
A sudden change in the cross section causes the turbulence in the flow of the melt and this turbulence is responsible for the air entrapment and mold deterioration. Therefor it is advisable to have a gradual transition between changing sections.



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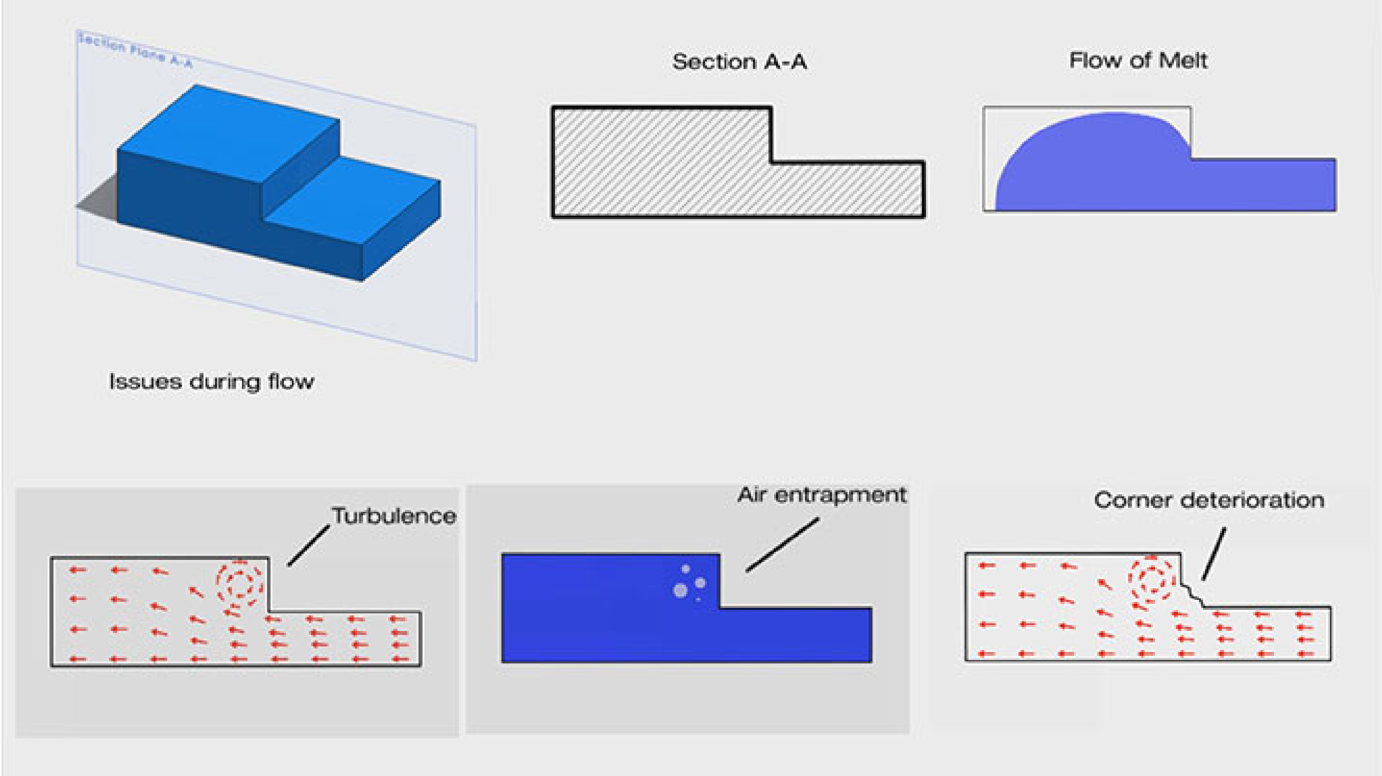
Thicker section will take more time to cool than thinner section this will cause the development of thermal stresses in the part and part will get deformed.



If thicker sections are unavoidable then provide radius at the edges or a slight chamfer, provide a core or provide ribs.

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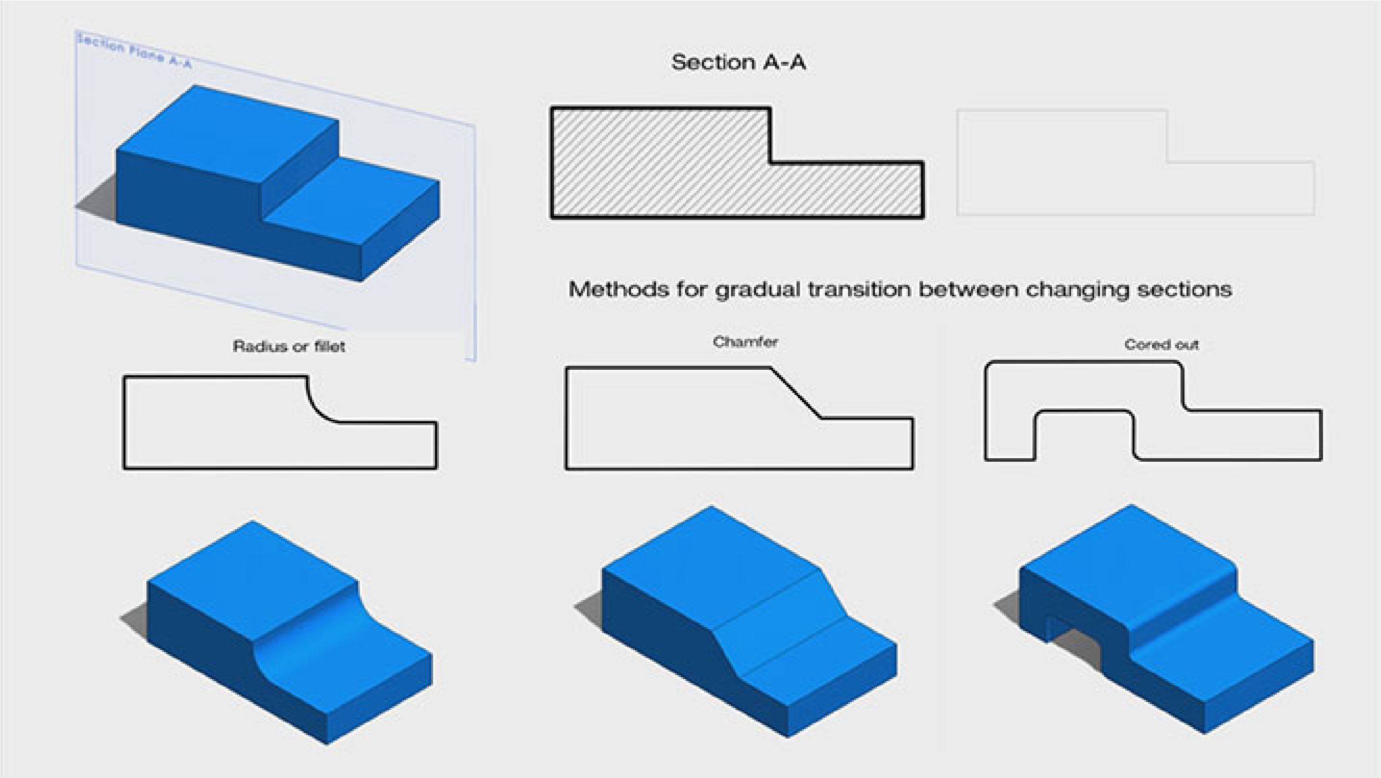

Design Considerations

- Always try to keep wall thickness uniform.
- There should be gradual transition between changing sections.
- Wall thickness for reinforced materials 0.75 mm to 3 mm and for unreinforced material it is 0.5 mm to 5 mm.

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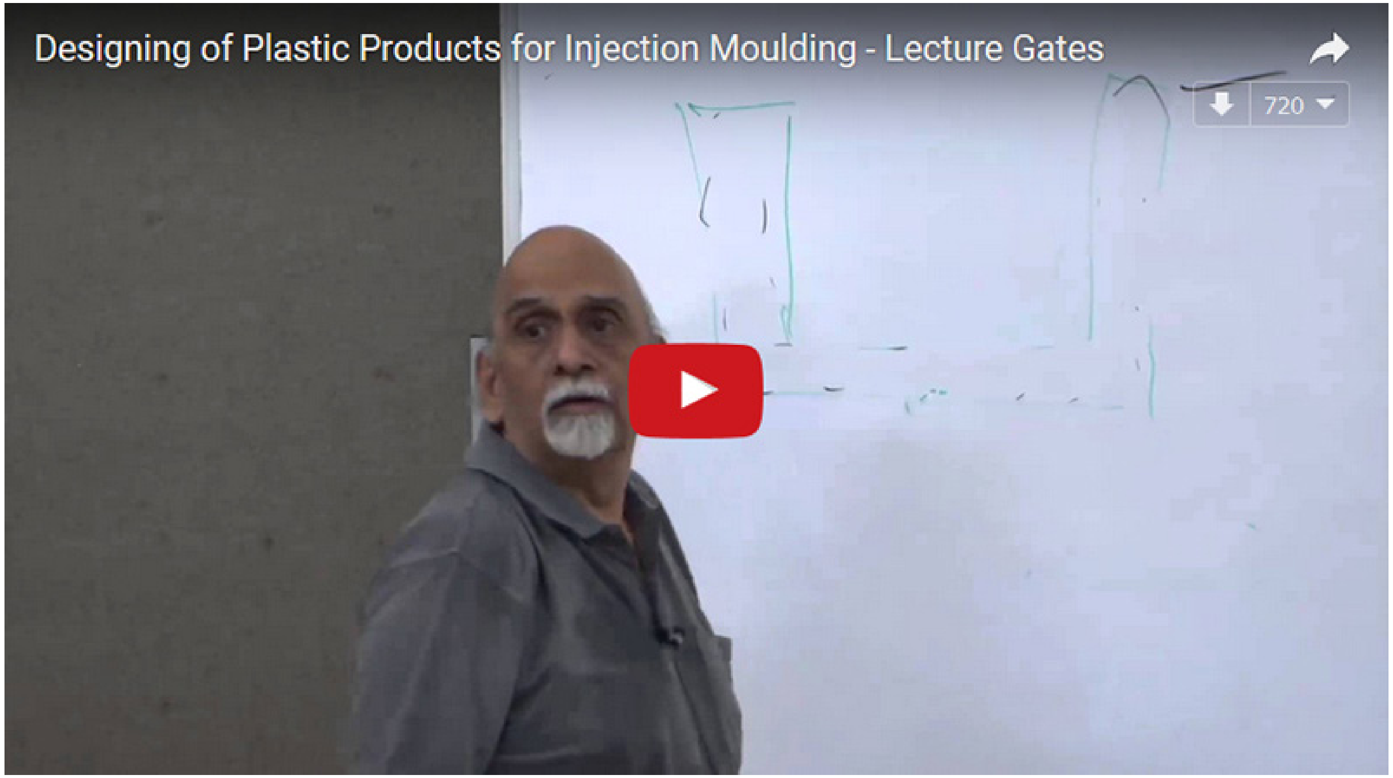
Gates



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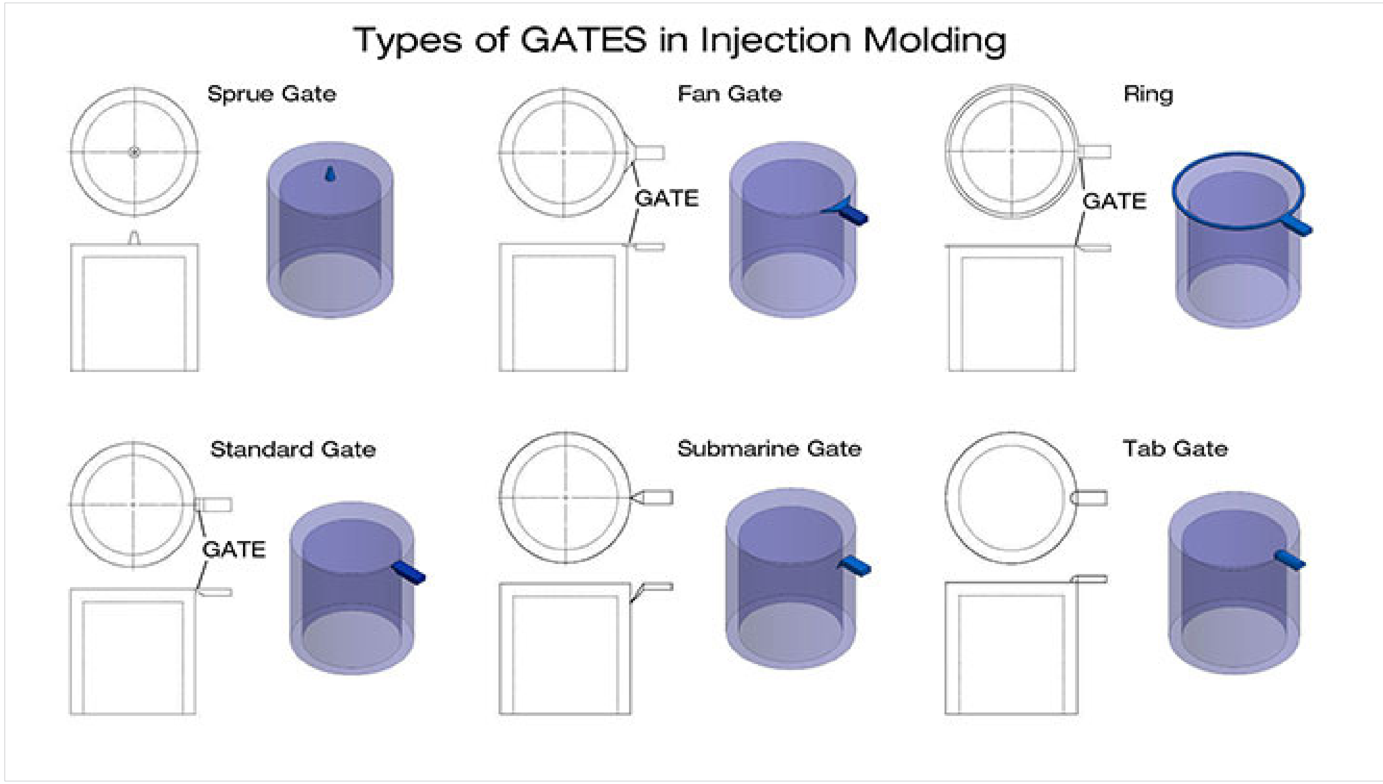
Gate is an opening that allow melt to be injected into the mold. There are many types of gates in injection molding like sprue gate, fan gate, ring gate, standard gate, submarine gate, tab gate etc.Gate type and design depends basically on part packing, part dimension, part appearance etc.



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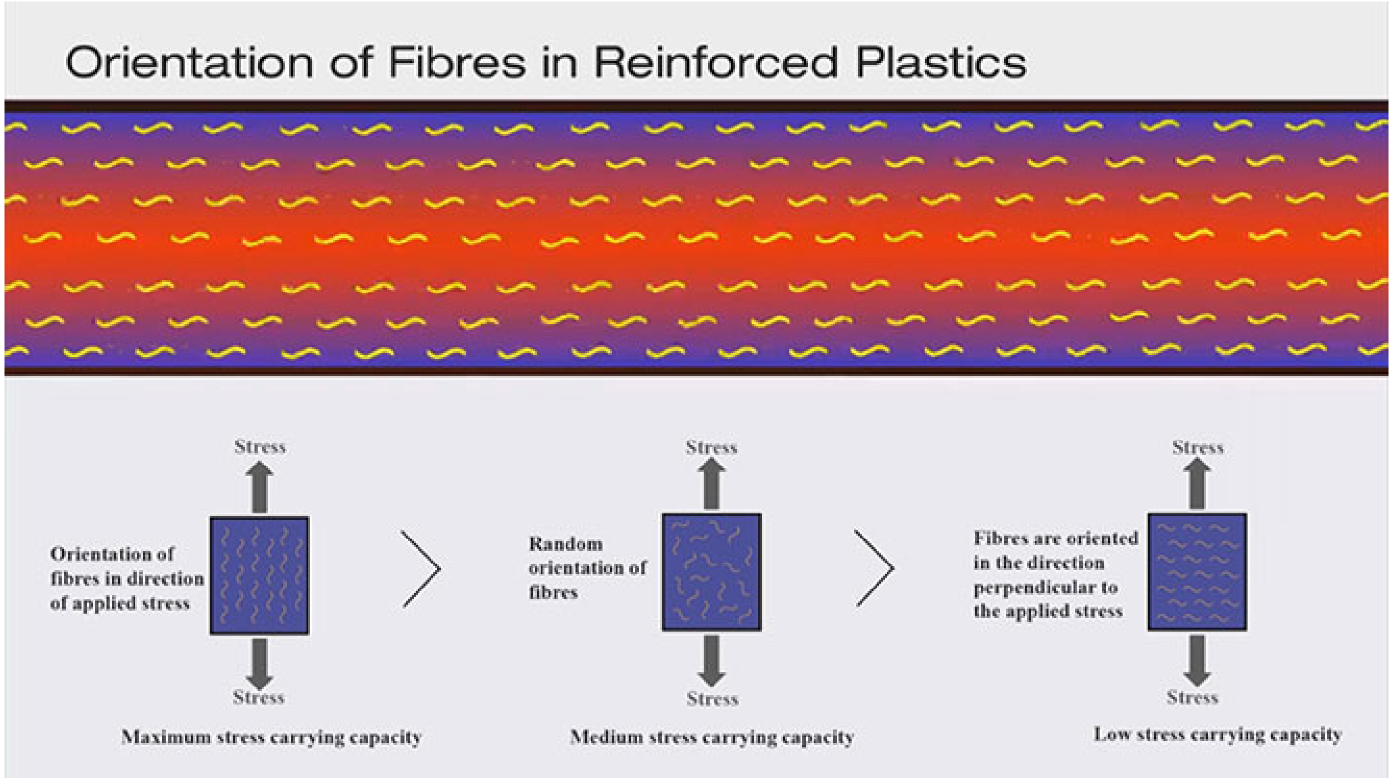
Location of the gate is also an important factor for the strength of a part. In reinforced plastic the orientation of fiber's is the factor that decides the strength of the part and the orientation of fiber's is decided by the location of injection point. If fibres are oriented in the direction of applied stress then part will have maximum strength, if fibres are oriented in a random manner then part will have a medium strength and if fibres are oriented in the direction perpendicular to the applied stress then the part will have lowest strength.



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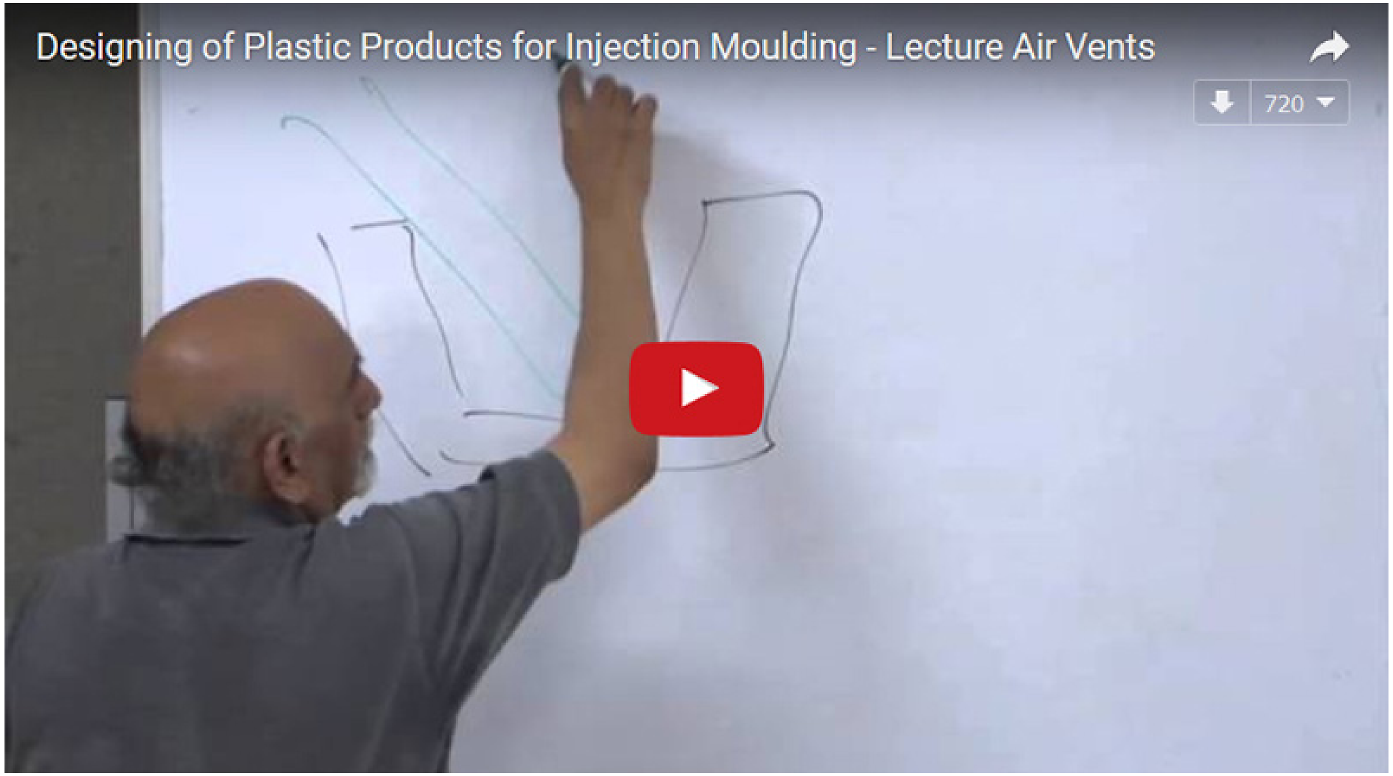
Air Vents



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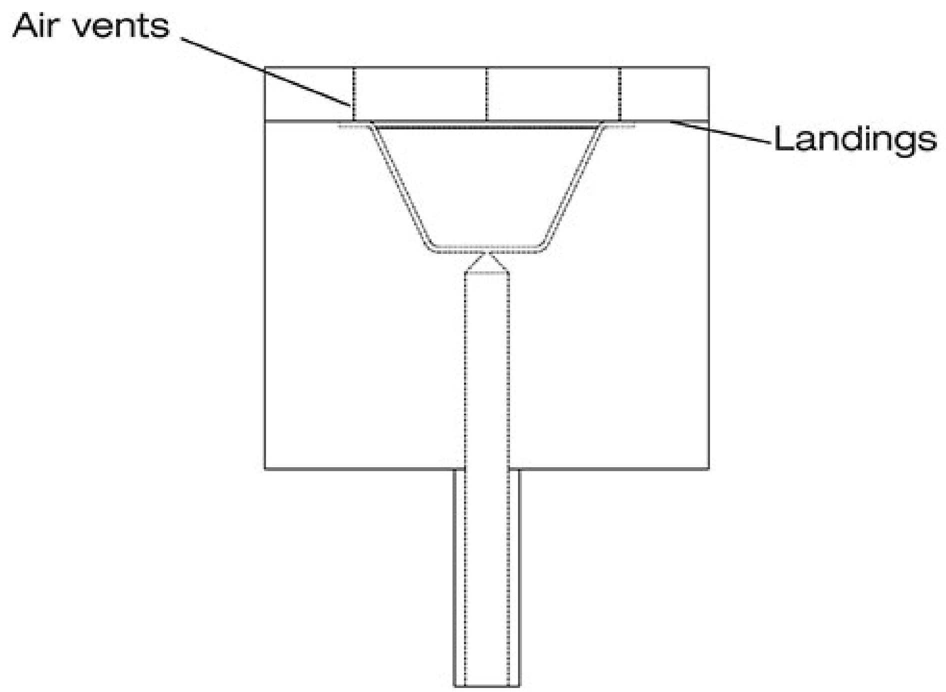
Air vents are the small holes in the land area that allow air to pass through them but don't allow melt to escape out. Providing air vents will reduce the resistance at the time of filling which will reduce the filling pressure and which will result in reducing the residual stresses in molded part. The reduced filling pressure will prevent the breaking of core pins. Air vents also helps to carry out the volatile constituents or gas generated from melt thus improving the quality of molded product.



Design Consideration

• Air vents can be provided on parting surface or on the core pins.

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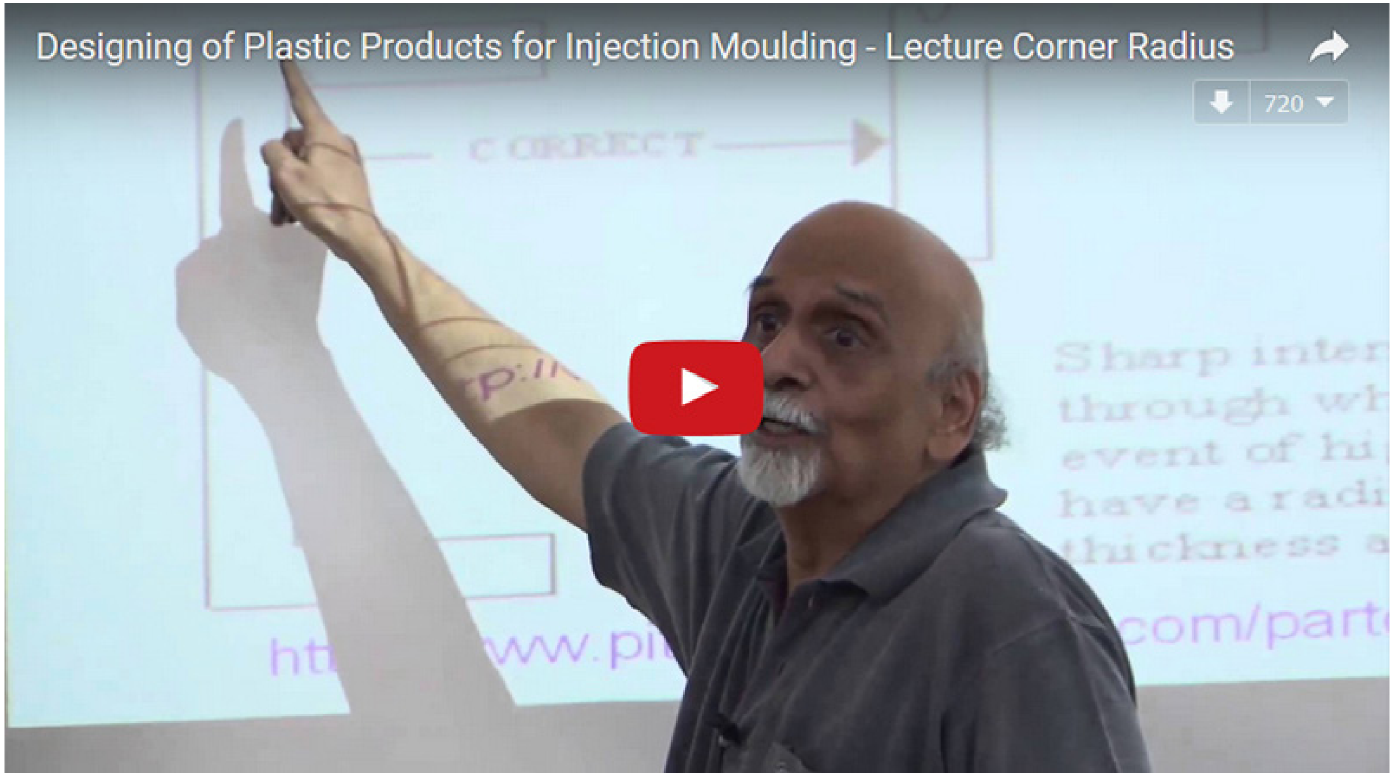
Corner Radius



The walls of the part usually meet the base at angle greater than 90o because of draft given to the part. If the walls are joined making a sharp corner then the wall thickness will not be uniform at corners, the maximum thickness at the sharp corner is about 1.4 times the nominal wall thickness. This will result in longer cooling time accompanied by sink marks and warping. Sharp corners have increased stress concentration. At the time of flow there is a turbulence created at the corner which causes the air entrapment and weakens the molding. The problem can be overcome by providing radius at the corners.

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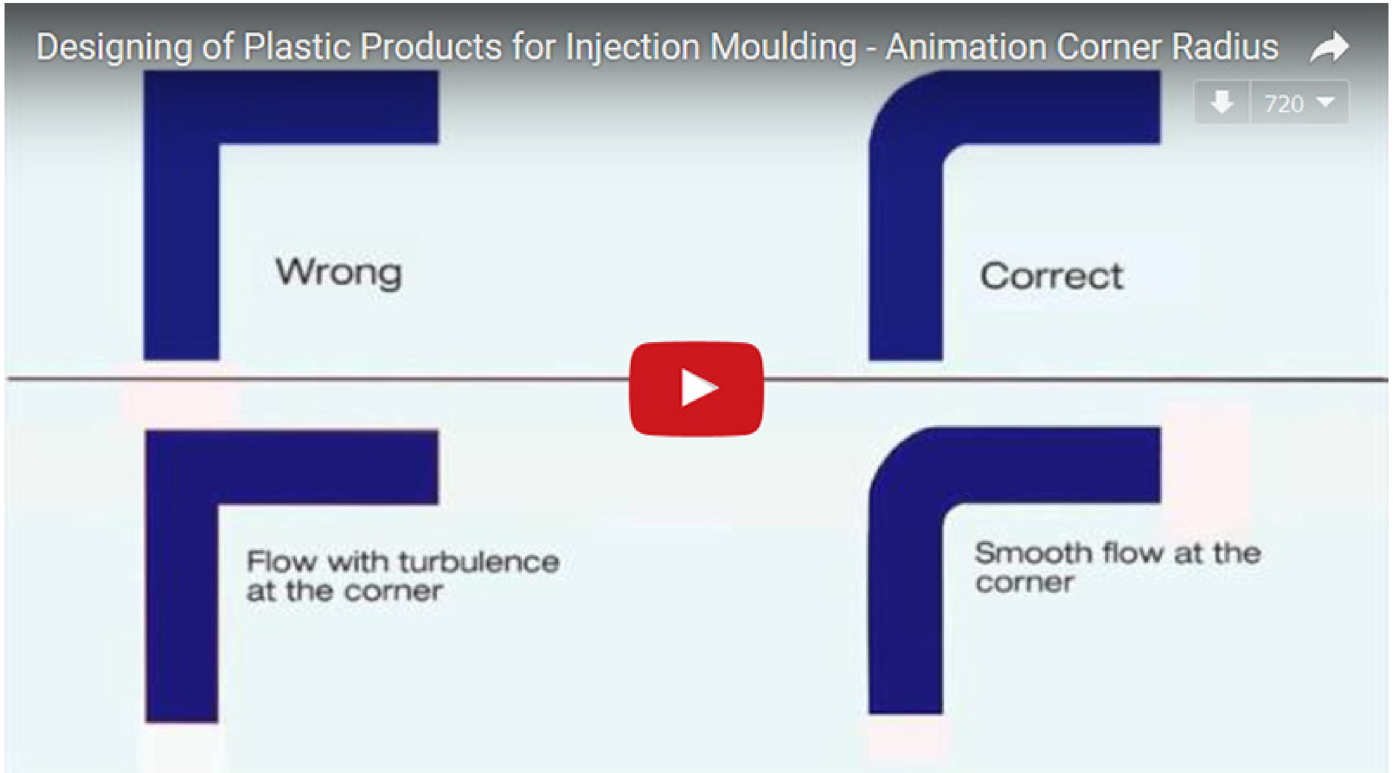

Design Considerations

- Internal radii should be at least 0.5 and preferred is 0.6 to 0.75 times the wall thickness.
- External radii should be equal to internal radii plus wall thickness.

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Ribs

When the normal wall thickness is not strong enough to withstand the loading conditions the part is strengthened by adding ribs rather than by making whole wall thicker. Providing running ribs across the part will increase the part rigidity in all directions. These running ribs cross each other at right angle and this create a thick section at the junction which is greater than the normal wall thickness. To maintain the uniform wall thickness at the junction one way is to use a cored out boss at the junction but the most suggested is to use a normal junction with ribs that are less than 0.75 times the wall thickness. Deep ribs are structurally more efficient than thick ribs because stiffening effect of rib is proportional to cube of its depth.

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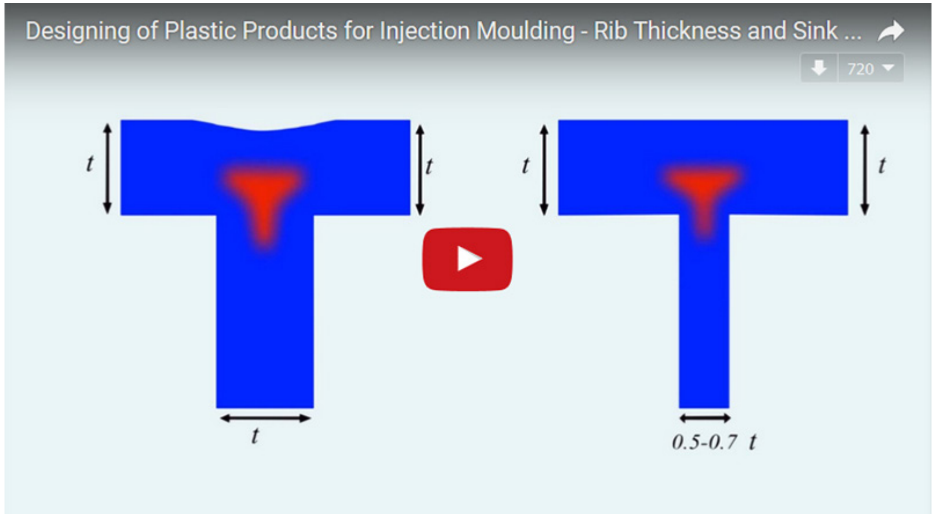

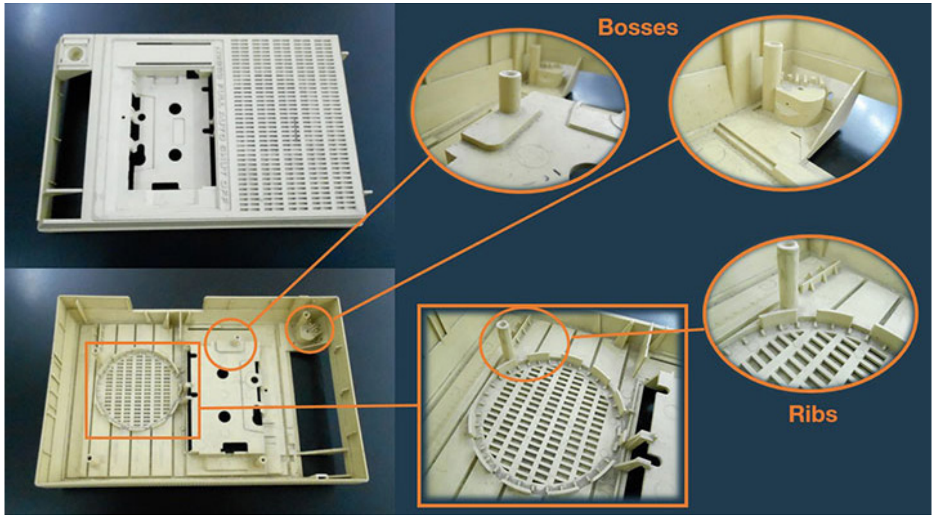

Design Considerations

- Rib thickness = 50 % to 75 % of wall thickness.
- Fillet Radius = 40 % to 60 % of rib thickness.
- Rib root thickness = 25 % of wall thickness.
- It is suggested to have deeper ribs than thicker ribs.
- Rib depth should be less than 5 times the rib thickness.
- Provide taper to ribs for their easy removal from mold.

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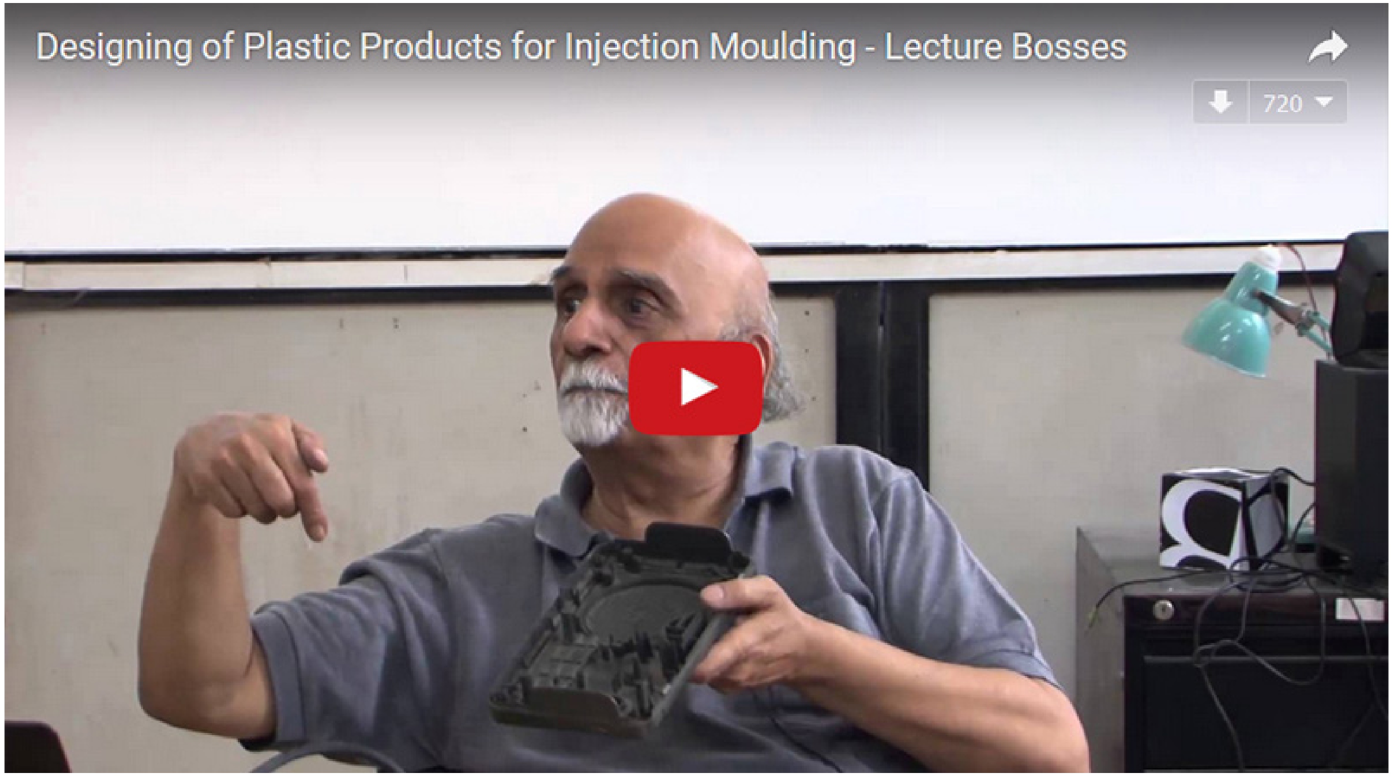
Bosses



Bosses are the cylindrical elements in the plastic parts which are used as a mounting point or a location point. Boss may receive a screw, insert or a shaft. Their cylindrical form is easy to machine and is the strongest shape in molded part.Bosses have to be rigid and it is achieved by supporting the boss with buttress ribs or linking it to a side walls or corners of the part. Extending the boss to meet side wall or corner will increase the diameter of boss which will give a thick section resulting in the sink marks. To avoid this boss is linked to side walls with a flat rib recessed below the boss or edge. Function of a boss is to accept screw fasteners. The screw hole of a boss is provided with a counter bore to reduce the stresses at open end and prevent its splitting. Dimension of boss and hole is decided by two factors screw thread diameter and the material of plastic used.

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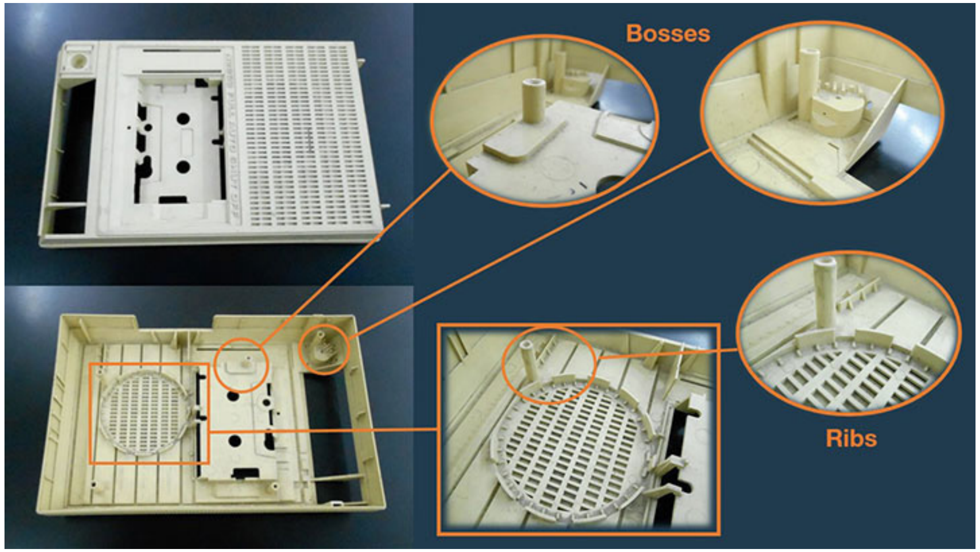
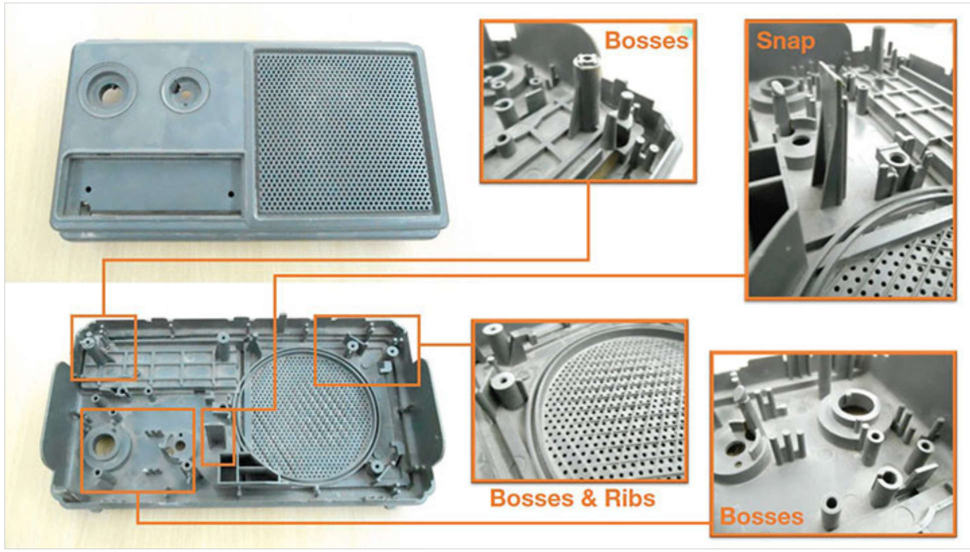
Design considerations

- Consider the forces acting on it during assembly and service.
- If forces are less then use buttress ribs otherwise extend the boss to walls or corner for greater forces.
- Avoid complex mold machining.
- Use counter bore to reduce stress at open ends.





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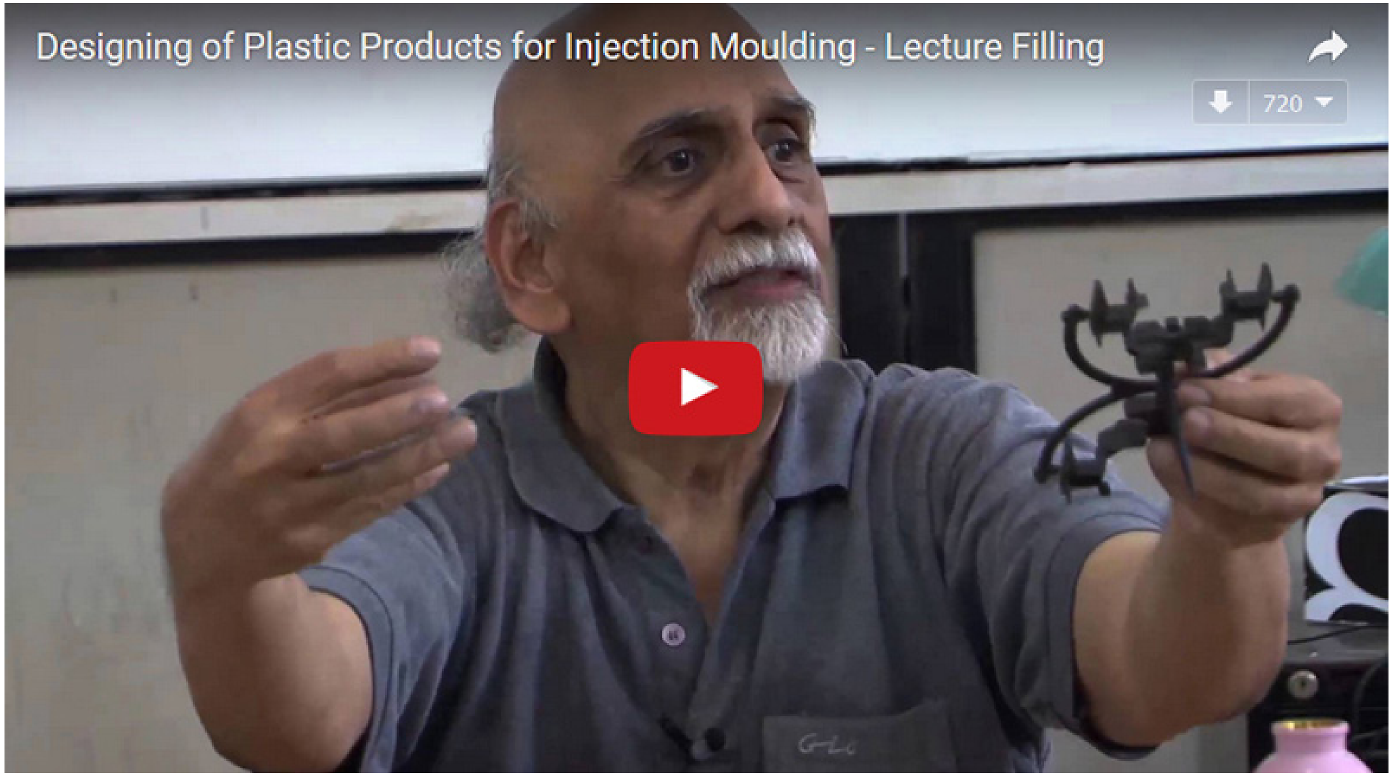
Filling



In multi-cavity mold balanced filling is critical for making parts identical and holding tight tolerances. The main reasons for unbalanced filling are
(1) non-uniformly melted plastic disrupt the flow in runner, gate and part.
(2) non-uniform cooling of mold
(3) unbalanced flow path
(4) laminar floe of melt.

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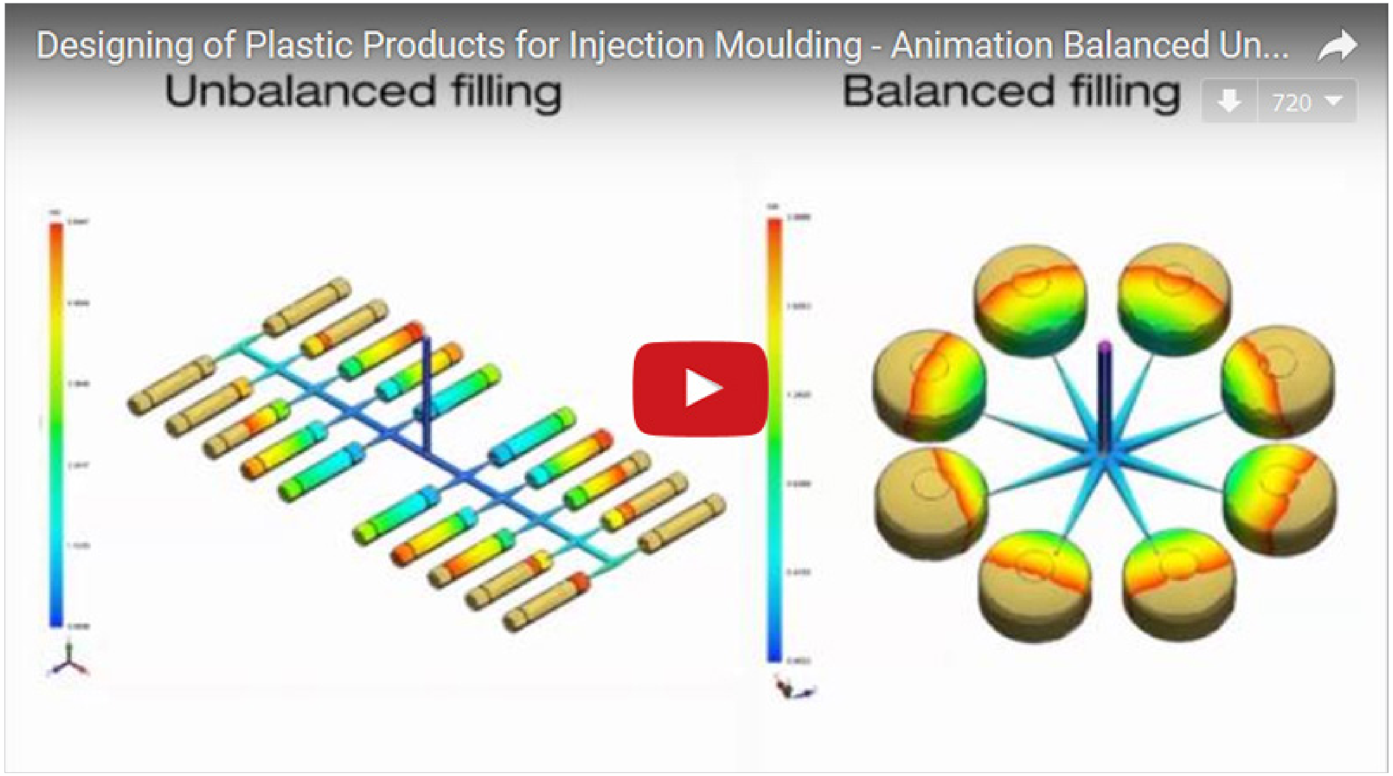
Balanced filling is essential for multi-cavity molds to maximize the quality and reduce part variation. Balanced filling involves the designing of a runner system so that each cavity fills at same time and same temperature so that the molded part will have uniform density and will shrink to same size when material solidifies. In such a runner system the distance between the runner entry point from where plastic enters the mold and gates of each cavity is same. This method of balancing runner is called artificial balancin.



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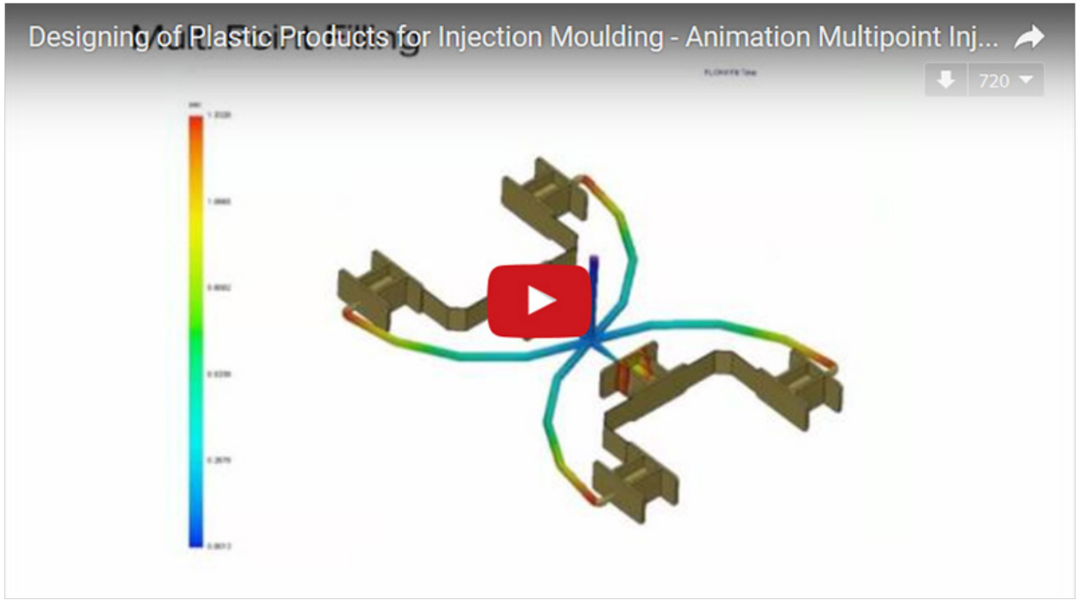
When part is very complex then single point injection is not enough to fill the part completely. In that case multi-point injection is employed. Multi-point filling reduces the required filling pressure and provide more uniform packaging and shrinking throughout part.



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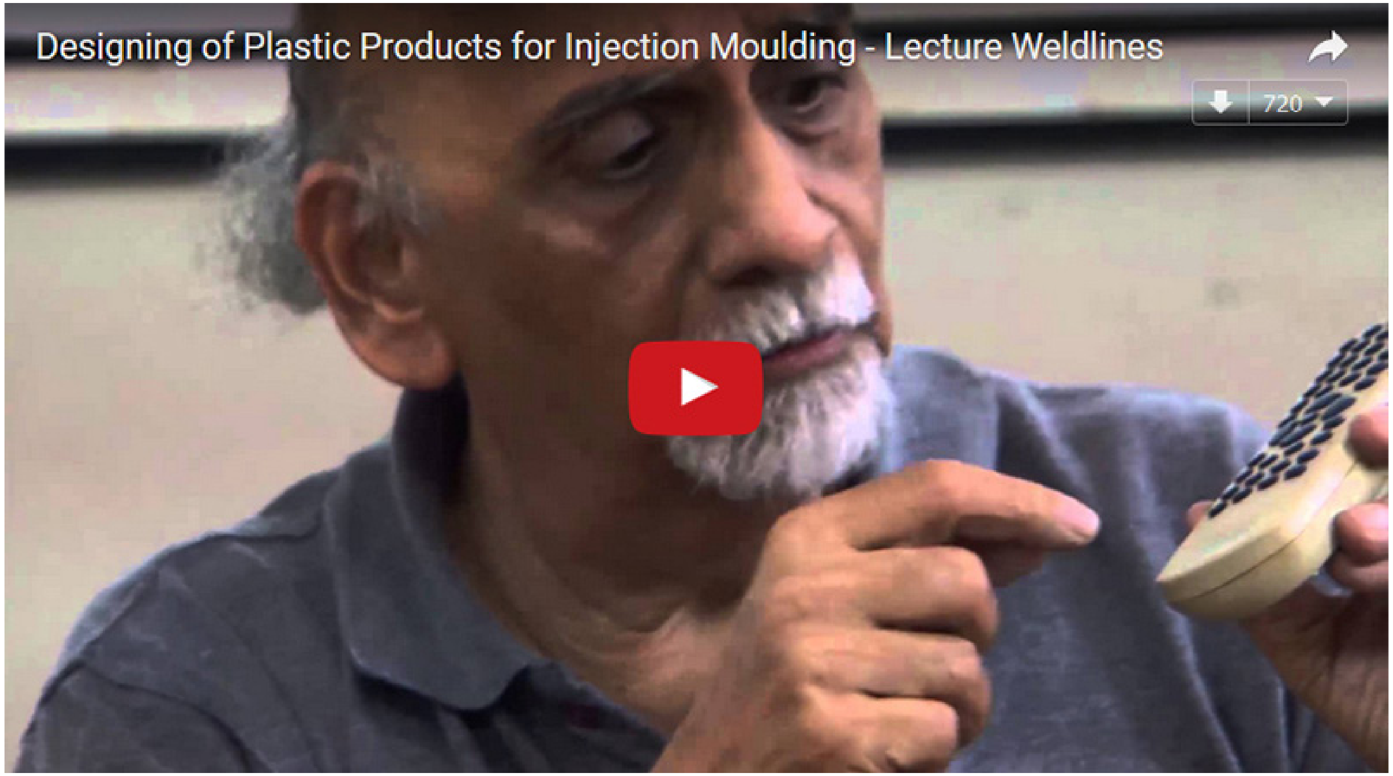
Weld Lines



Weld lines are the regions where two melt front meets and bond during filling of a part. Weld lines occurs when melt fronts are forced to go around an obstacle like a hole and then they meet or when the melt front coming from two different gates at opposite ends of a part meet together. Since the temperature at the melt front is lower than the temperature of the melt entering into the mold the bonding at the weld line is weak thus strength in the weld line area is reduced.

Design considerations

- Locate weld line in structurally non critical areas, in aesthetically non critical area.
- Use proper texture if possible to hide weld lines.
- Locate weld line in the area where thickened ribs can be used.

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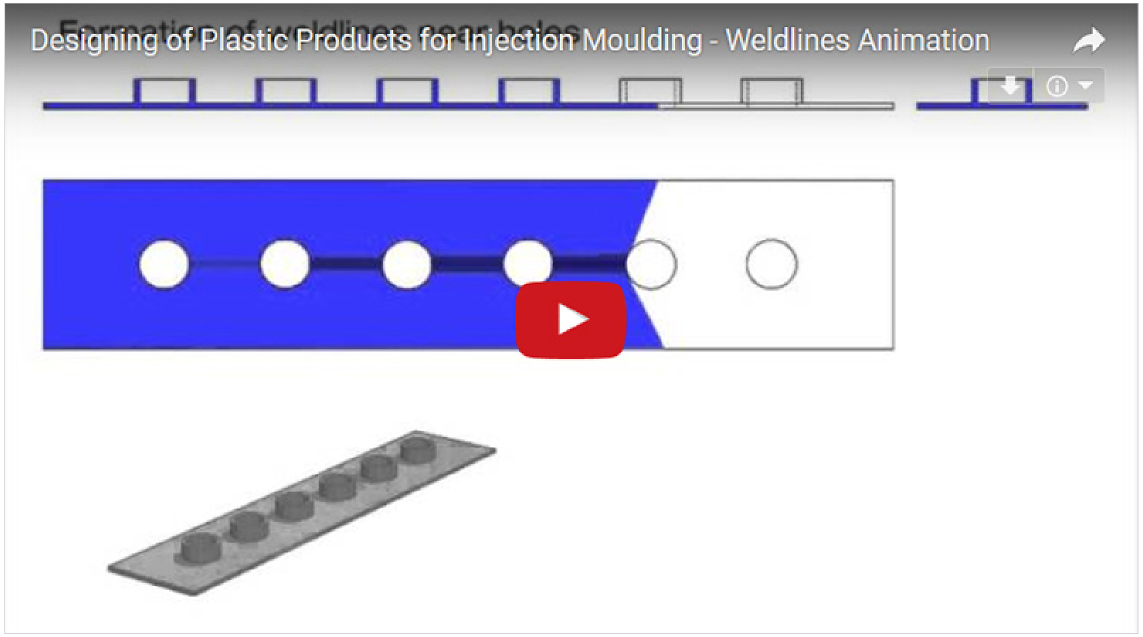
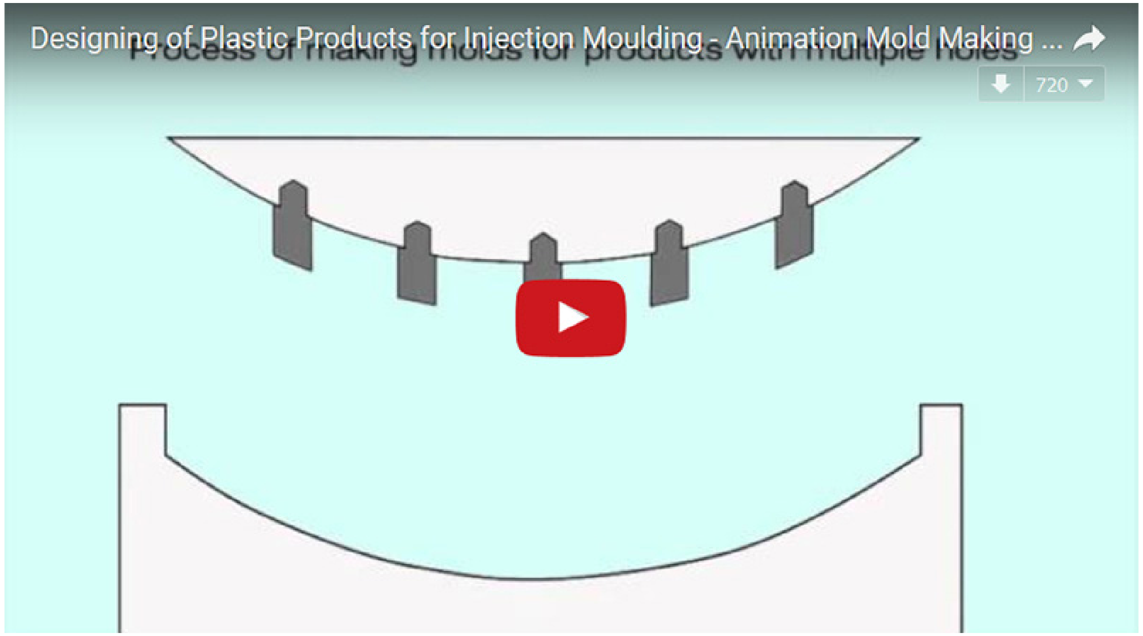


Mold Making for Holes



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Draft

Draft is defined as a taper given to the walls of plastic parts in direction of line of draw to facilitate the easy removal of the part from the mold. Since plastic parts shrink as they cool they grip core of mold tightly. Without sufficient draft normal ejection from mold will be difficult. The value of draft depends on surface finish on the mold. A polished mold requires less draft than anunpolished mold.

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Design considerations

- 0.25 degrees to 0.2 degrees per side for both inner and outer wall for untextured surface.
- For textured surface add 1 degree draft per 0.001 inch depth of texture.

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Undercut

Any projection or hole which is perpendicular to Line of Draw creates obstruction in removal of piece such elements are called undercuts. Undercuts are formed by using split cavity molds or collapsible cores. Internal undercuts are molded by using two separate core pins but in this process flash must be controlled where the two core pins meet. For internal side wall undercut or holes offset pins are used. Undercuts are also formed by stripping the part from the mold but for such an operation mold must be designed to permit the necessary deflection. Slight undercut can be stripped from the tool.

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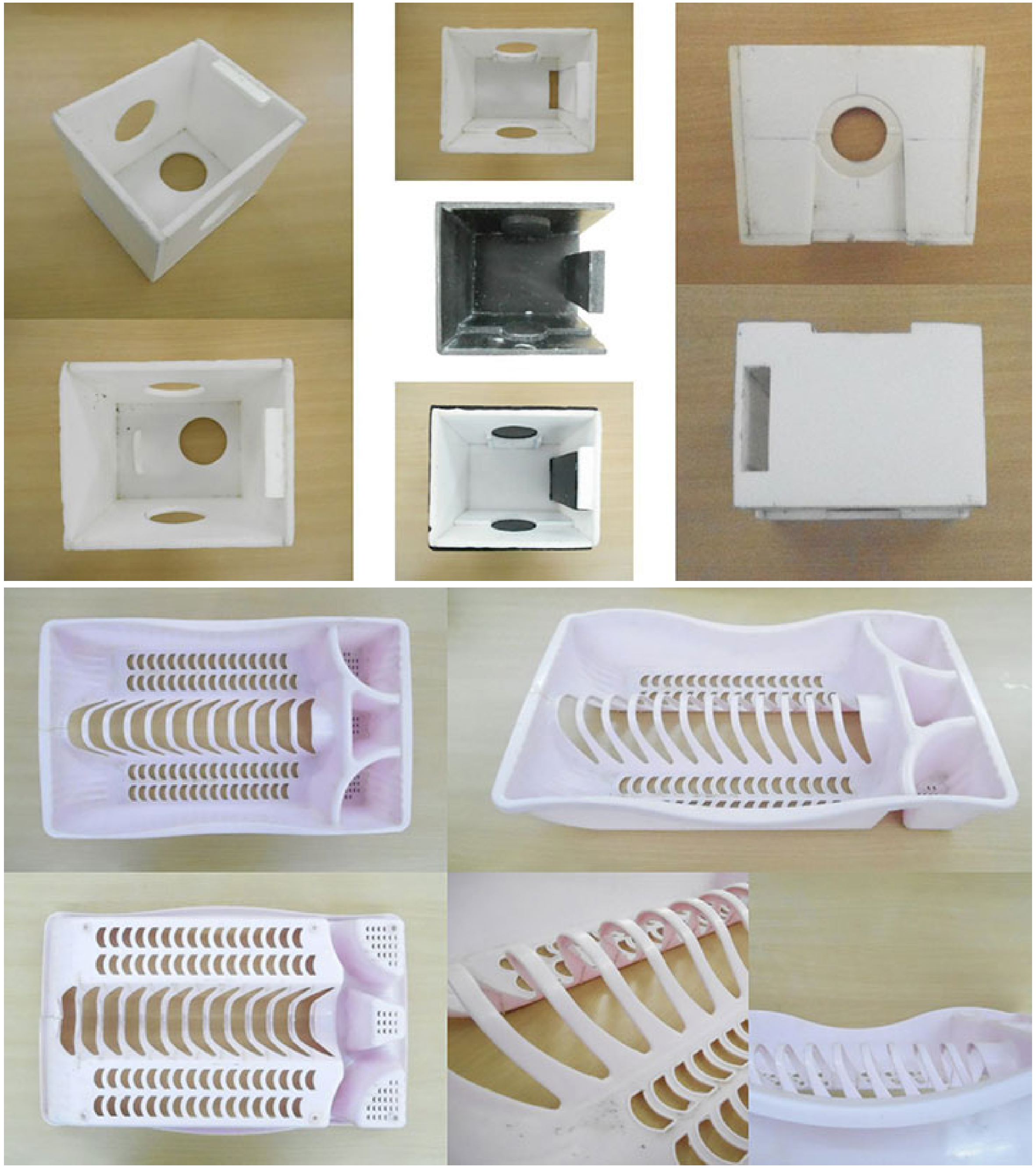

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Prof. Vijay. P. Bapat and Shiv Kumar Verma
IDC, IIT Bombay

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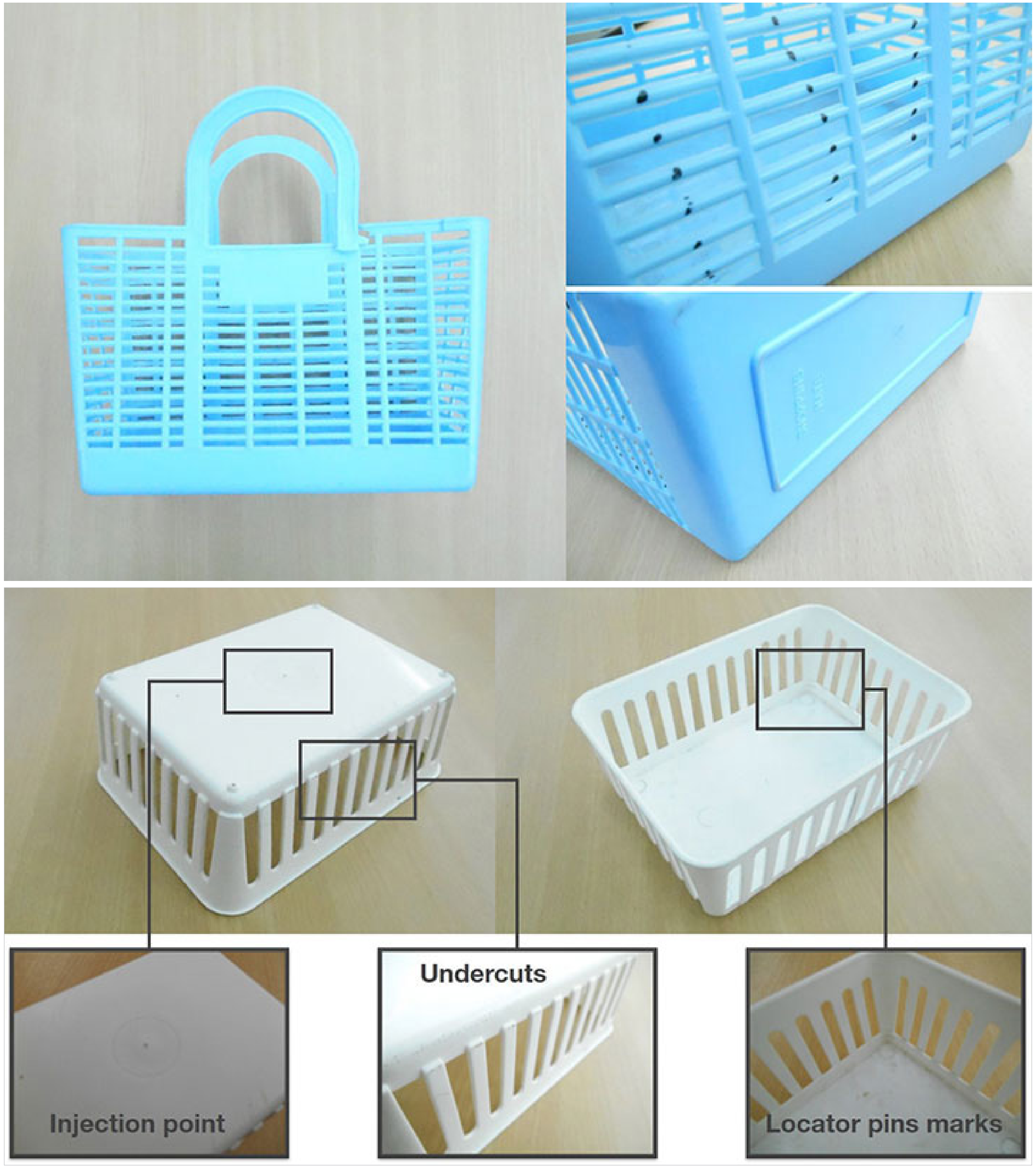

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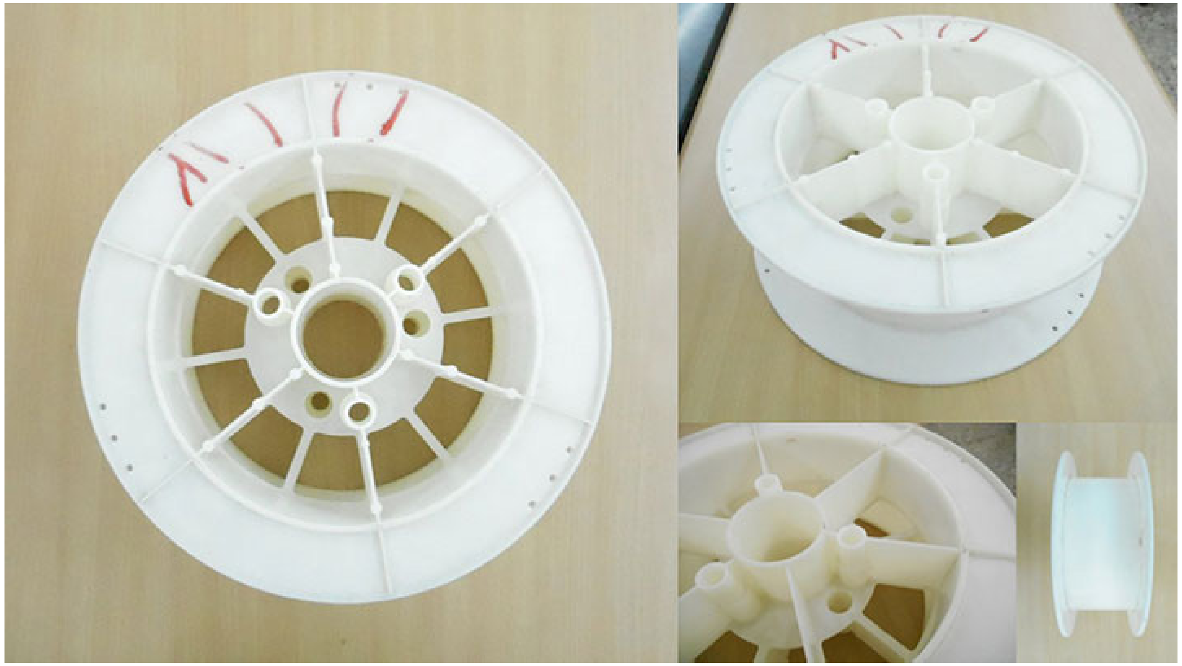

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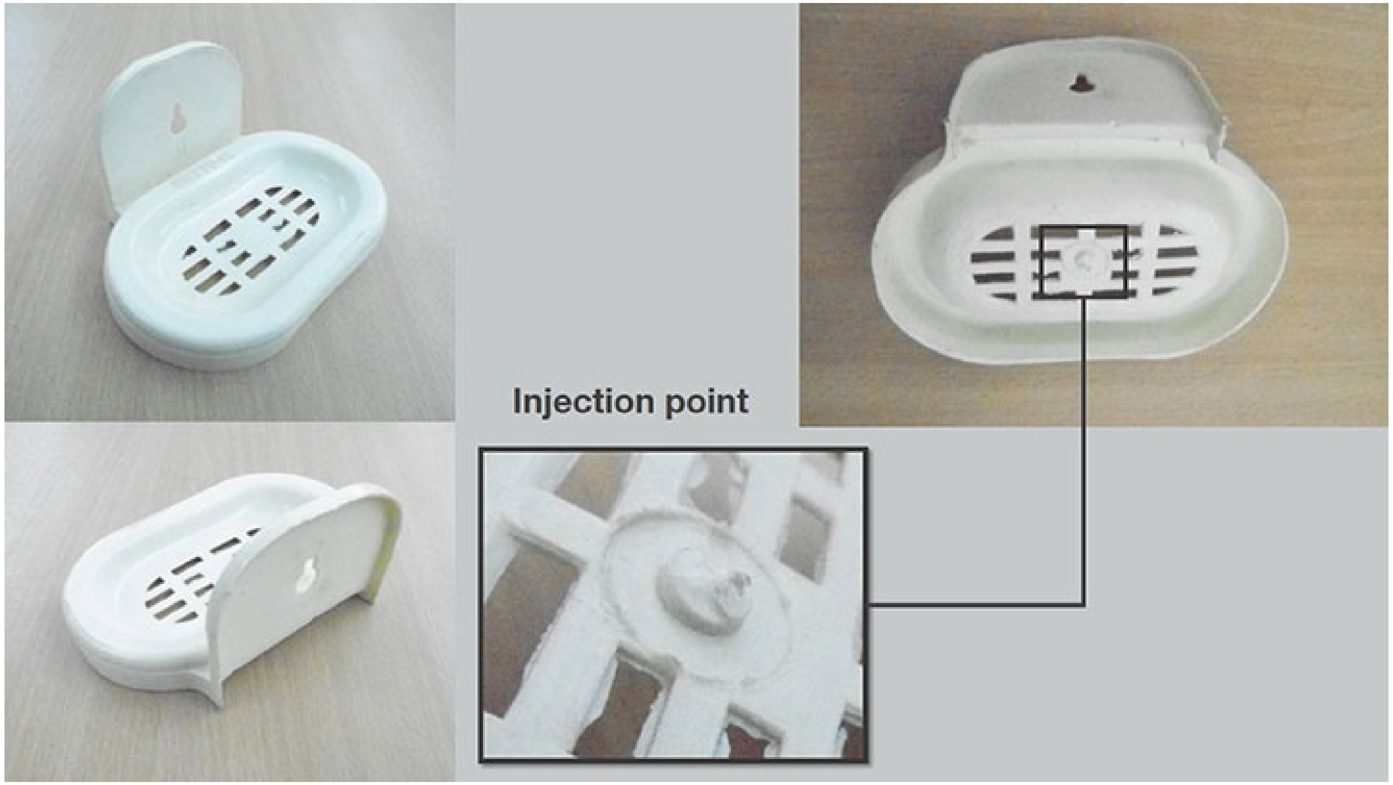

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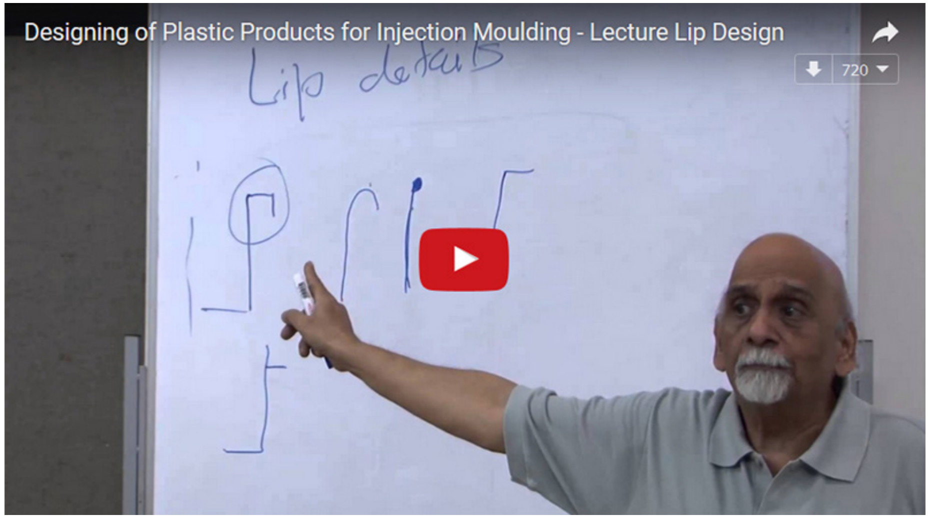
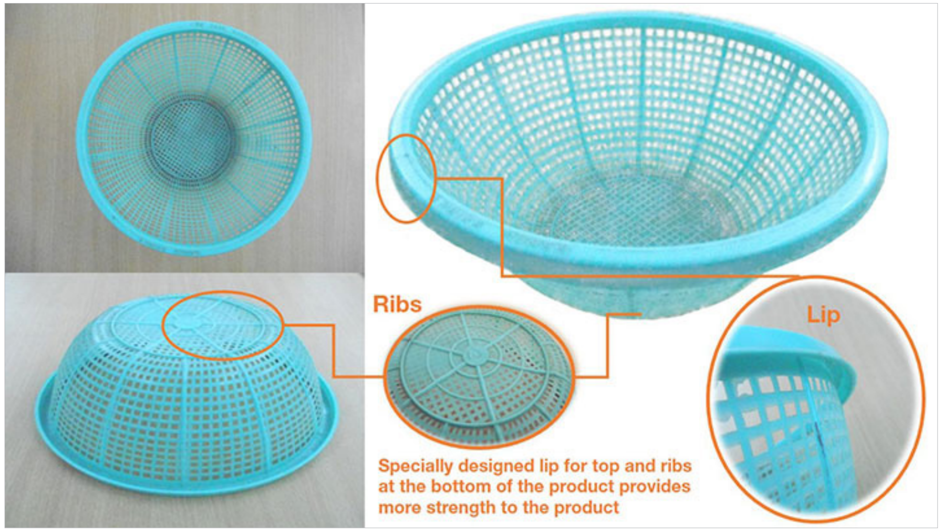
Lip Design



Lip design is a kind of special treatment given to the top of plastic products like bowl, bucket and all kind of plastic containers to provide the strength to the product. Lip design may vary with the usage of product. Plastic bucket and small bowls have an L-shape lip over the top. Medicine bottles and other PET bottles have a solid protruding ring at the top. Apart from giving the desired strength to the part lip may have other functions like acting as stopper for a cap, preventing a locking between the components during stacking etc.



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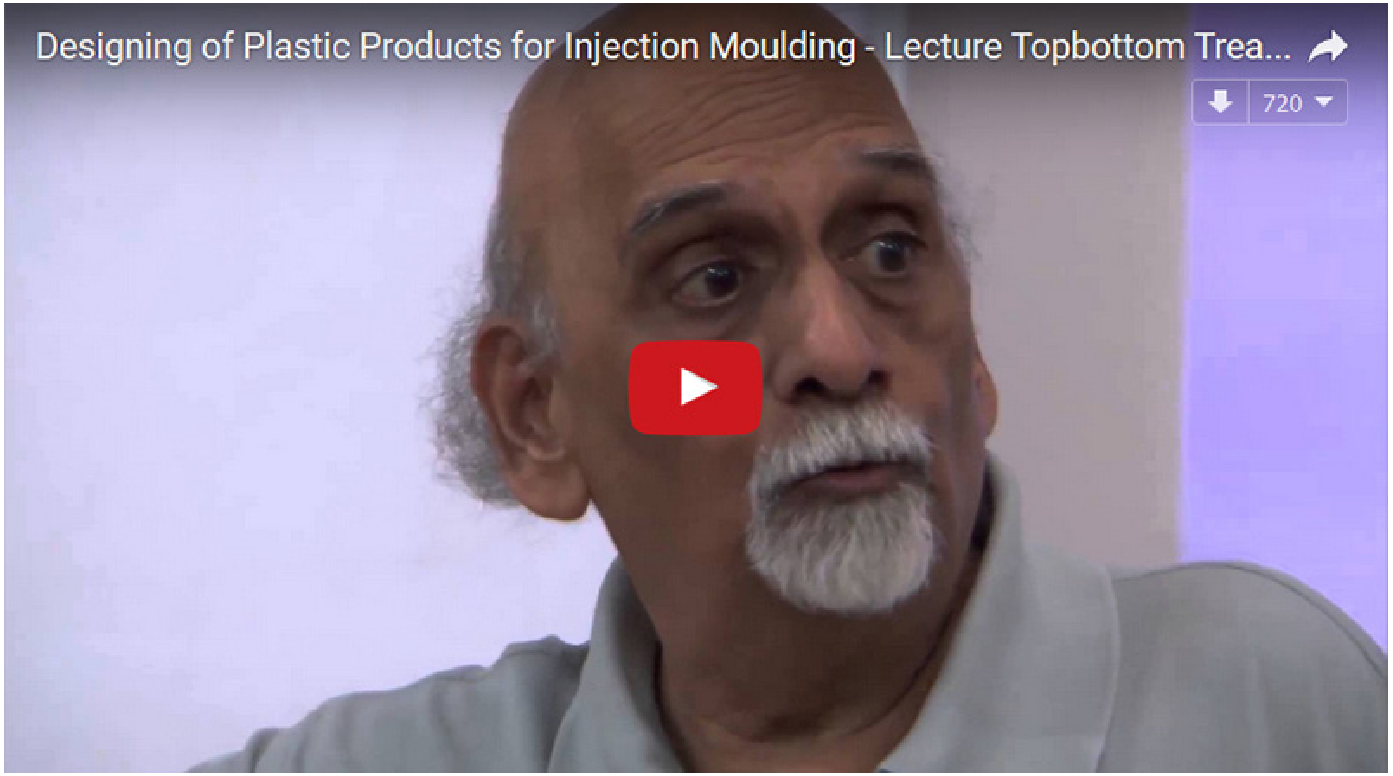
Top and Bottom Treatment



Thin flat surfaces of the plastic parts are weak like top and bottom of the plastic containers and air tight jars. To give them desired strength there is a top as well as bottom treatment given to those parts. The top treatment may involve a kind of corrugation over the top. These corrugations not only provide the strength but also act as a locator for the other parts during stacking. There are small protrusions at the bottom. This thick element is acting like a rib providing the desired strength to the part. This element at the bottom also prevents the bottom surface to come in direct contact with the rough surface which may cause scratches. A special type of these protrusions may also contain some rubber pads which will provide a proper grip to the product with ground. Corrugation at the bottom of the PET bottles provides both strength as well as stability to the bottle.

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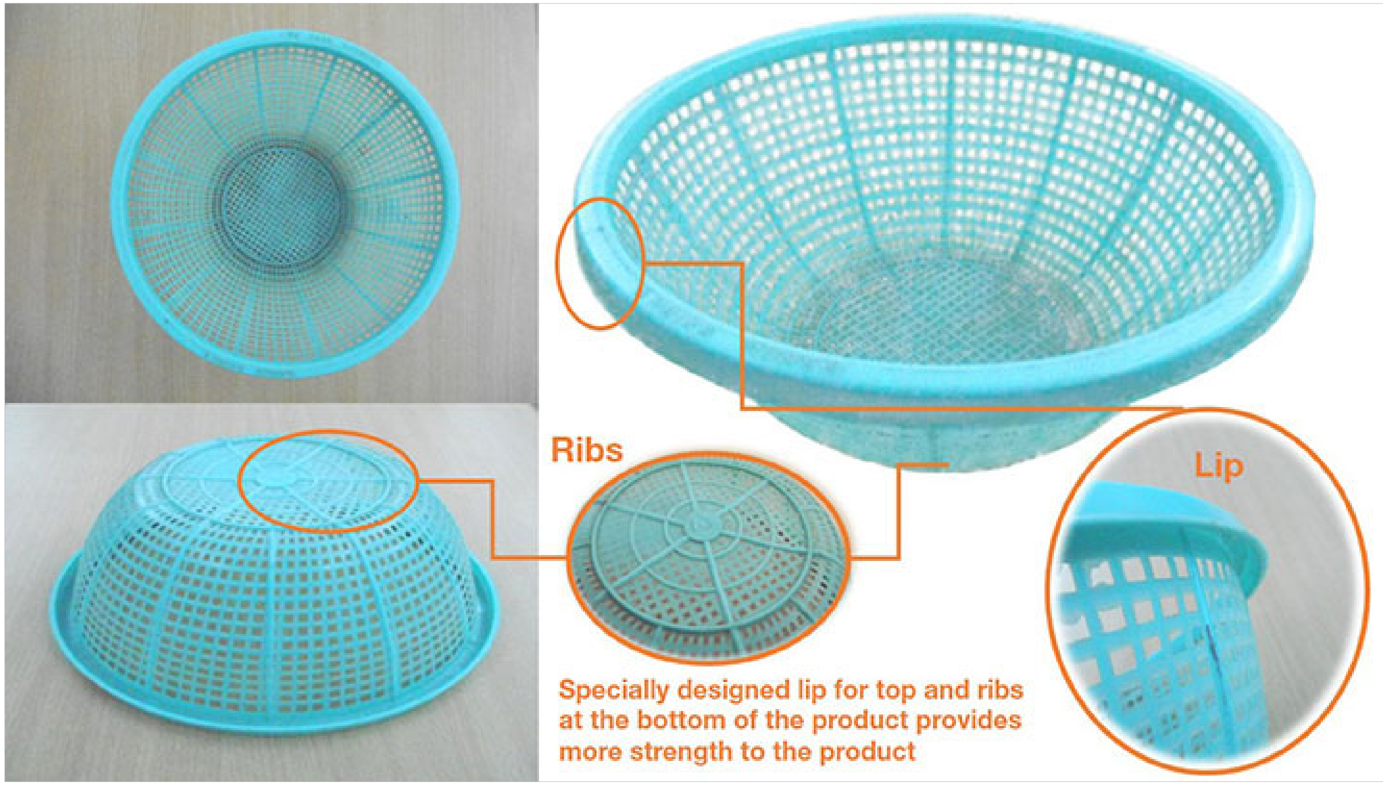

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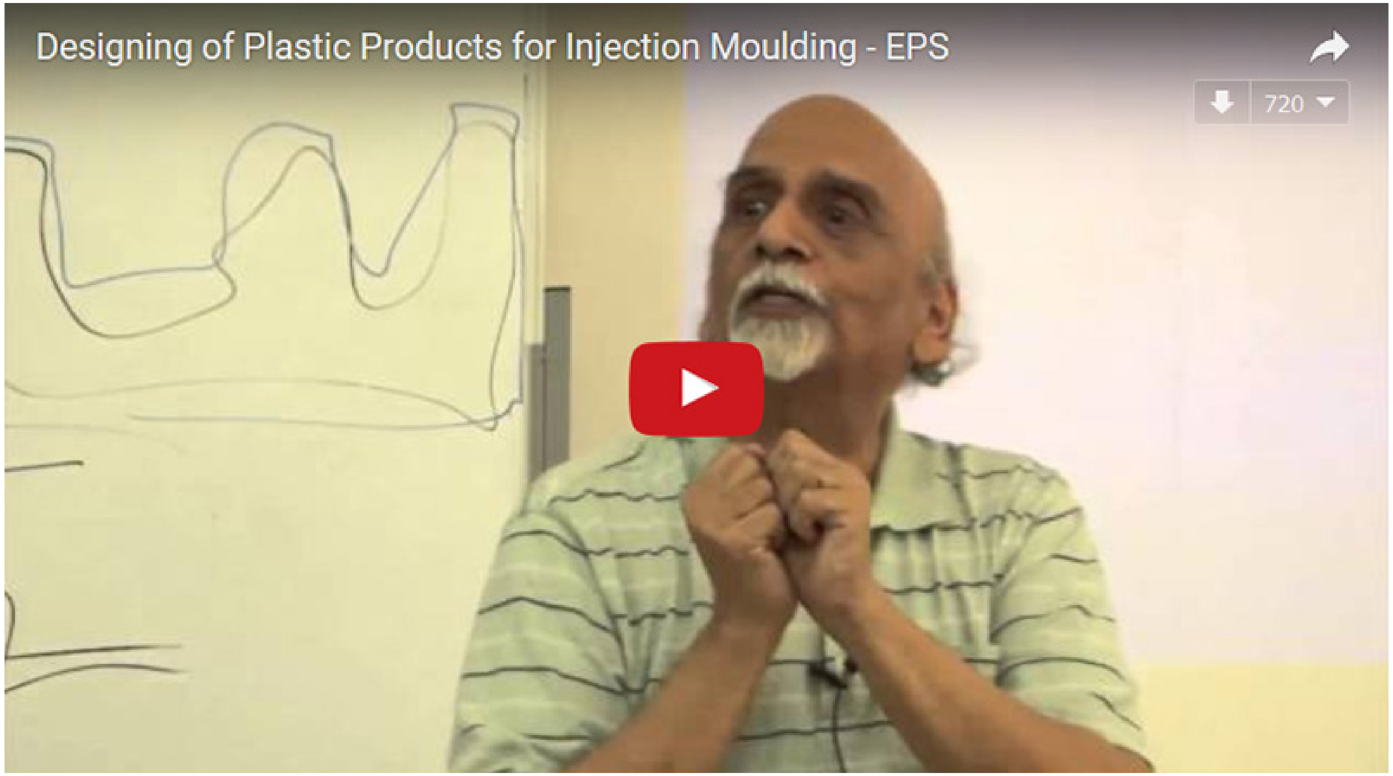
Foam Plastics



Expanded Polystyrene (EPS) is a foam plastic material. EPS is made up of 98 percent air and due to its extreme low weightand shock absorbing properties it is used as packaging material for consumer goods. Its insulation properties make it an ideal packaging material for fish and other food stuffs.

Pre expansion – Tiny spherical polystyrene beads are expended to 40 times of their original size. The blowing agent used in the process is pentane (5 % by weight). In the process beads are heated using a flow of steam due to which blowing agent gets boiled and thus a honeycomb of closed cell are formed.
Drying – Pre expanded beads are dried in a drier using a flow of air.
Stabilization – After drying beads are moved to a stabilization tank where they are stored for about twelve hours to allow the pressure differential to equalize. The beads are now having stabilized granules.
Molding – The pre-expanded beads are again reheated with steam in the mold and during this final expansion beads coalesce to give a shaped molding.

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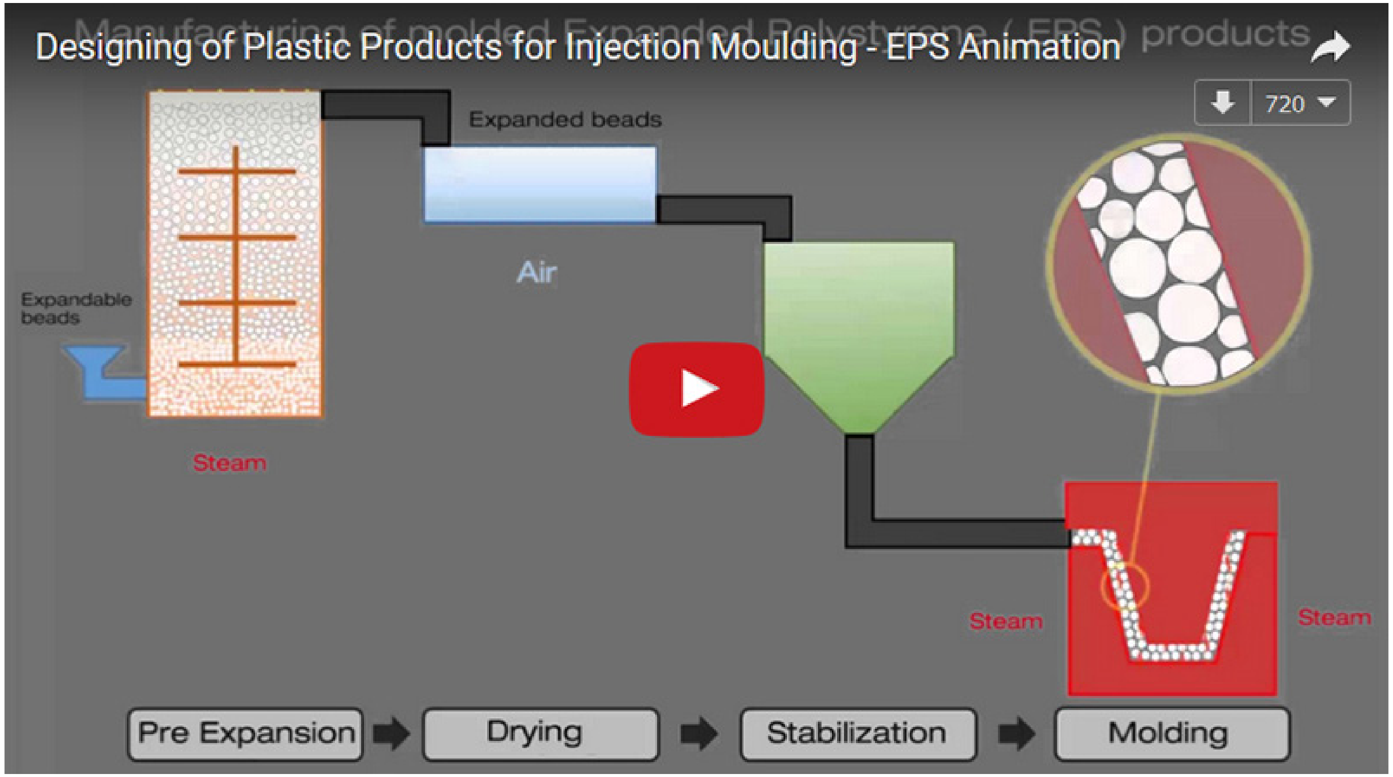

Polyurethane is a polymer manufactured by combining two different types of monomers isocyanates and polyols. Polyurethane can be in the form of liquid, foam or solid depending upon the proportions of the two monomers mixed together. Manufacturing of polyurethane part involves a chemical reaction. Isocyanates, polyols and additives are added together in specific quantities under specific conditions to produce a polyurethane product with properties required for that application.

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Types and applications of polyurethane

- Low density flexible foam used in bedding and seating.
- Low density rigid foam used for thermal insulation.
- Soft solid elastomers used for gel pads and print rollers.
- Low density elastomers used in footware.

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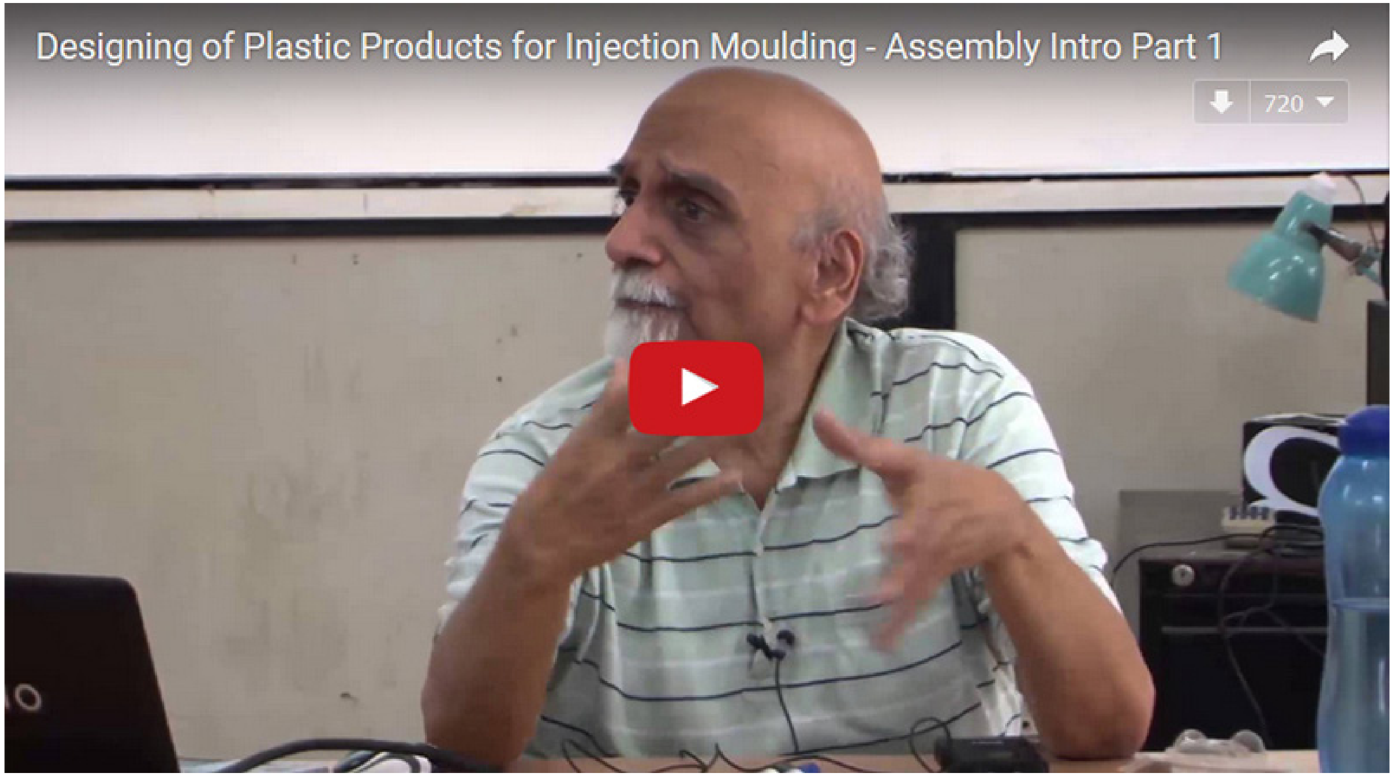
Assembly Techniques for Plastics



In plastics every finished product requires some kind of assembly for example many consumer electronic products like hair drier or kitchen appliances like mixer. The outer body parts of such products are manufactured separately and then finally assembled through mechanical fasteners, welding, snap fits etc.

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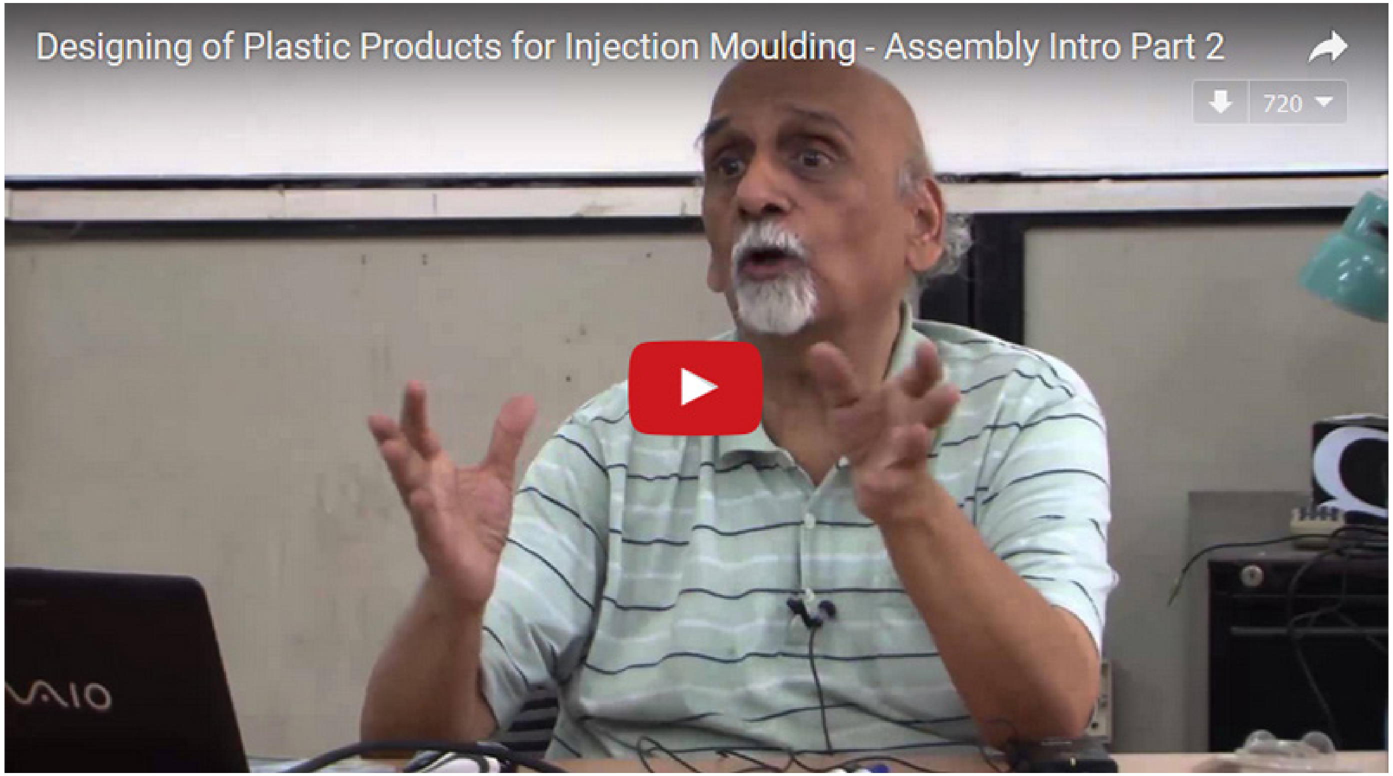

Assembly techniques for plastics depend upon the application of the product and the type of plastic used for the product. Broadly assembly techniques are classified under two categories detachable and non-detachable assemblies. Detachable assemblies are used in those parts which often needs to be separated like cap of a ball point pen, battery case etc. detachable assemblies includes special category of snap fits, threaded assemblies, hub assemblies and press fit assemblies. Non-detachable assemblies are kind of permanent assemblies and they cannot be separated easily. Non-detachable assemblies include welding, riveting, adhesive bonding, insert technology and special category of snap fits.

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Types Of Assembly

Detachable

- Snap-fits with < 90° retaining angle
- Threaded assemblies
- Press-fit assemblies.

Non-detachable

- Welding
- Riveting
- Adhesive bonding
- Snap-fits with 90° retaining angle.

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Snap Fits

Snap fits are most economical and rapid methods of assembly for high volume production. Snap-fits may be a detachable or a non-detachable joint. All snap-fit designs consist of two basic parts. First one is a flexible member which is acting like a cantilever which bends and returns to its original position during snapping action. The second member holds the cantilever having sufficient space to accommodate the flexing of cantilever. Snap-fits can be broadly categorized as cantilever snap-arms and annular snap joint. The shape of the undercut determines whether the joint can be separated or not. Snap-fits with angled undercut can be disassembled easily. Snap-fit provide both secure as well as easy assembly of the parts. They facilitate easy and quick detachment of electrical components for repair.

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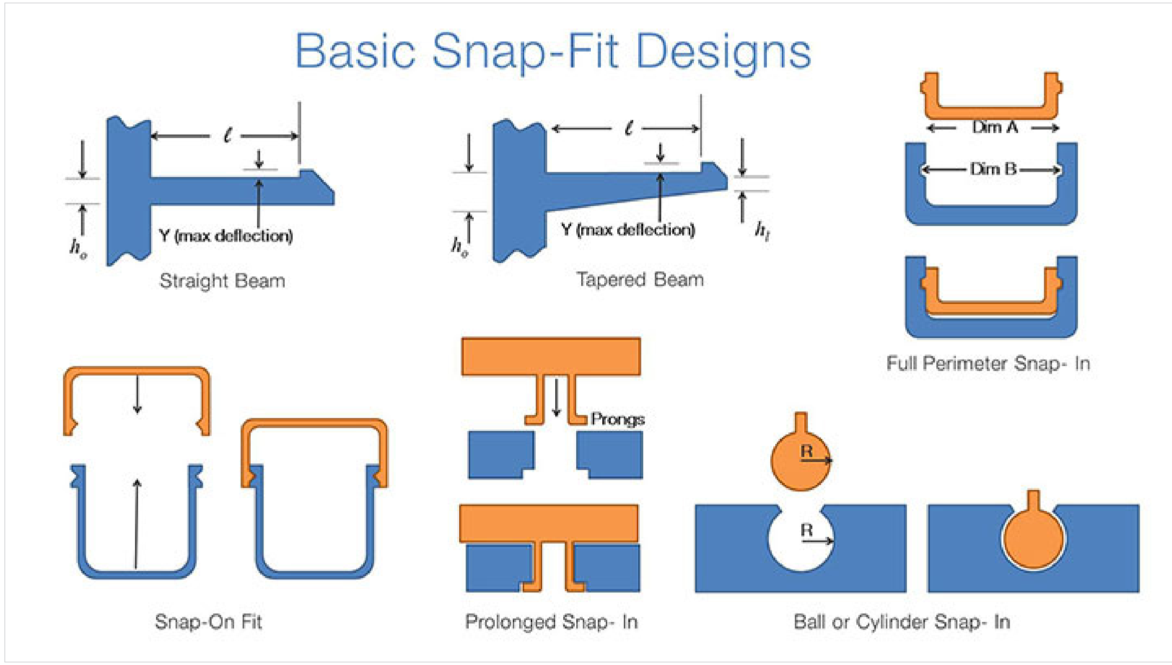

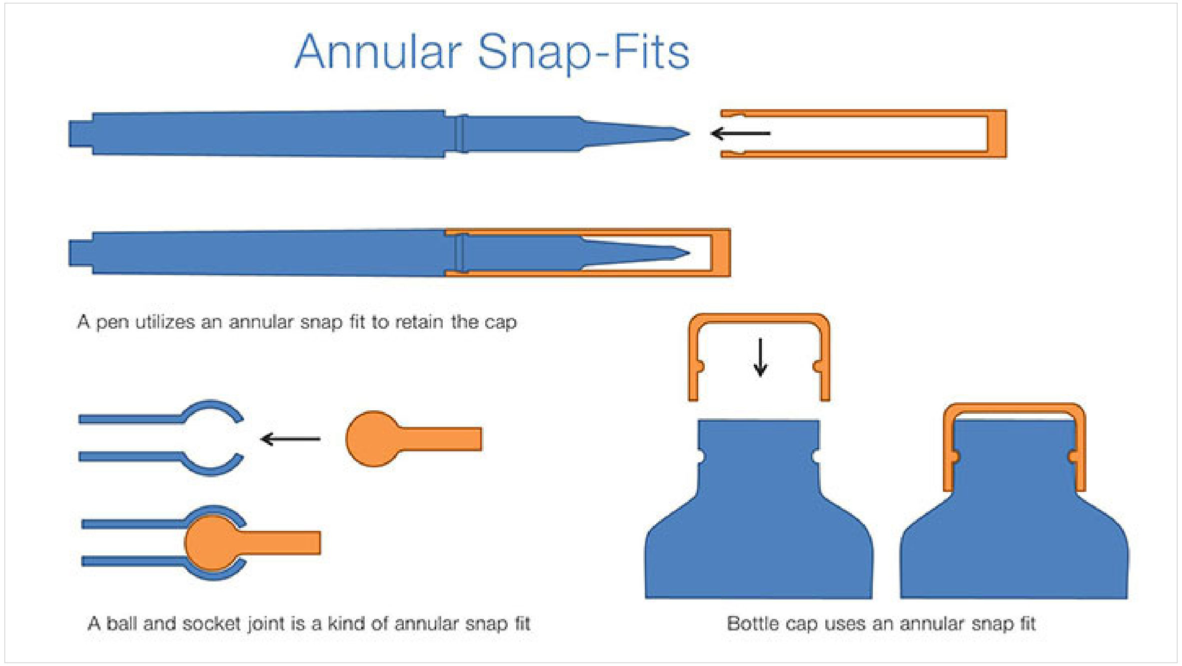

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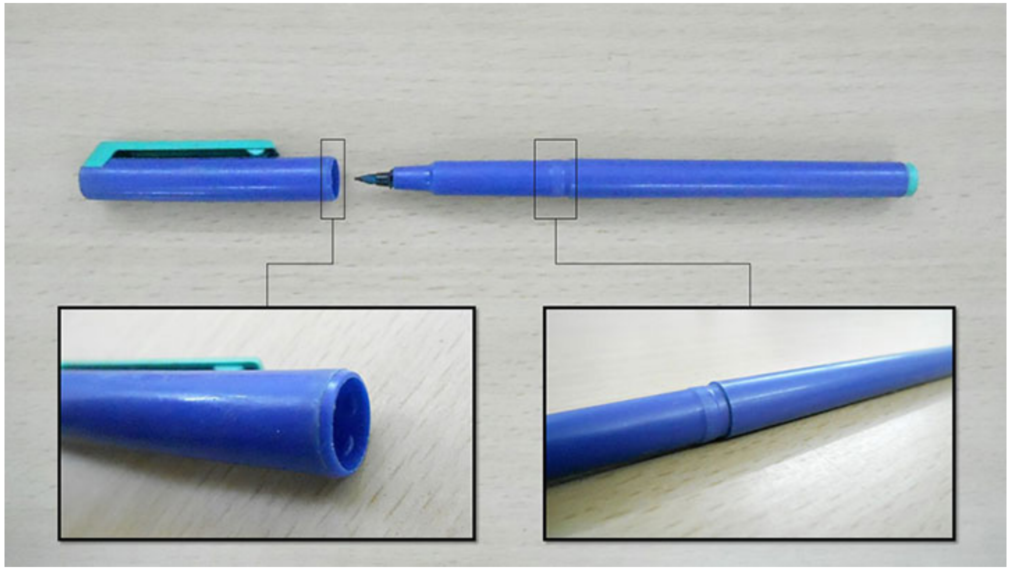
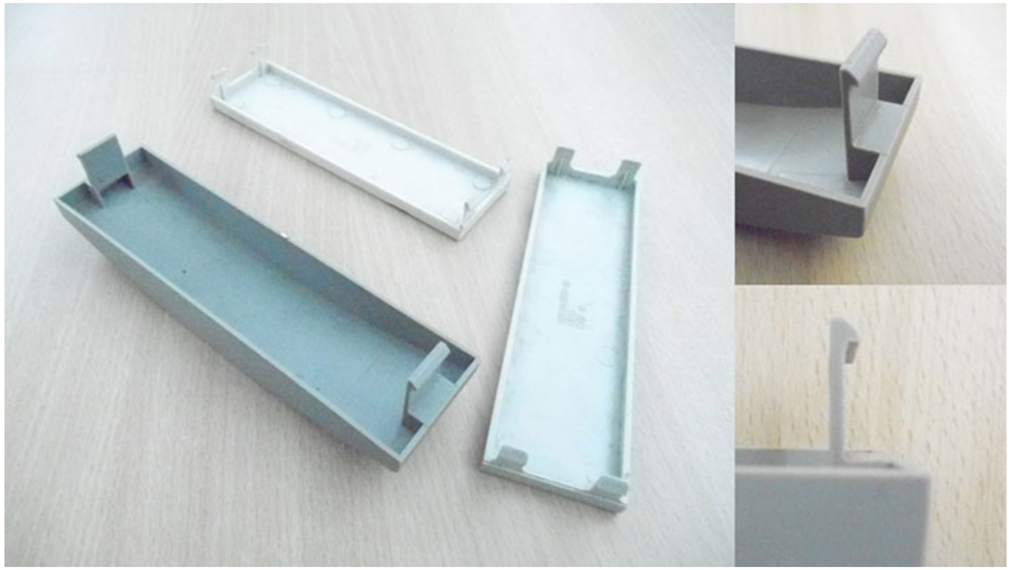
Design considerations

- The flexure during snapping should not exceed the allowable strain limit of material.
- The flexing member of the snap-fit joint should return to a relaxed position after assembly.
- Avoid sharp corners in high stress areas, such as at the base of cantilever arm.





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Hinges

Hinges are used to join two parts in which one member is allowed to rotate with respect to other. The common application includes joining a lid to a box or joining a door to a frame. A normal assembly using hinges consist of three parts they are two parts which are to be hinged and one hinge itself. Due to certain properties of the plastics these three parts can be reduced to one in a special feature called living hinge or integral hinge or sometimes called molded-in hinge. Living hinge consist of a thin section that joins the box and a lid. It is injection molded with them in a single operation. The factors which decides the success of living hinge includes 1. The material 2. The hinge design 3. The molding conditions. Mostly thermoplastic which are flexible in thin sections are preferred for hinges. The hinge section must be thick enough to allow melt to flow through to fill downstream cavity of lid and to withstand the stresses arising during service.

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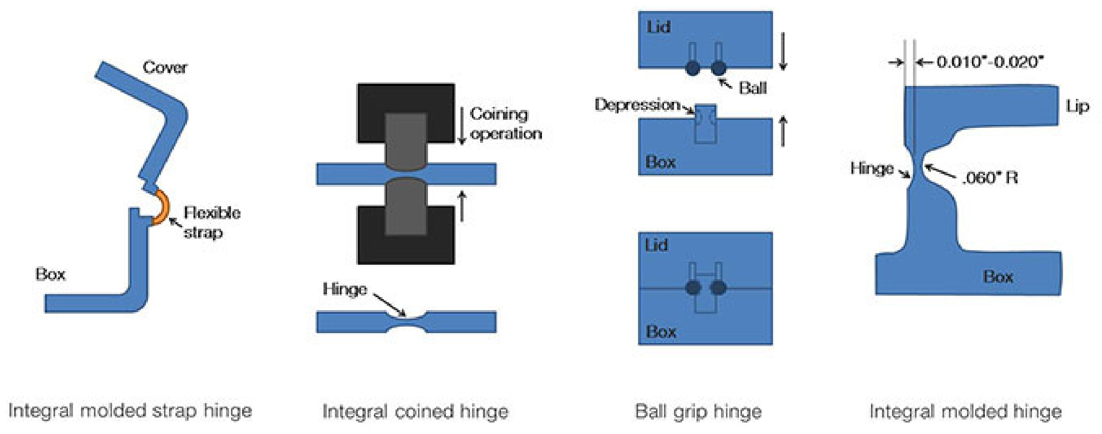
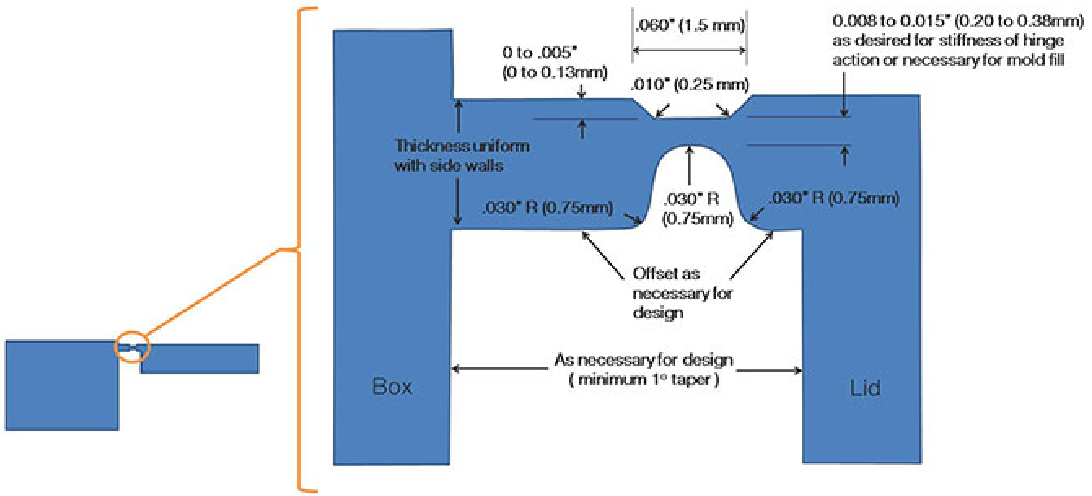
Hinges

Four types of plastic hinges



Dimensions for a 180º polypropylene and polyethylene living hinge



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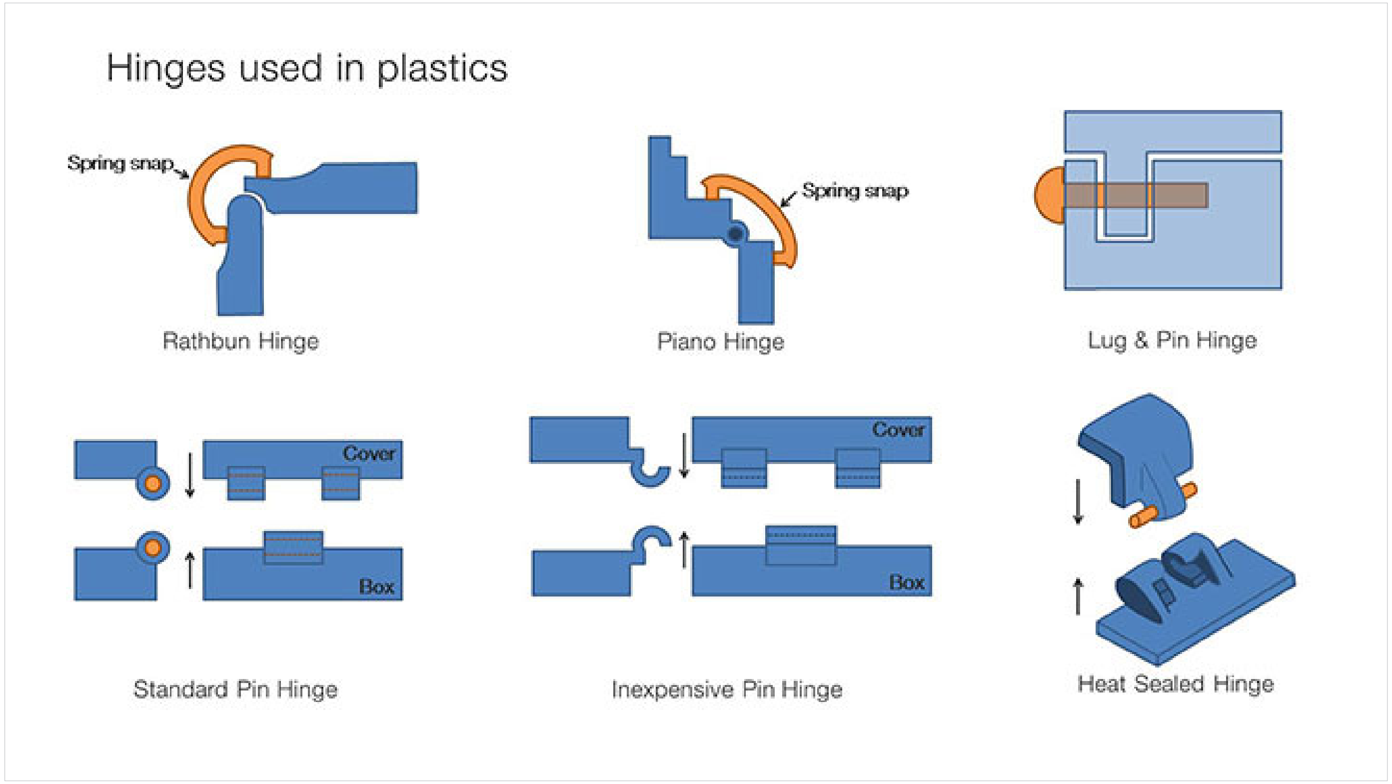

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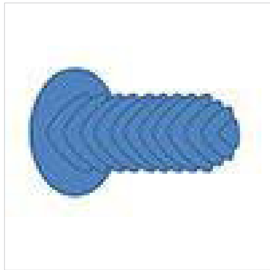
Detachable Assemblie


Snap Fit less than 90


Threaded Assemblies


Press Fit Assemblies

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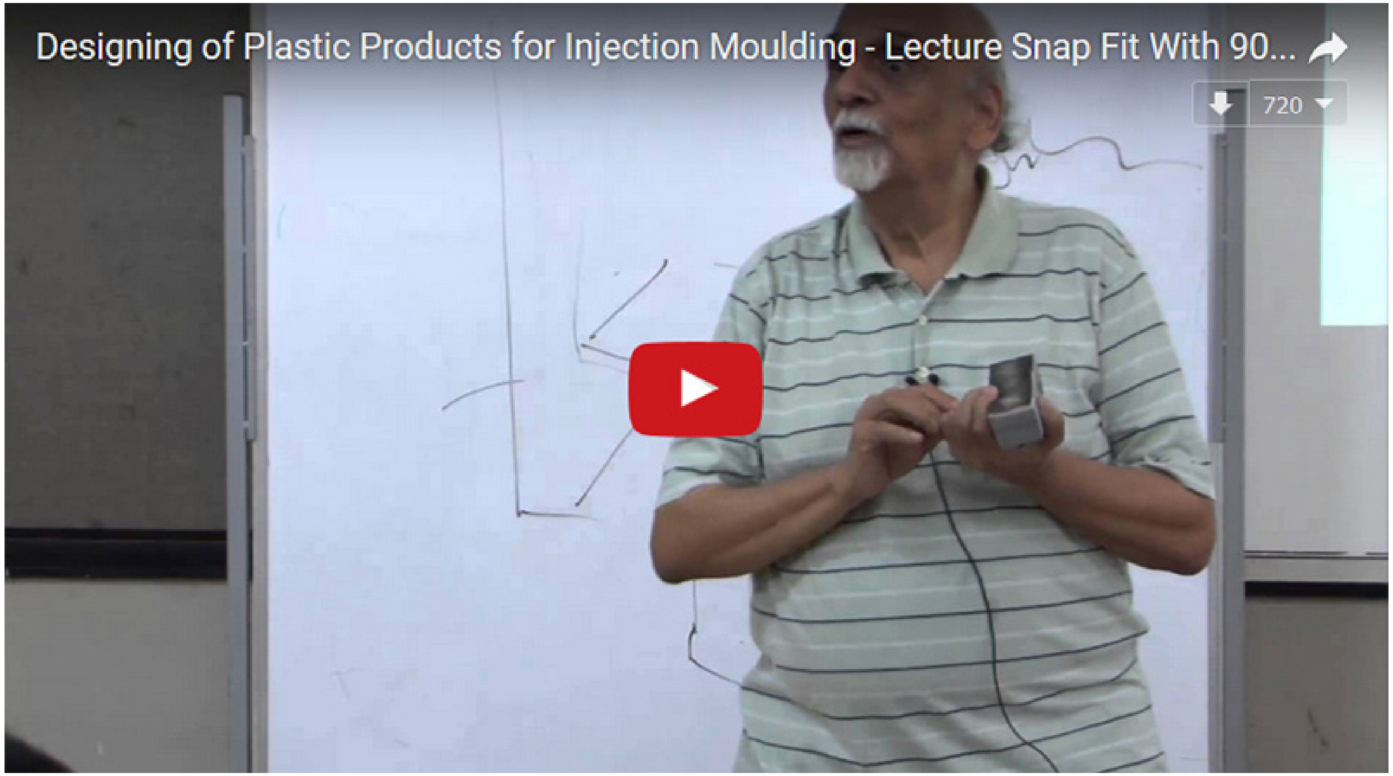
Snap Fit less than 90



Snap-fits are designed using classical beam theory and stress and strain during assembly of snap beam are calculated using standard beam equations. There are also equations to find out the deflection in the beam, length of straight snap beam, thickness of a straight snap beam.

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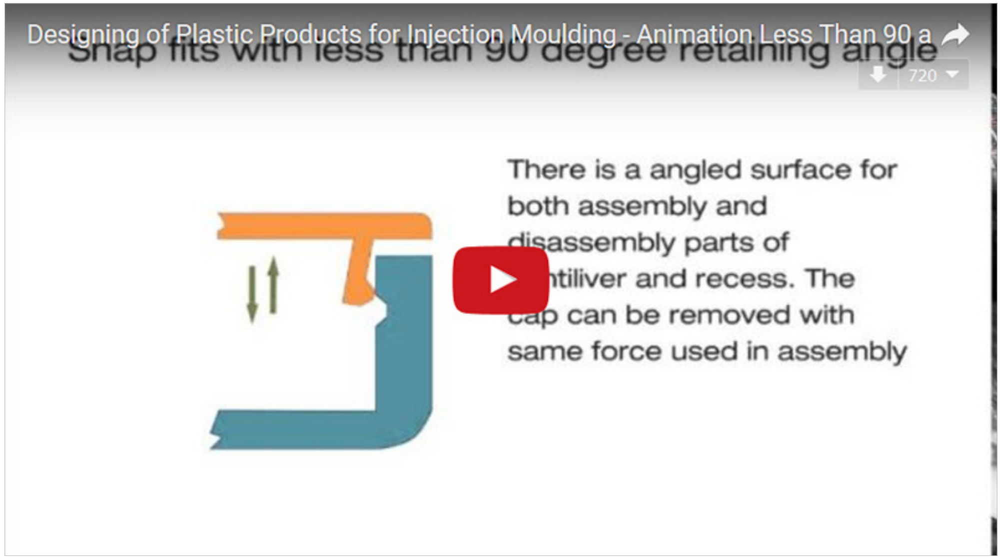
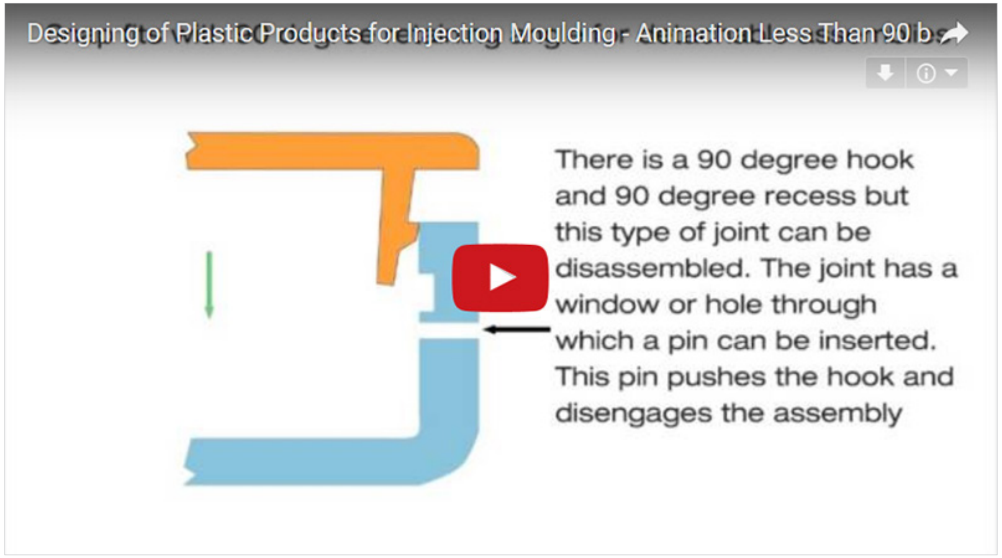


Snap-fits for detachable joints have angled undercuts. It is mostly preferred to have a retaining angle between 30 degrees to 45 degrees to have a smooth snapping action.



A special class of snap-fit having 90 degree retaining angle is used for detachable assemblies. There is a hole or a window in the recess area through which a pin can be inserted. This pin pushes the cantilever and disengages the assembly.

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U-shaped cantilever snap-fits are commonly used in battery cases. Due to the U-shape of cantilever plastic does not experience a much strain, so multiple flexes are possible without damaging the beam.

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Threaded Assemblies

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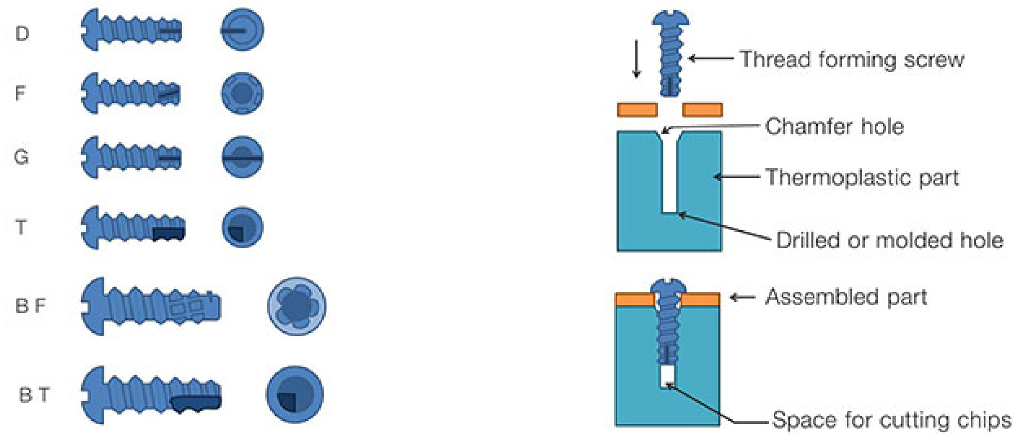
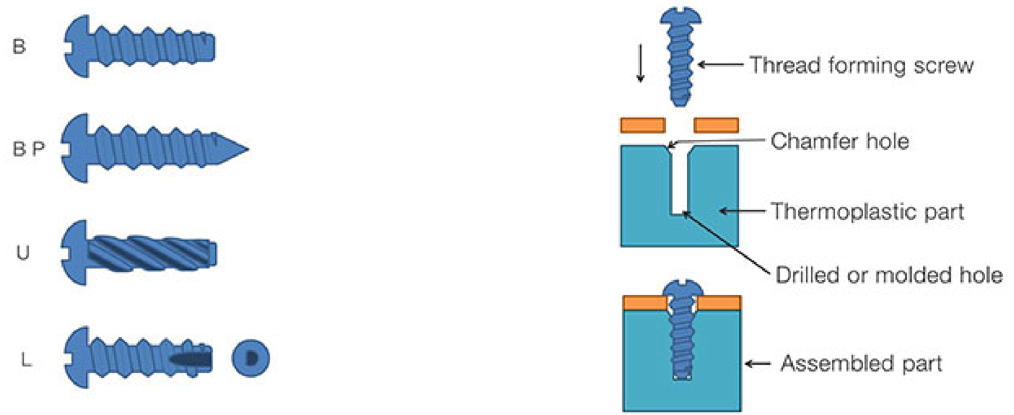
Thread cutting screws



Thread-cutting screws cut away material from the boss inner diameter to form a mating thread. Compared to thread forming screws, the radial and hoop stresses in the boss wall are lower after installation, resulting in better long-term performance.

Thread forming screws



Thread-forming screws do not have a cutting tip. They displace material in the plastic boss to create a mating thread. Because this process generates high levels of radial and hoop stress, avoid using these screws with less-compliant materials, such as polycarbonate blends.

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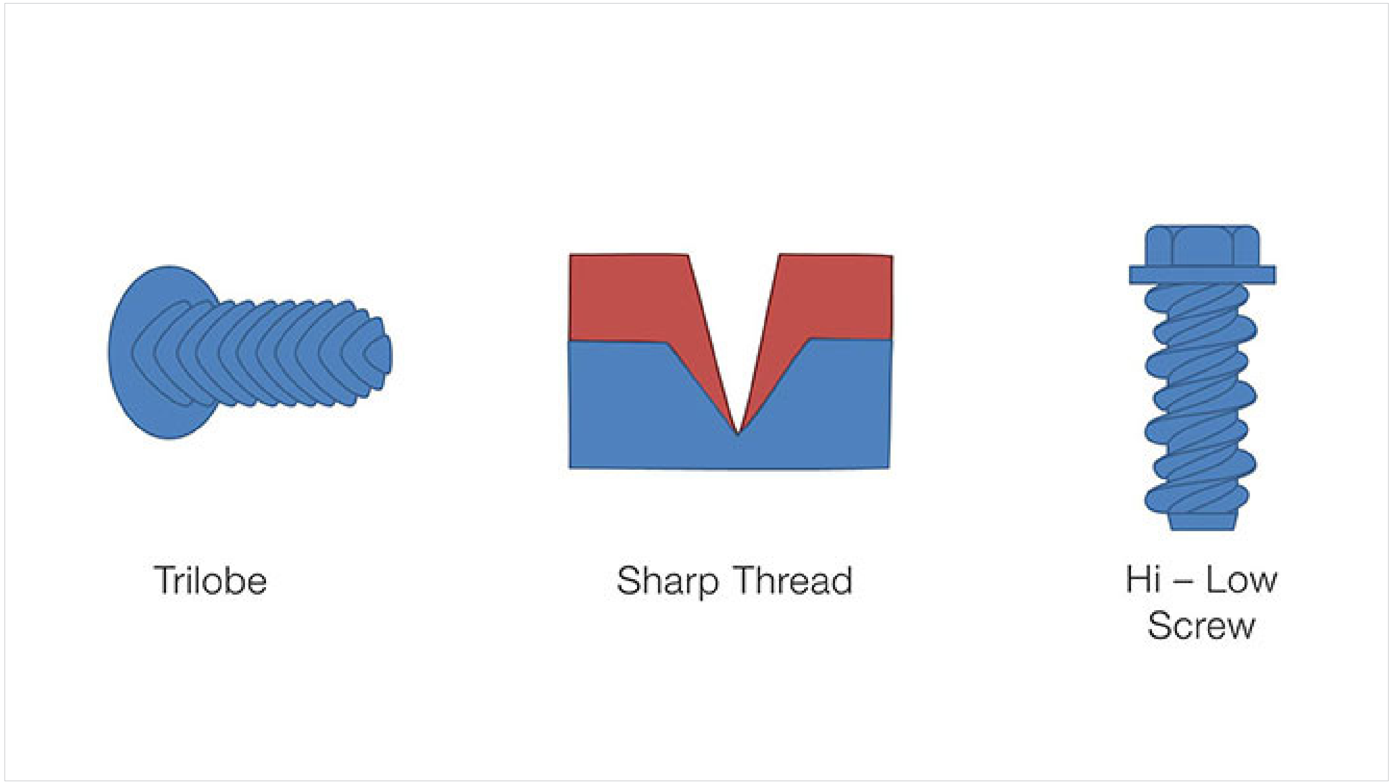
Thread forming screws deform the material when inserted, forming threads in the plastic parts whereas thread cutting screws remove the material and form the thread. The selection of self-tapping screw depends on modulus of elasticity of the plastic used.

Design considerations
- Thread forming screws – when modulus < 1380 MPa
- Thread cutting screw – when modulus is in between 1380 MPa to 2760 MPa



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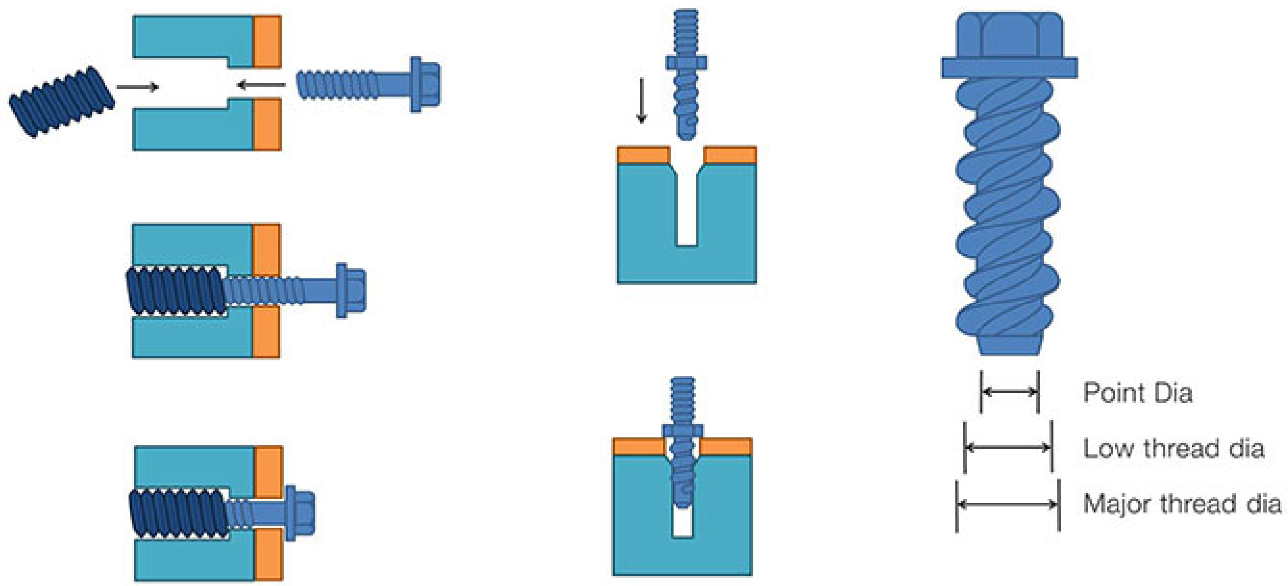
A trilobe is a thread forming screw having three swaging lobes which displaces material as screw drives into the hole. Trilobe allows the displaced material to cold flow back into relief areas which minimizes radial stress and reduces possibility of boss failure. Sharp thread are those in which the included angle is of 30 degrees or 45 degrees which makes sharper threads that can be forced into ductile plastic more readily which create deeper mating thread and reduces stress. Hi-Lo fastener has double lead thread where one thread is high and other is low. Hi-Lo fasteners have higher holding power due to the increased amount of plastic captured between threads.



Wire – type screw thread installed in a molded through hole

A double threaded insert

A double threaded Fastener

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Press Fit Assemblies

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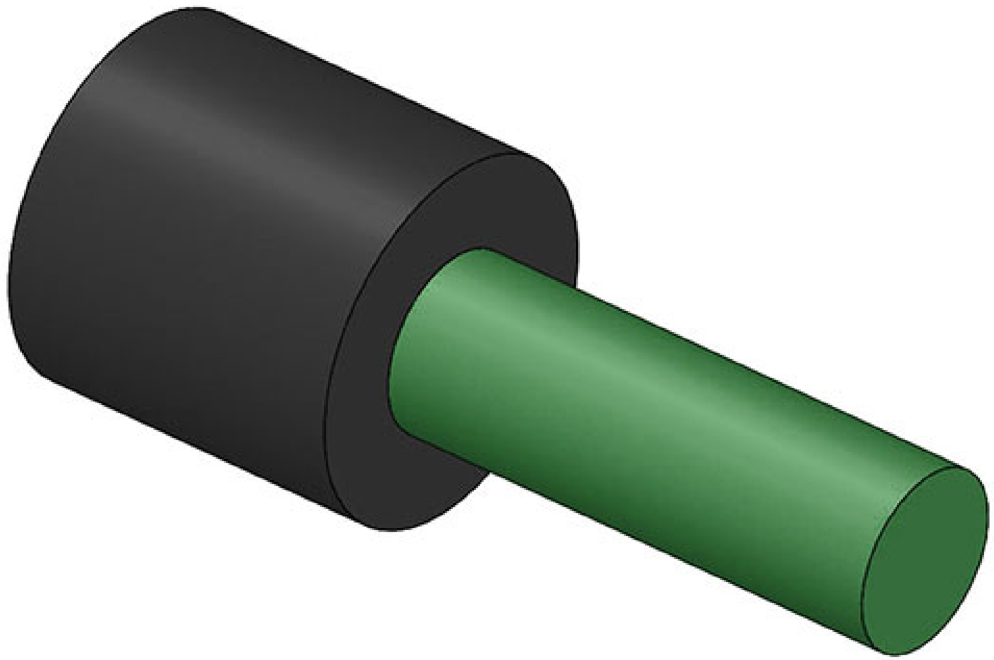

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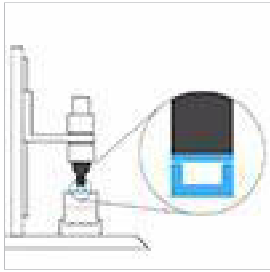
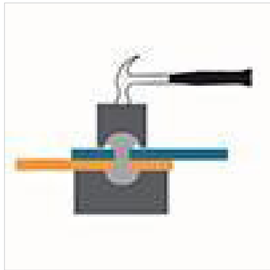
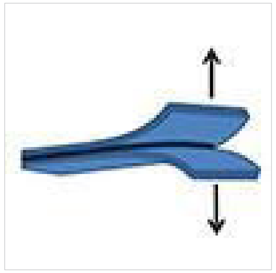
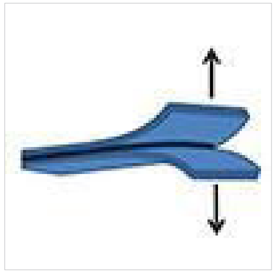
Non Detachable Assemblies


Welding


Riveting


Adhesive Bonding


Snap Fit with 90

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Designing of Plastic Products for Injection Moulding

Manufacturing Methods and Technologies

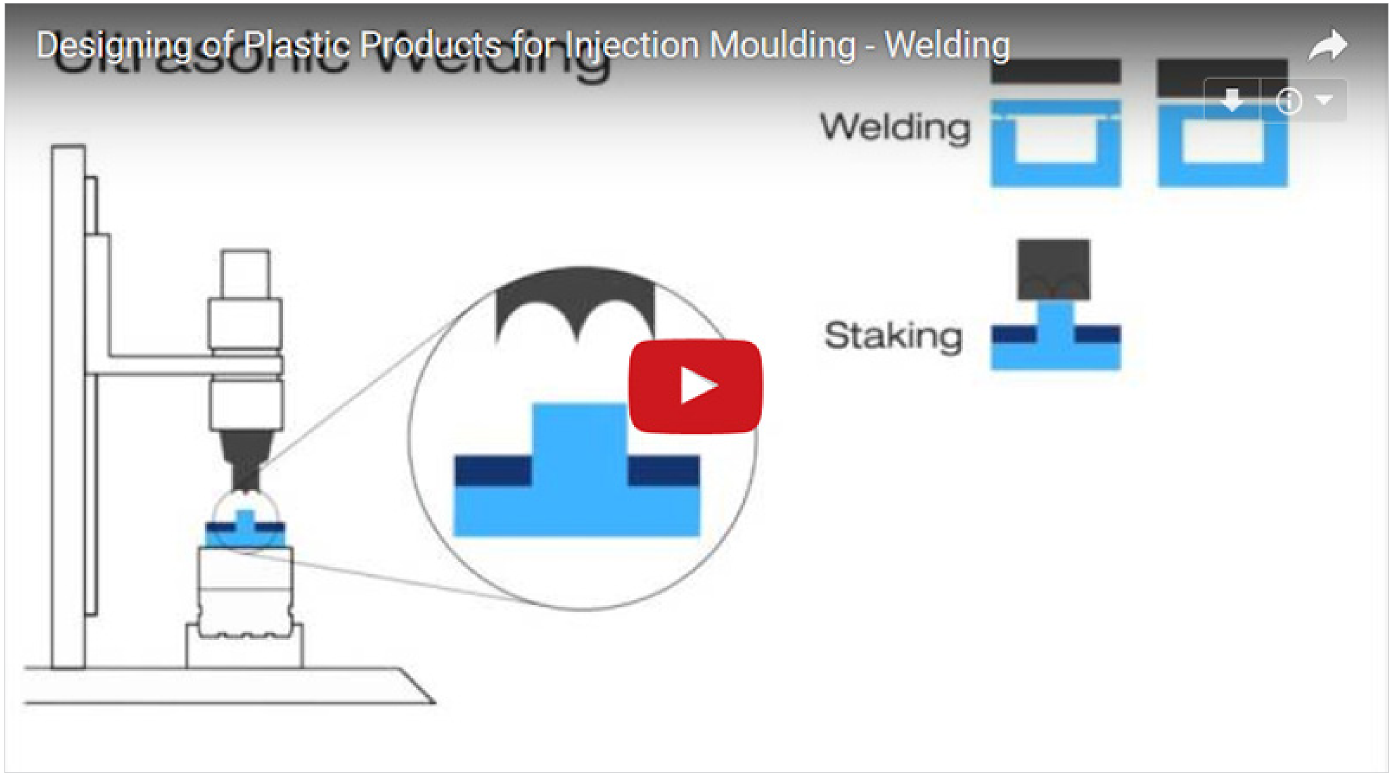
by

Prof. Vijay. P. Bapat and Shiv Kumar Verma
IDC, IIT Bombay

Source:
http://www.dsource.in/course/designing-plastic-products-injection-moulding/assembly-techniques-plastics/non-detachable-0

Welding

Welding of plastics involves the creation of molecular bond between two similar thermoplastics. Welding forms a permanent joint between two parts which are joined. Welding involves three main steps pressing, heating and cooling however pressure is applied throughout the process to improve melt flow across interface and to orient the parts properly. Heating provides the intermolecular diffusion or melt mixing. Cooling is required for newly formed joint which also decide the strength of the joint. The various welding methods for plastics include ultrasonic, vibration, hot plate, spin and laser/infrared welding.



Ultrasonic Welding
This welding technique includes the generation of ultrasonic vibrational energy at ultrasonic frequencies using piezoelectric ceramics. This vibrational energy generates a frictional heating between the mating parts and due to this heat plastic part melts at the interface and forms the weld.

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Vibration Welding

This technique is used to form a weld over a large area. In this process one part is stationary and other vibrates on the joint plane generating heat required to weld. The vibrating part may have a linear or orbital motion.

Hot plate Welding

In this process of welding the facing surface of plastic parts are heated through conduction, convection or radiation from a heated platen. The heated plate contacts the two parts or held close to them for some period of time then hot plate is removed and parts are pressed together to form a weld.

Spin Welding

This process is used to weld circular parts with continuous joints. The process relies on frictional heat generated between two mating part in which one is stationary and other is spinning to melt plastic at the interface. When friction melt sufficient amount of plastic the spinning stops and pressure is applied to complete the bonding process.

Laser/Infrared Welding

There are two ways of laser/infrared welding. First one is to heat the joining surface of both parts to create the melt and then pressing the parts to form the weld. The second one involves the use of a transparent part that allows laser and another that absorb it. When projected the laser will pass through the transparent part and reaches to the absorbing part which will get heated up. This heat will melt the plastic and weld is formed.

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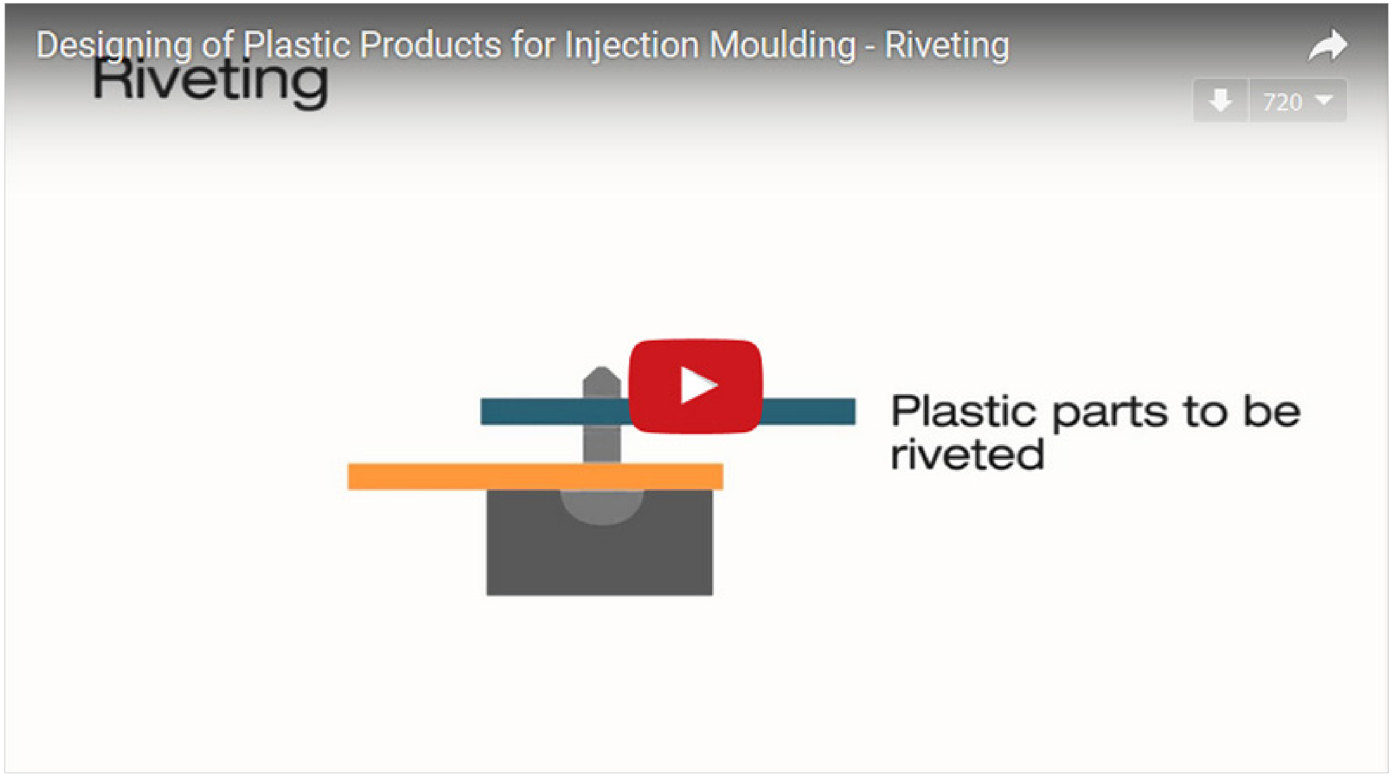
Riveting



Riveting involves permanent deformation of a rivet, stud or similar part at room temperature or elevated temperature. A rivet consists of three parts head, shank and tail. Smooth holes are drilled in the two plates to be joined and rivet is inserted. The heading operation is performed by holding the body of the rivet and necessary force is applied at the end of the rivet till the tail deform plastically in required shape. Riveting operations are of two types 1. Cold riveting at room temperature 2. Hot riveting in which rivets are heated before applying force.

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Adhesive Bonding

Adhesives for plastics are a chemical compound that adheres to the mating surfaces of the plastic and cure to form the bond. Adhesives are capable of joining plastics with other plastics, metal, rubber, ceramic, glass wood etc. This technique produces permanent bond. Curing time is the most important factor for selecting an adhesive.

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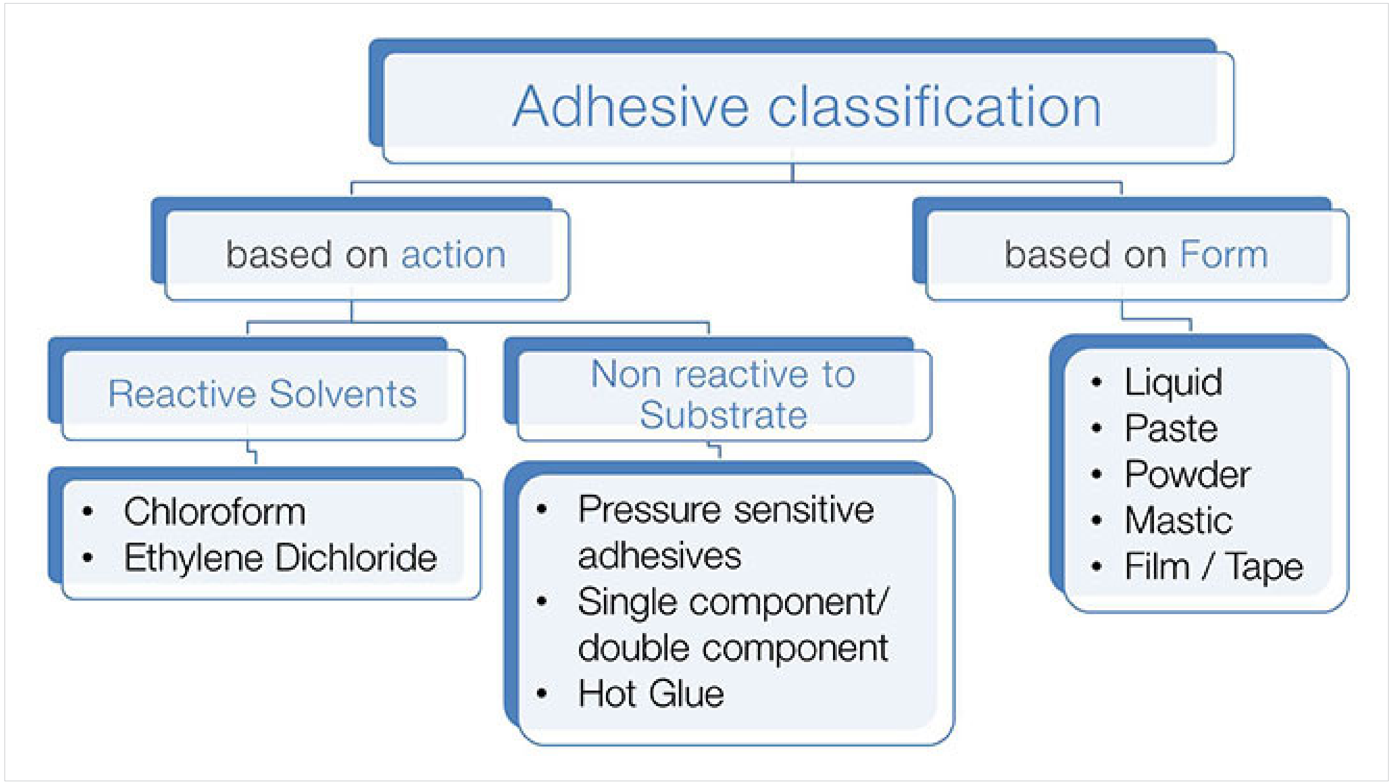

Adhesives are classified broadly based on the action and on their physical form. Based on action adhesives are classified as reactive solvents such as chloroform, ethylene dichloride etc. and non-reactive to substrate like pressure sensitive adhesives, single component/double component adhesives and hot glue. Based on form adhesives are classified as liquid, paste, powder, mastic and film/Tape.

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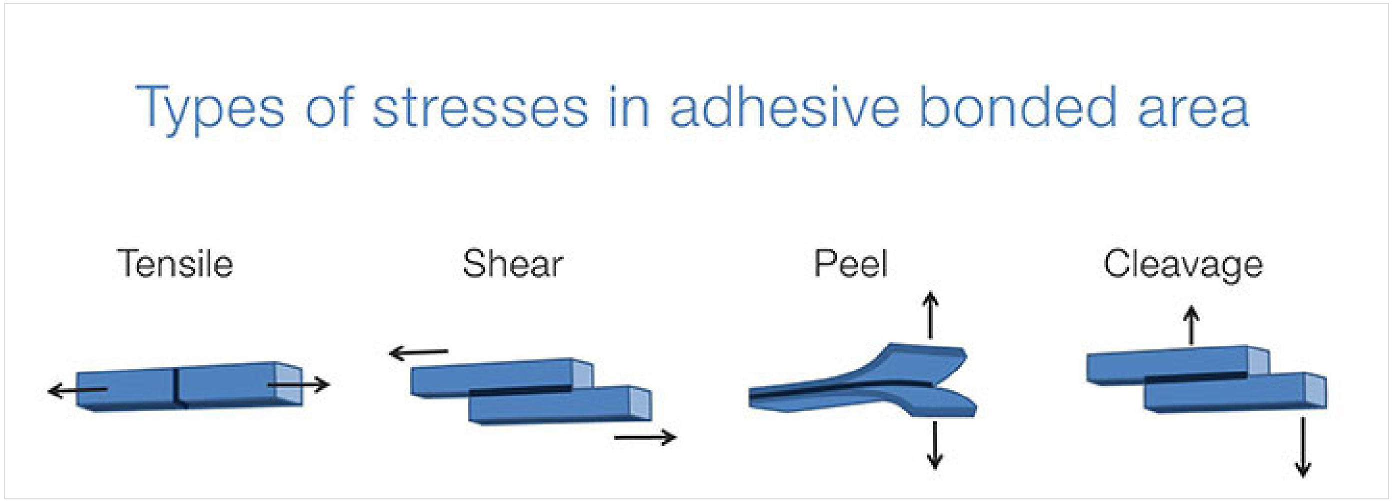
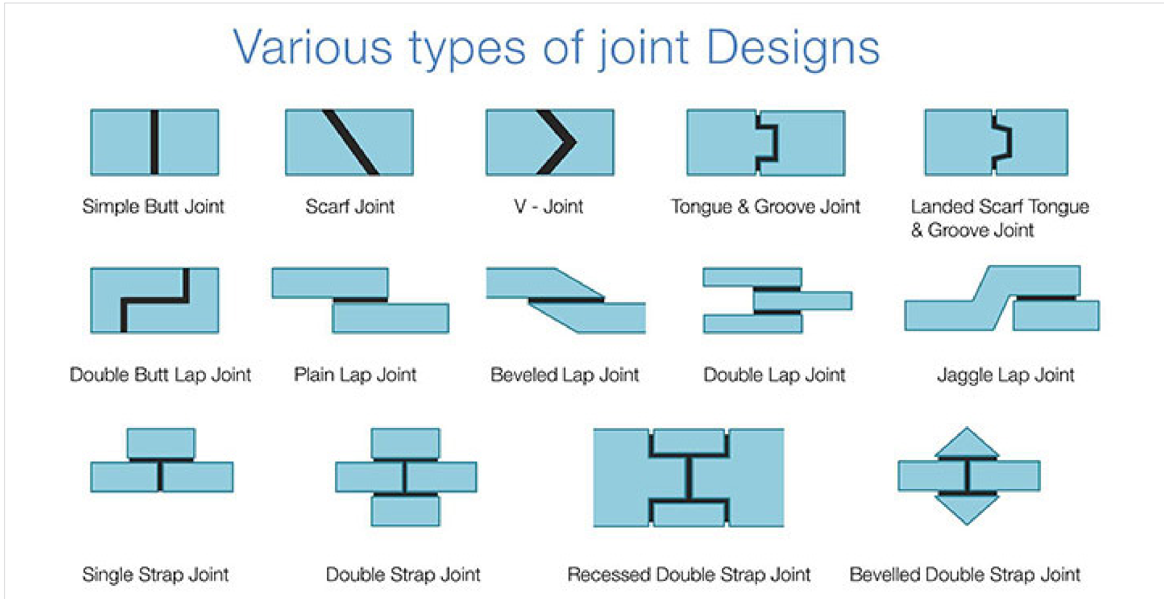


All the plastic components are subjected to the stresses during their service time. Based on the direction of application of force the types of stresses existing in adhesive bonded areas are tensile, shear, peel and cleavage.



Adhesive joints are stronger in shear and tension than in peel and cleavage. Therefore a joint must be designed to sustain load in a way that utilizes their strength. For designing the joints for maximum strength the shear area is maximized so that shear force gets distributed over a large area and shear stress gets reduced.

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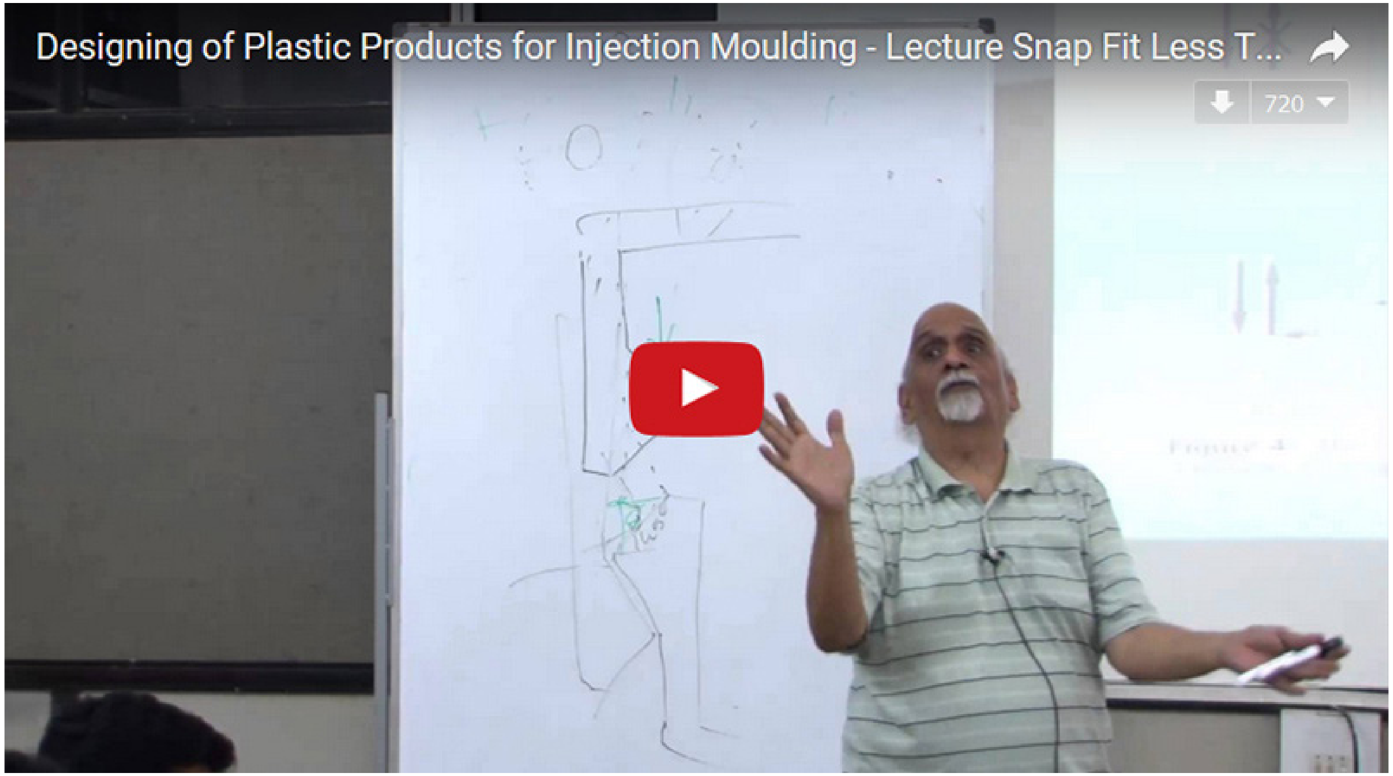
Snap Fit with 90



Adhesives for plastics are a chemical compound that adheres to the mating surfaces of the plastic and cure to form the bond. Adhesives are capable of joining plastics with other plastics, metal, rubber, ceramic, glass wood etc. This technique produces permanent bond. Curing time is the most important factor for selecting an adhesive.

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Decorative Techniques for Plastics

Aesthetics plays a vital role in the product success and plastics provide a wide scope of decoration through various decorative techniques. Unlike metals where color is only at the surface in plastics color is distributed with in the material. This section deals with the decorative techniques of plastic parts. Techniques of lettering/multi colors on plastic parts are broadly categorized as processes during molding and post molding processes. Coloring techniques during molding process are performed during the molding of a component. They are double injection molding, dye injection molding and in-mold decoration. Post molding processes of coloring are those which are performed after the component is molded. They are painting, printing, screen printing, hot stamping, pad printing, water transfer, flocking, masking and vacuum metallizing.

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Lettering / Multi Colors on plastic parts

During moulding processes

- Double injection / insert moldings
- Dye injection
- In-mold decoration techniques

Post moulding processes

- Painting
- Printing
- Screen printing
- Hot stamping
- Pad printing
- Water transfer
- Flocking
- Masking
- Vacuum metallization

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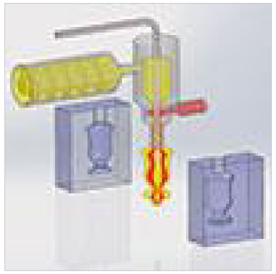
During Molding Process

Double Injection Molding



Dye Injection Molding

In Mold Decoration

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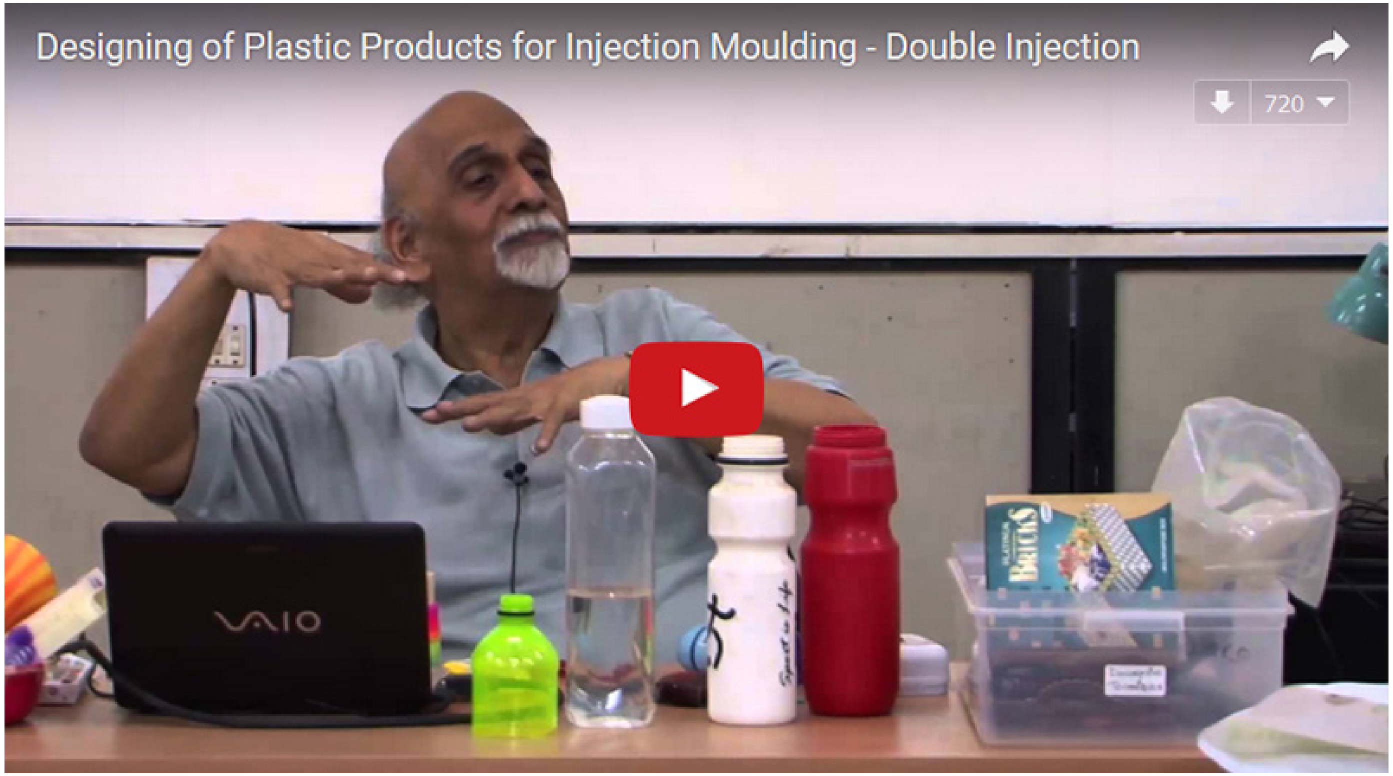
Double Injection Molding



Double injection molding is a process of producing parts with two different polymers or two different colors during single operation. The process starts with injecting the melt into primary cavity. Then the cavity plate rotates by 180 degree or the primary molding is moved to the secondary cavity. Finally the second color or a different polymer is injected into secondary cavity to fill the space between primary molding and secondary cavity. When filling is complete mold opens and finished product is ejected.

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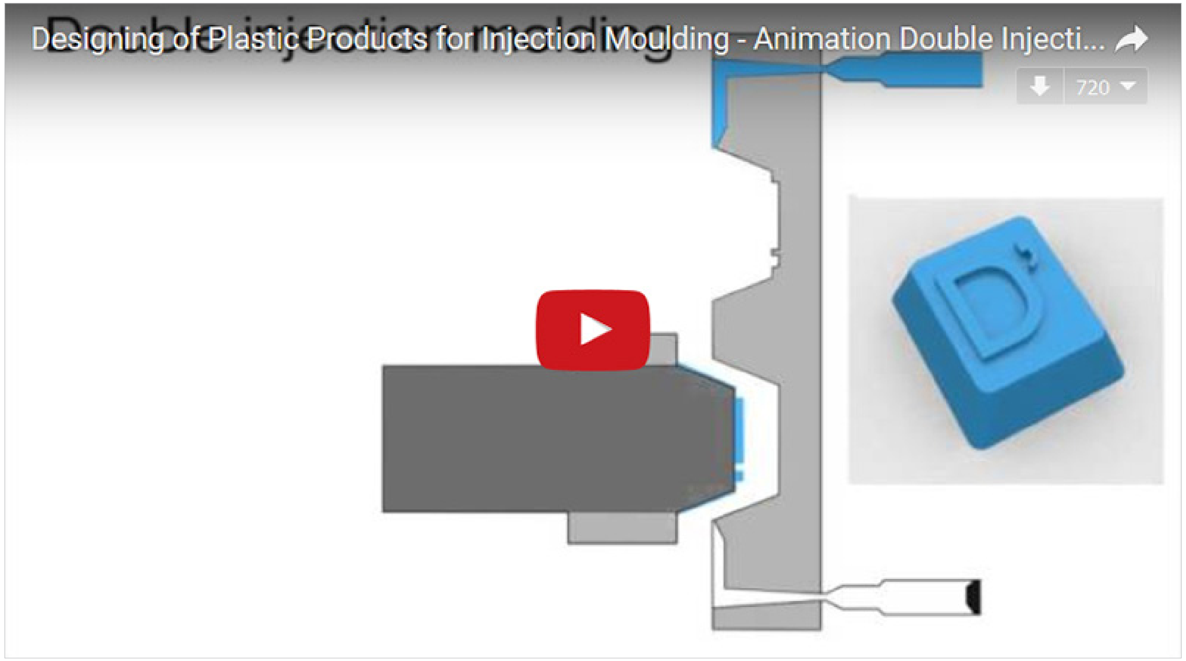

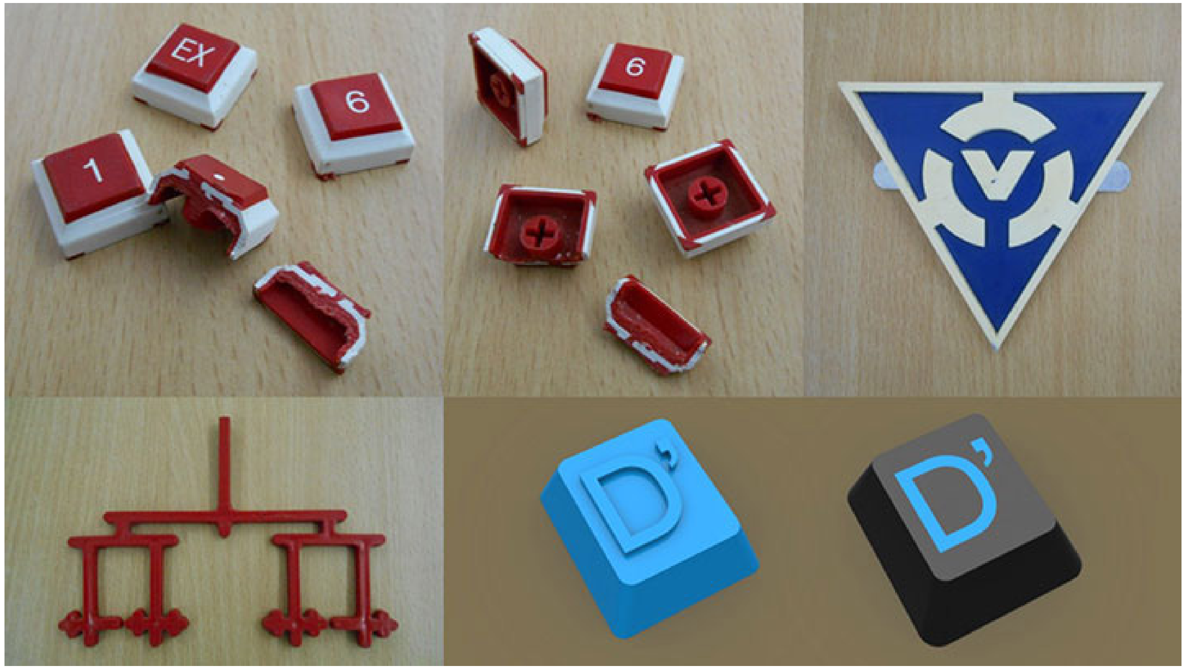

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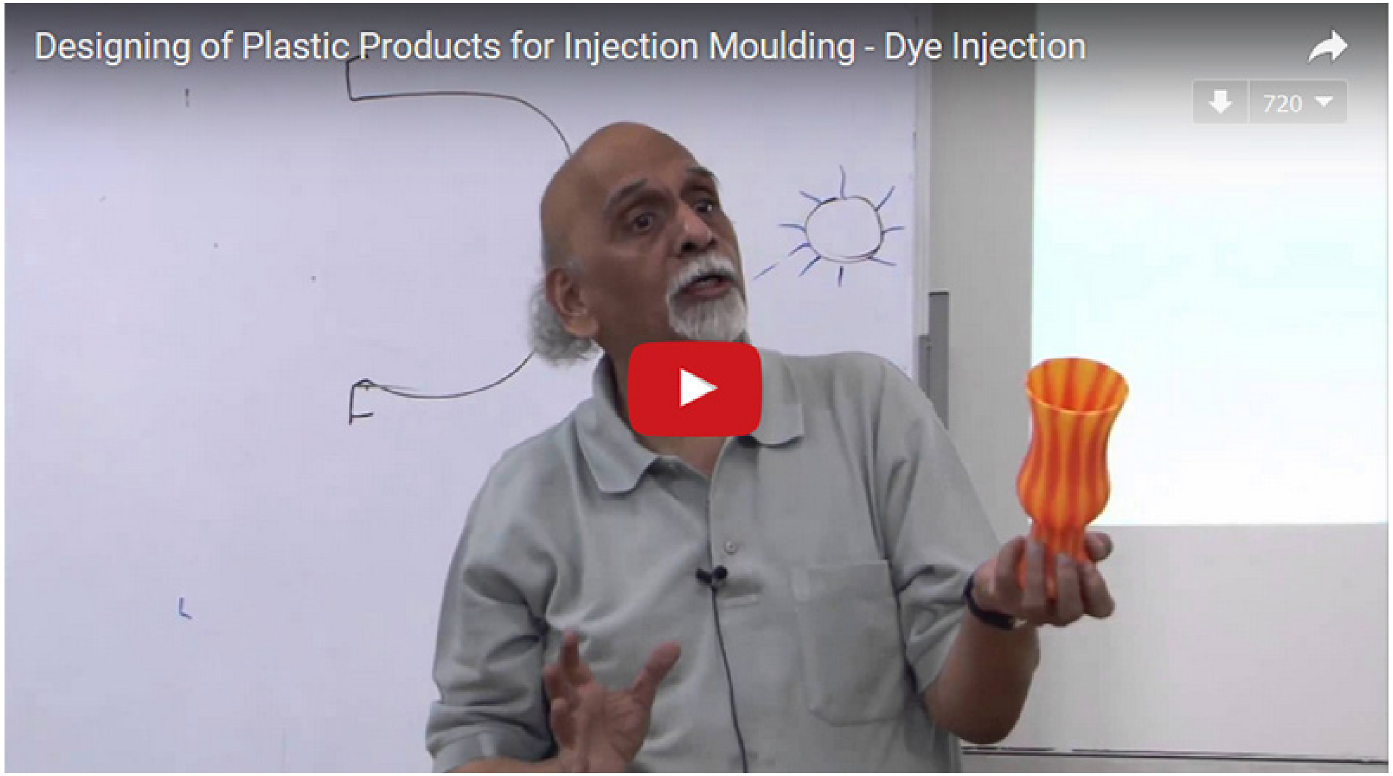
Dye Injection Molding



In dye injection molding the dye is injected at predefined points during the formation of parison. Theparison is a hollow tubular structure having the desired color pattern. In successive stages this parison is heated and inflated until it fills a mold and forms a desired shape.

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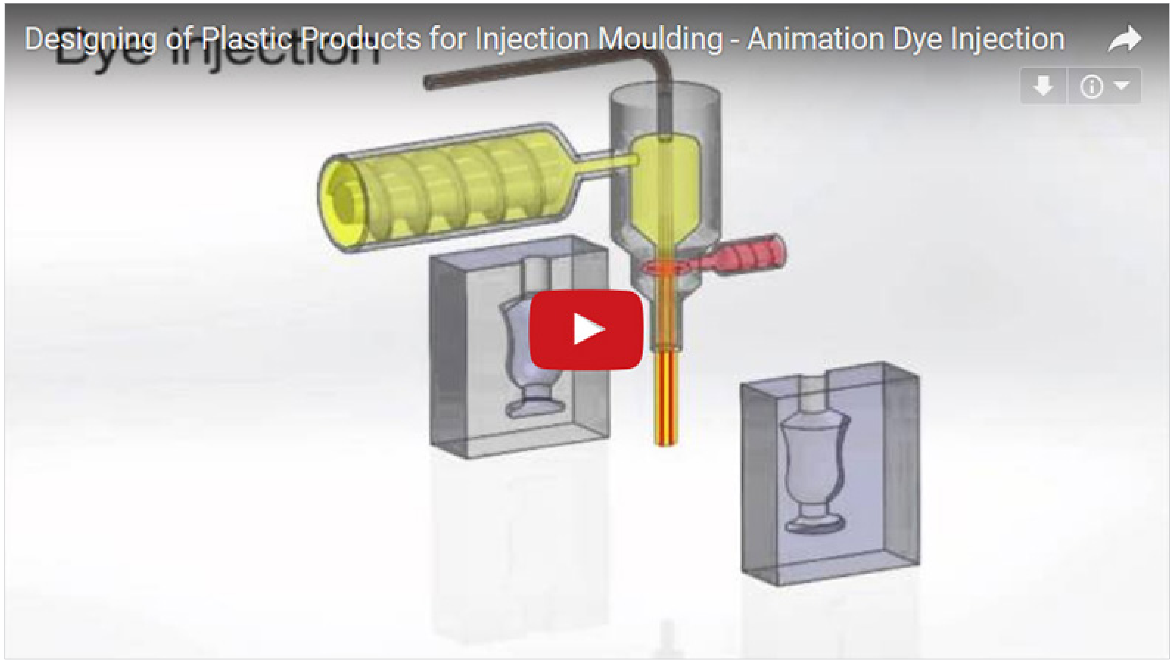

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In Mold Decoration

In-mold decoration techniques are applied during molding process. These techniques can reduce the decorating cost. These techniques also reduce or eliminate the use of chemicals thus reducing the environmental or health hazards. In-mold decoration also offers the feasibility of applying multi-color graphics and patterns which is not possible with conventional painting methods.

The two common in-mold decoration methods are:

• Powdered-paint method – In this process a powder is sprayed inside the mold before injecting the thermoplastic resin. When resin is injected the paint gets melted and bonds to the plastic part surface. This process involves the need for an automatic painting process.
• In-mold transfer decoration – This process involves the transfer of graphics from a preprinted carrier polyester film to the plastic surface during molding. The film is held by an electrostatic charge over the cavity surface. due to heat and pressure of the molding the decoration gets transferred from film to the molded part.

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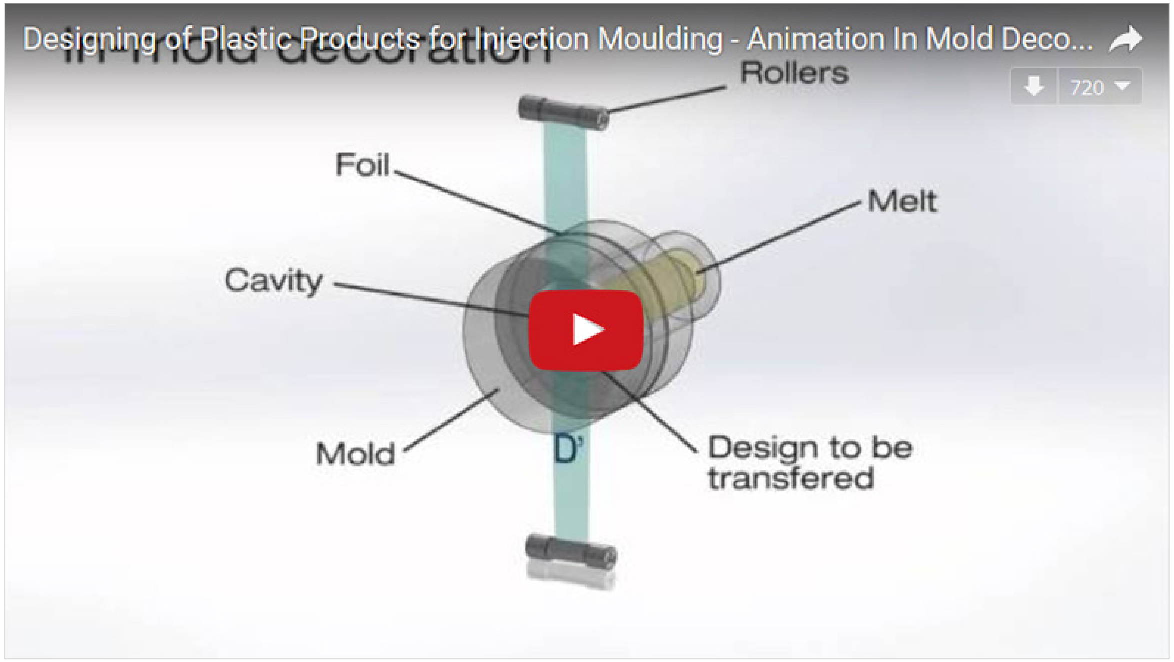

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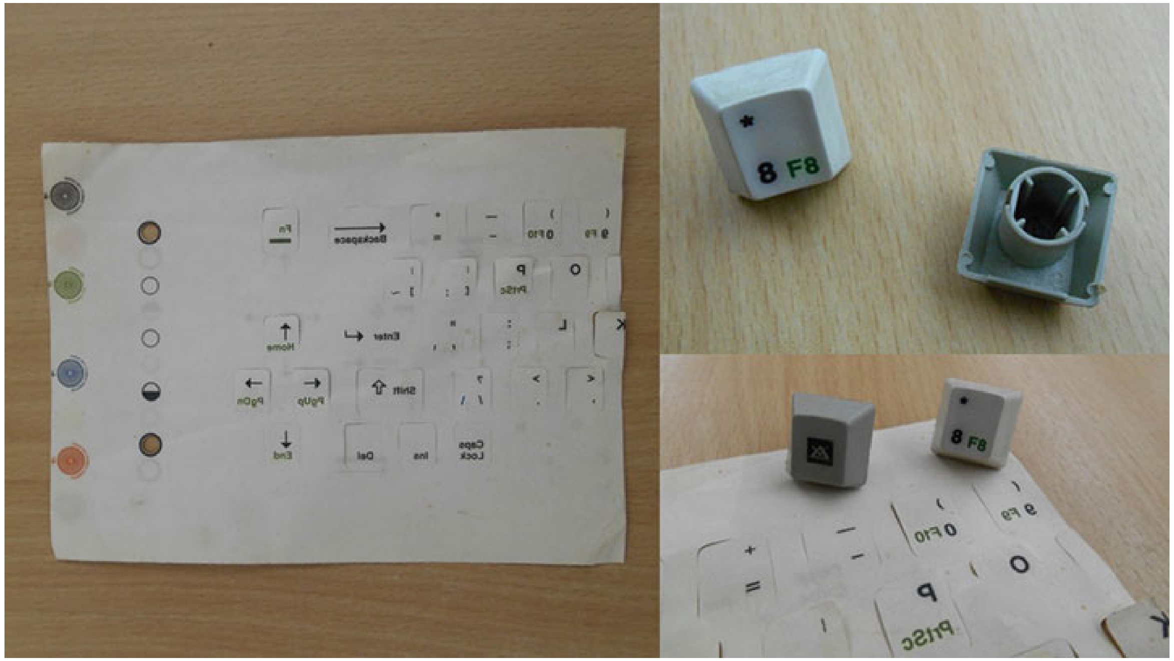

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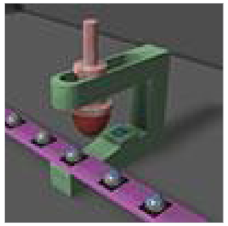
Post Molding Process

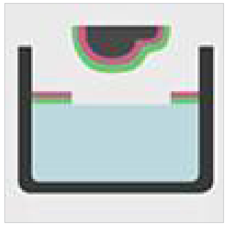
Painting

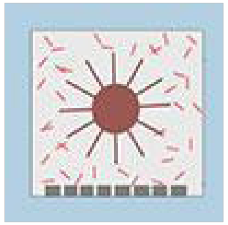
Printing

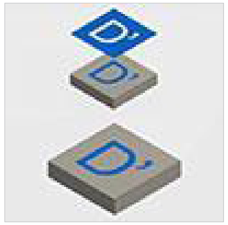

Screen Printing

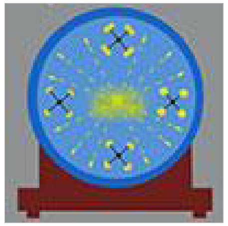

Hot Stamping


Pad Printing


Water Transfer


Flocking


Masking


Metallization

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Painting

Painting on plastic parts are done to enhance the aesthetics and to obtain uniformity in color and texture in assemblies made of different material and different processes. Painting also hides the molding defects. Painting also protects the plastic part from harsh environmental conditions. There are four basic components of paints. They are polymeric resign, pigment or dyefor color, thinning agent and additives for adhesion and appearance.

Types of paints used on plastics:

- Polyurethane paints – It provides durable finish and cures without heat. It is compatible with most of the plastics.
- Vinyls – They produce soft rubbery finish.
- Epoxies – They produce hard, tough and glossy finish.
- Acrylic paints – They provides brittle, scratch resistant and oil resistant finish.

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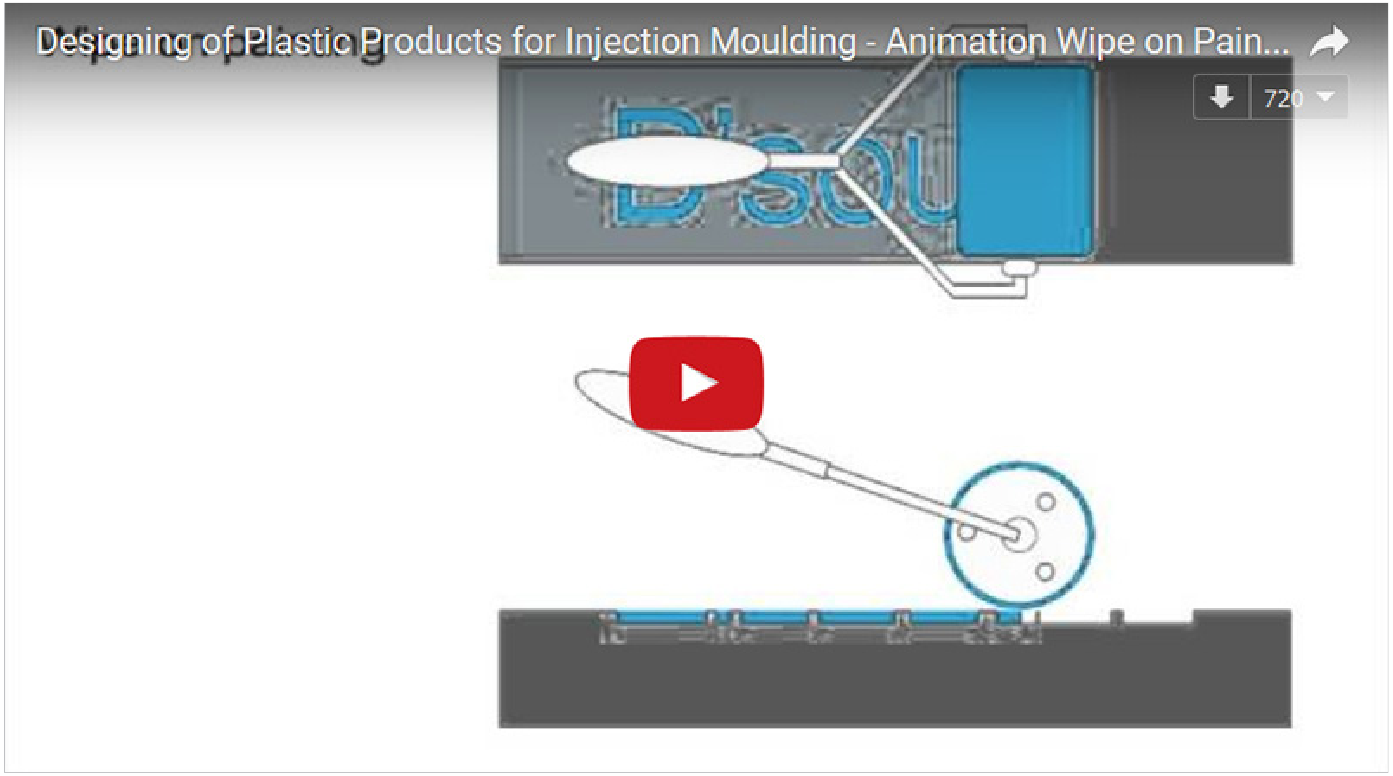
Type of solvent system used in painting of plastics:

- Organic solvent system – In this the organic solvent forms a strong chemical bond with the plastic substrate for better adhesion.
- Water based system – In this the solvent forms a weaker bond with the plastic substrate. They are mostly preferred because of environmental and health issues.

Methods to cure paint:

- Air-curing
- Heat curing
- Two component paint system
- Exposure to oxygen or UV radiation

Animation Wipe on Paint:



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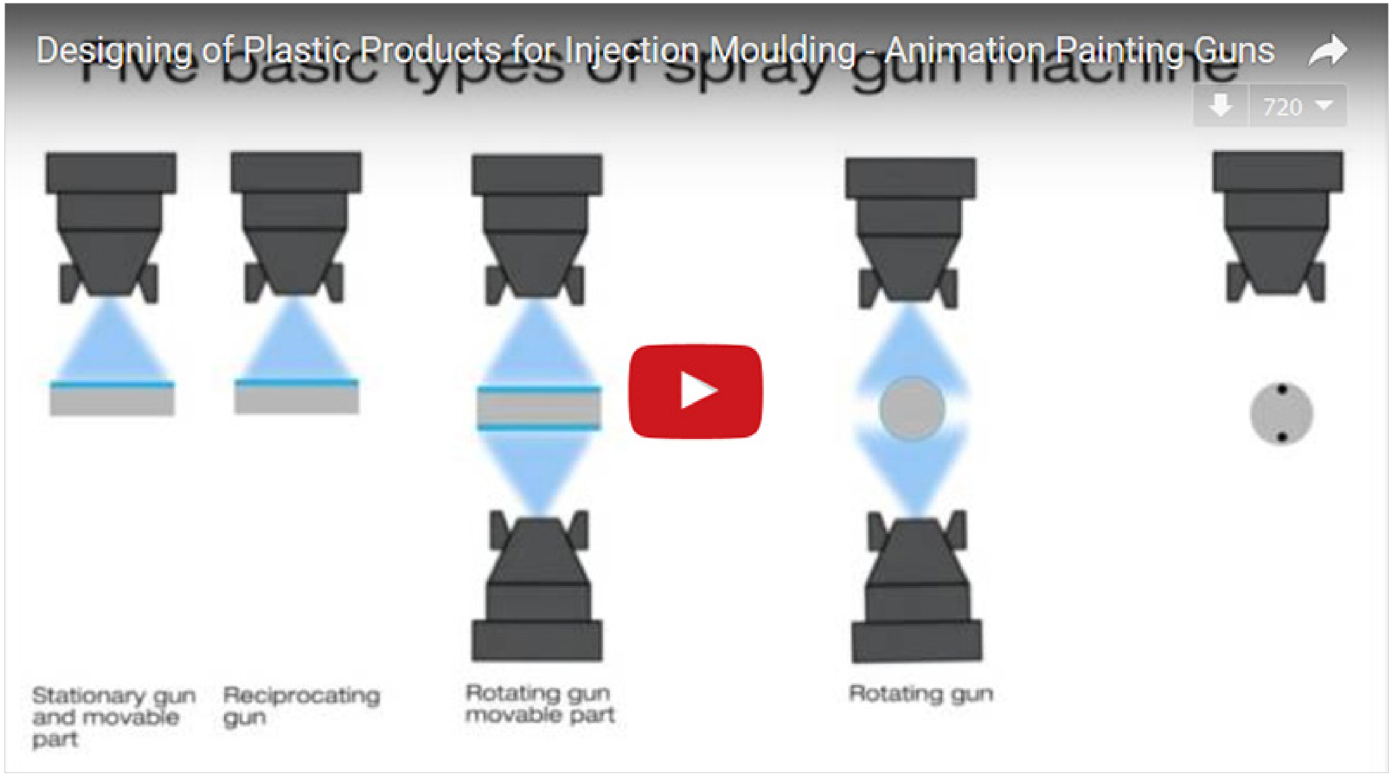
Animation Painting Guns:



Spray Painting – This is the most common method for painting plastics. The method can be conventional, airless or electrostatic.

There are five basic type of spray gun machine used:

- Gun is stationary and part is movable.
- Gun is reciprocating part is stationary.
- Rotating gun and movable part.
- Rotating gun and stationary part.
- Spinner type movable part.

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Printing

Printing is the process in which the ink is transferred from a custom designed ink pad to the product which is to be printed through rollers. There are various types of printing processes for plastics like dry offset, letterflex, flexographic, letterpress, gravure and gravure offset.

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Rollers with ink paste transfers the ink to the blanket cylinders made of rubber like material. The blanket then contacts the part one time thus transferring all the colors simultaneously to that part.

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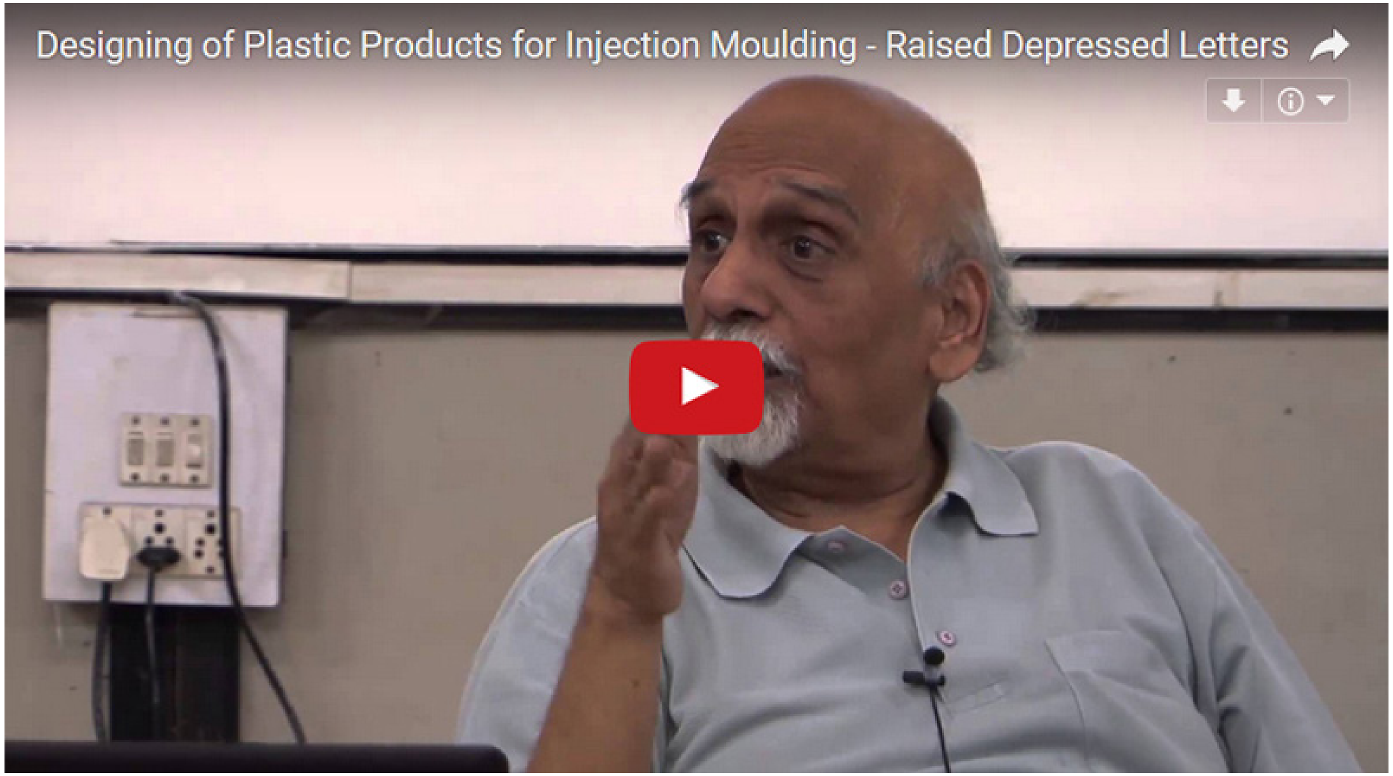
Raised and Depressed Letters:



Molded plastic parts can have raised or depressed letters. Depressed letters on the plastic parts are more expensive because during the process of making molds the material is etched or machined around the letters which increases the cost of machining. Whereas in raised letters on the plastic parts the mold is made by etching or machining only the letters which is a cheaper process.

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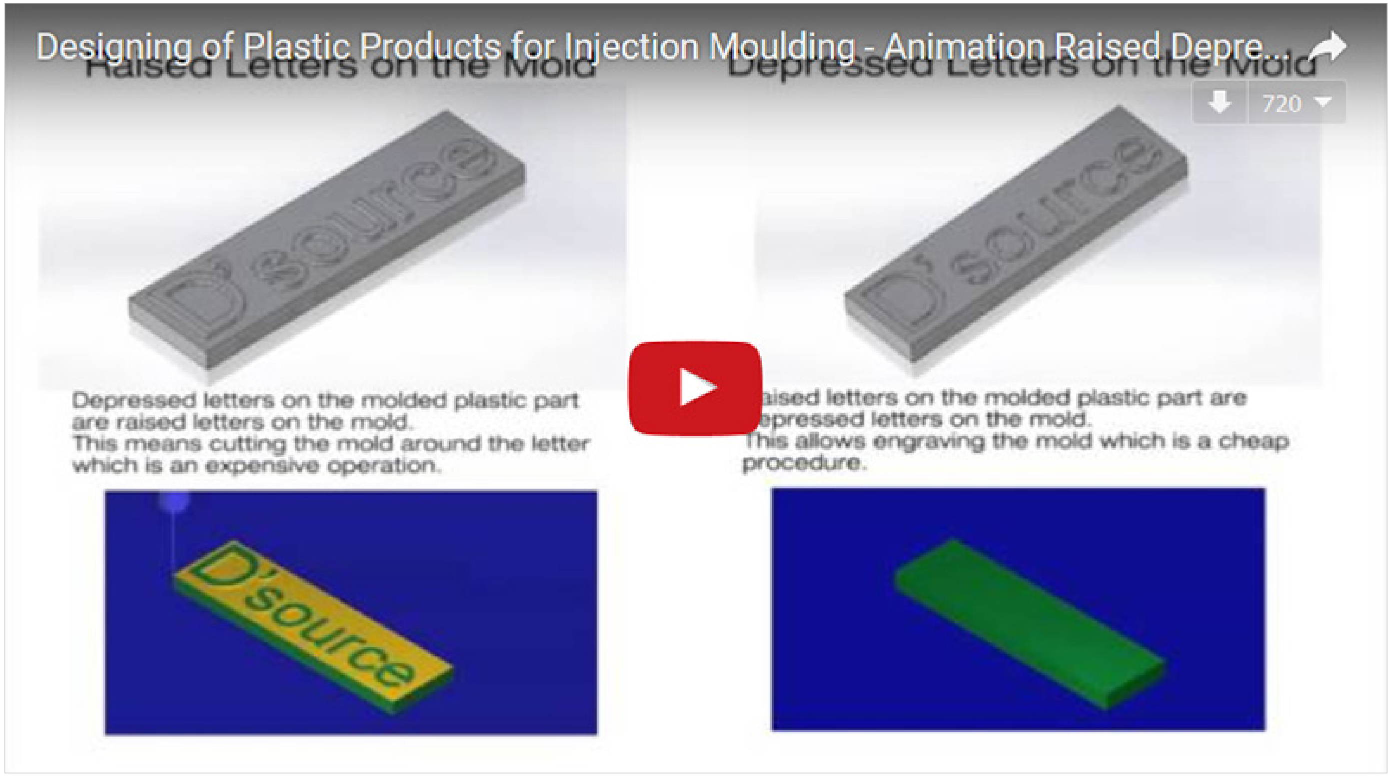

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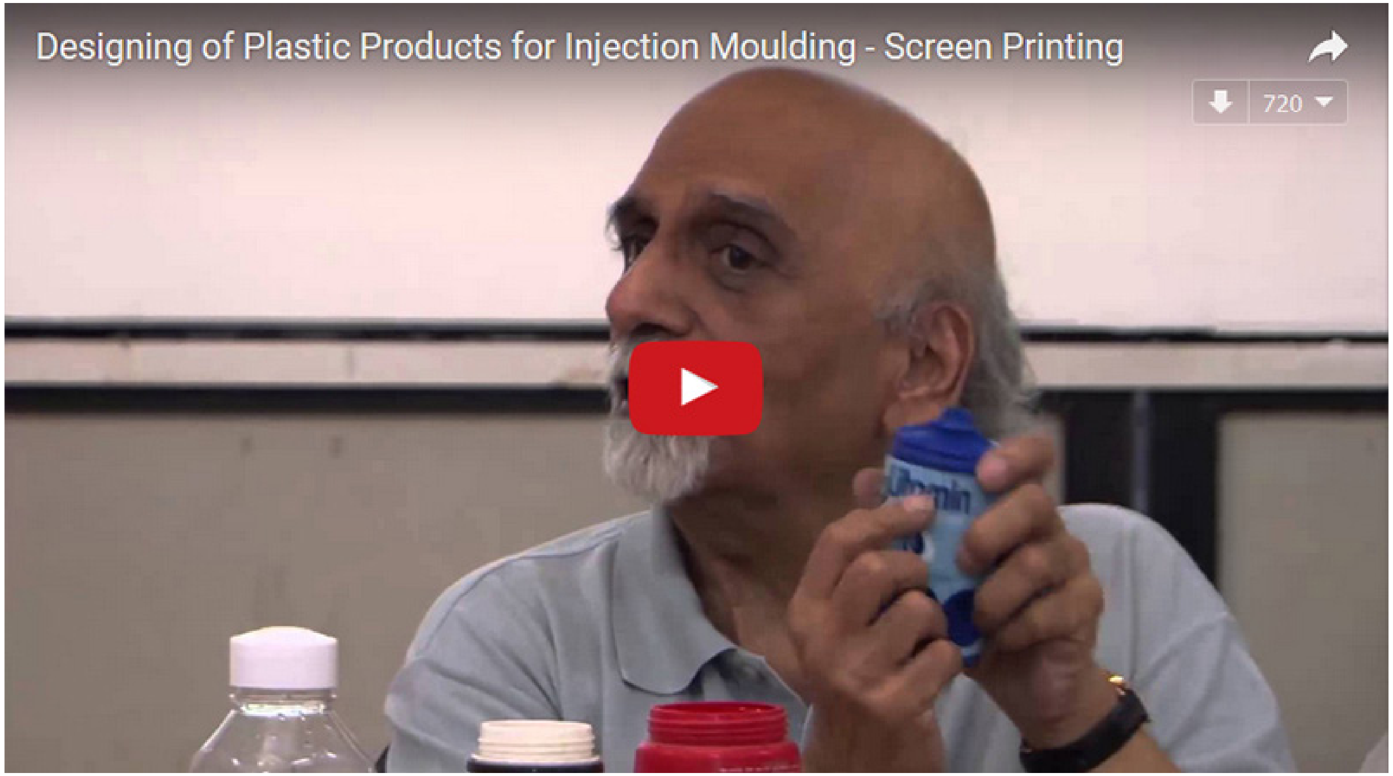
Screen Printing



Screen printing involves the use of an open-weave fabric or screen usually made of silk, polyester or stainless steel stretched in a frame. Stencils made by photoetching process are placed on the screen where ink transfer is not desired. A rubber squeegee forces ink through screen and on to the part surface. The process requires periodic cleaning of screens and careful control of ink viscosity. It is an inexpensive technique which can be used to decorate flat or cylindrical plastic parts.

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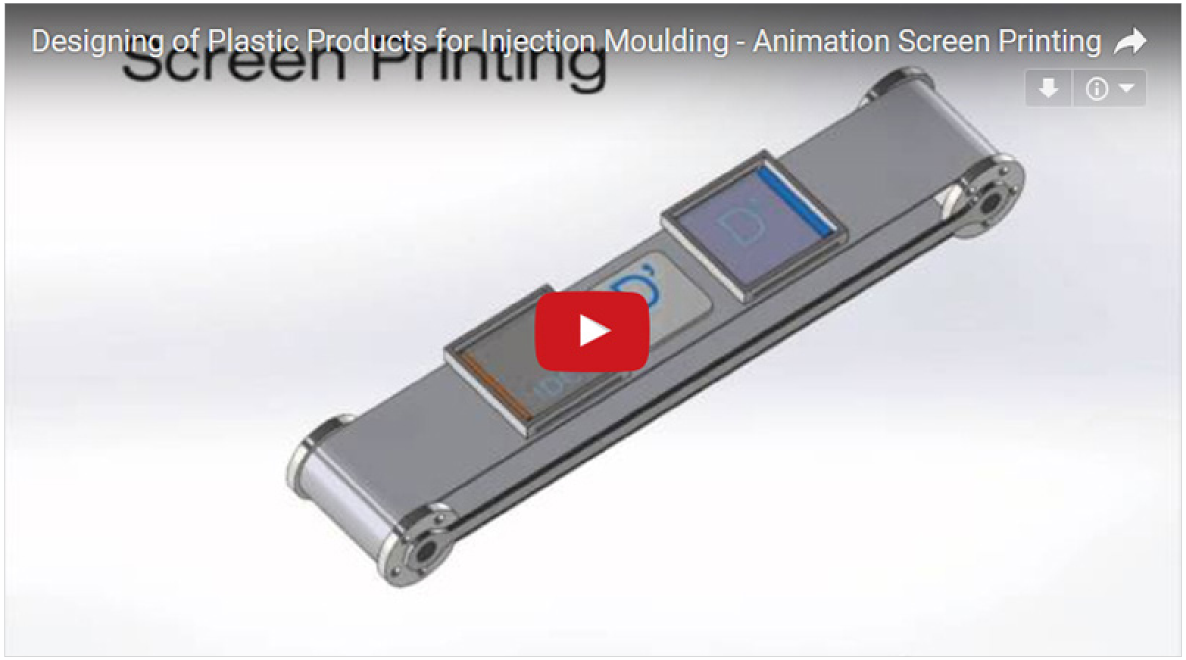

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Manufacturing Methods and Technologies

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IDC, IIT Bombay

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Hot Stamping

Hot stamping is a process in which an engraved image on a hot stamping die is heated and forced down against a part with a hot stamping foil in between them. The area on the foil which comes in contact with the die gets transferred on the part. The hot stamping foil is composed of several layers these include a polyester carrier, release layer, lacquer, metalized or pigment layer and hot melt adhesive layer. The dies used in hot stamping are made from brass and are produced by etching or machining using CNC.

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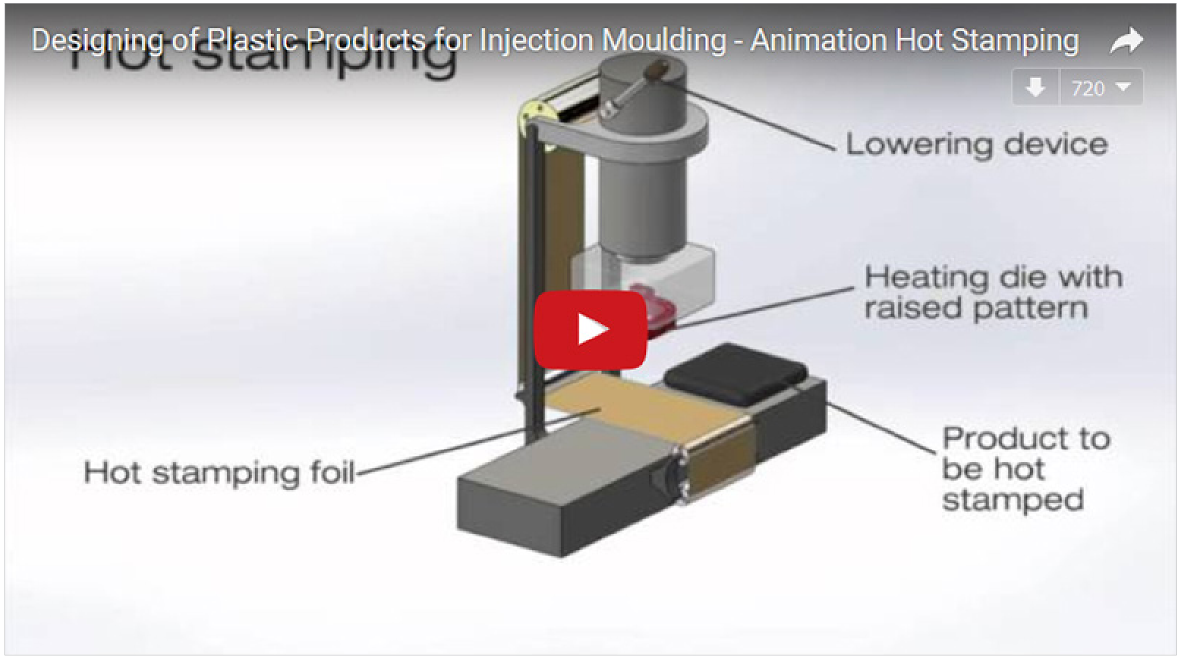

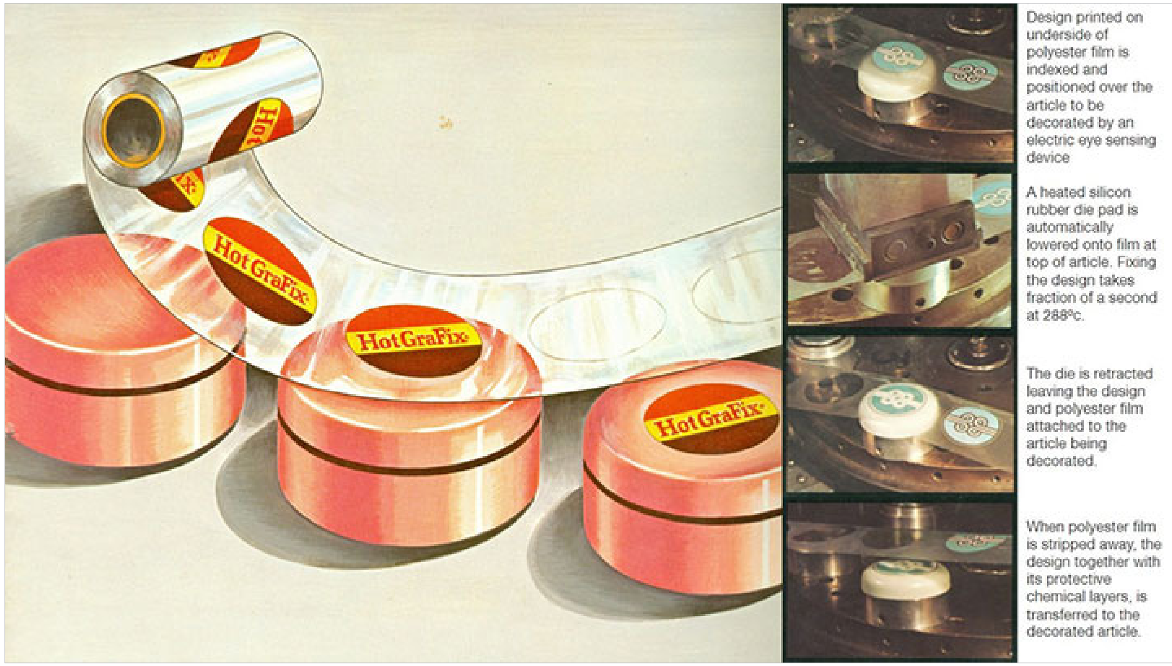

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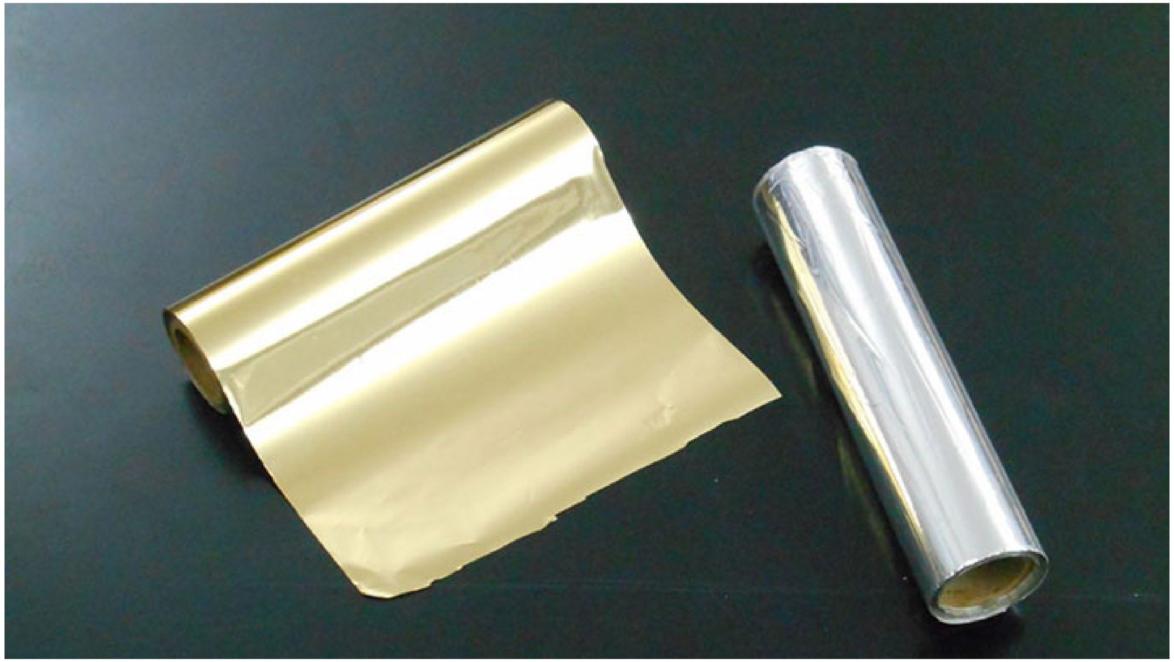

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Pad Printing

Pad printing involves the transfer of the ink from a custom designed ink pad to a curved or contoured part using a soft silicone pad. The soft pads are mostly used for textured and irregular shapes. The image which is to be printed is created on the printing plate by chemical etching with a etch depth of 25-30 microns. The etched area is filled with the ink using color rollers. The silicone rubber printing pad picks up the ink from this etched area and transfers it on the curved surface of the plastic part.

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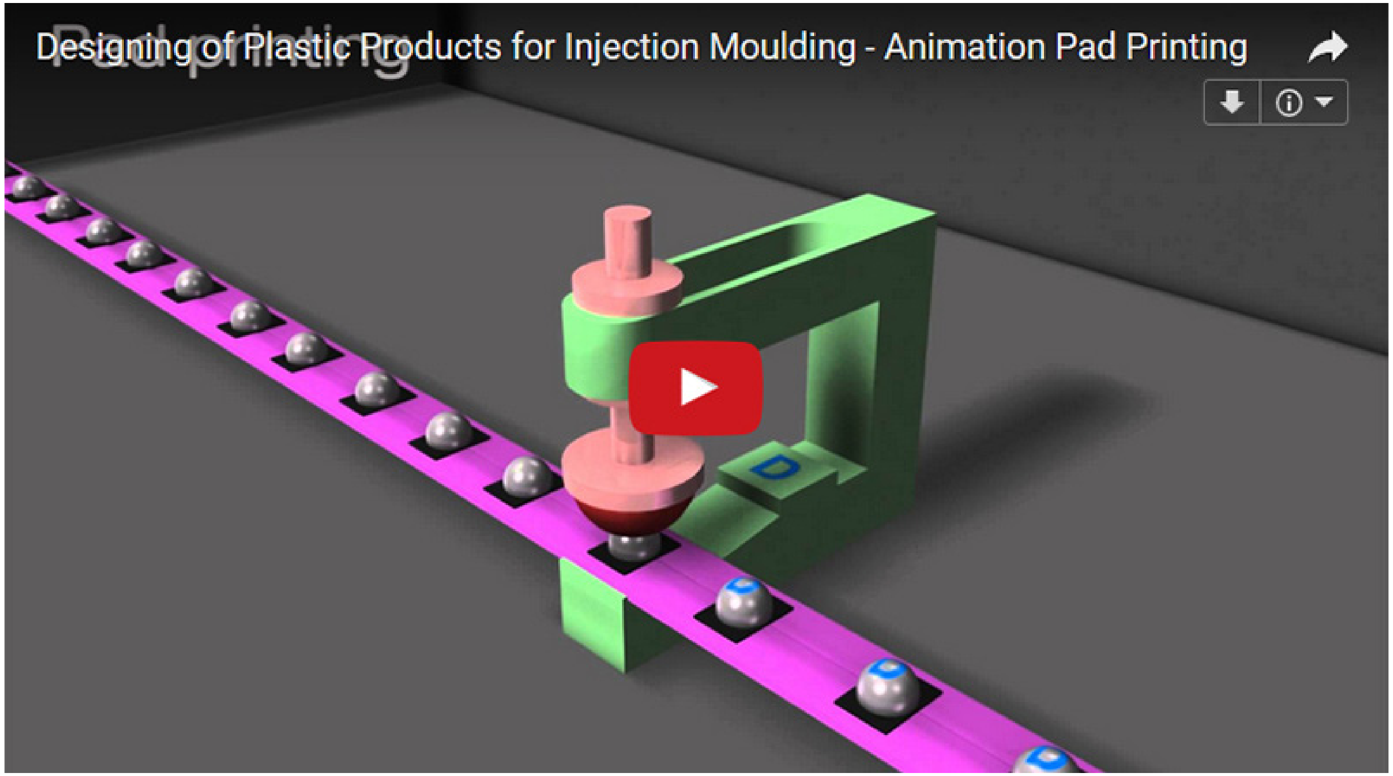

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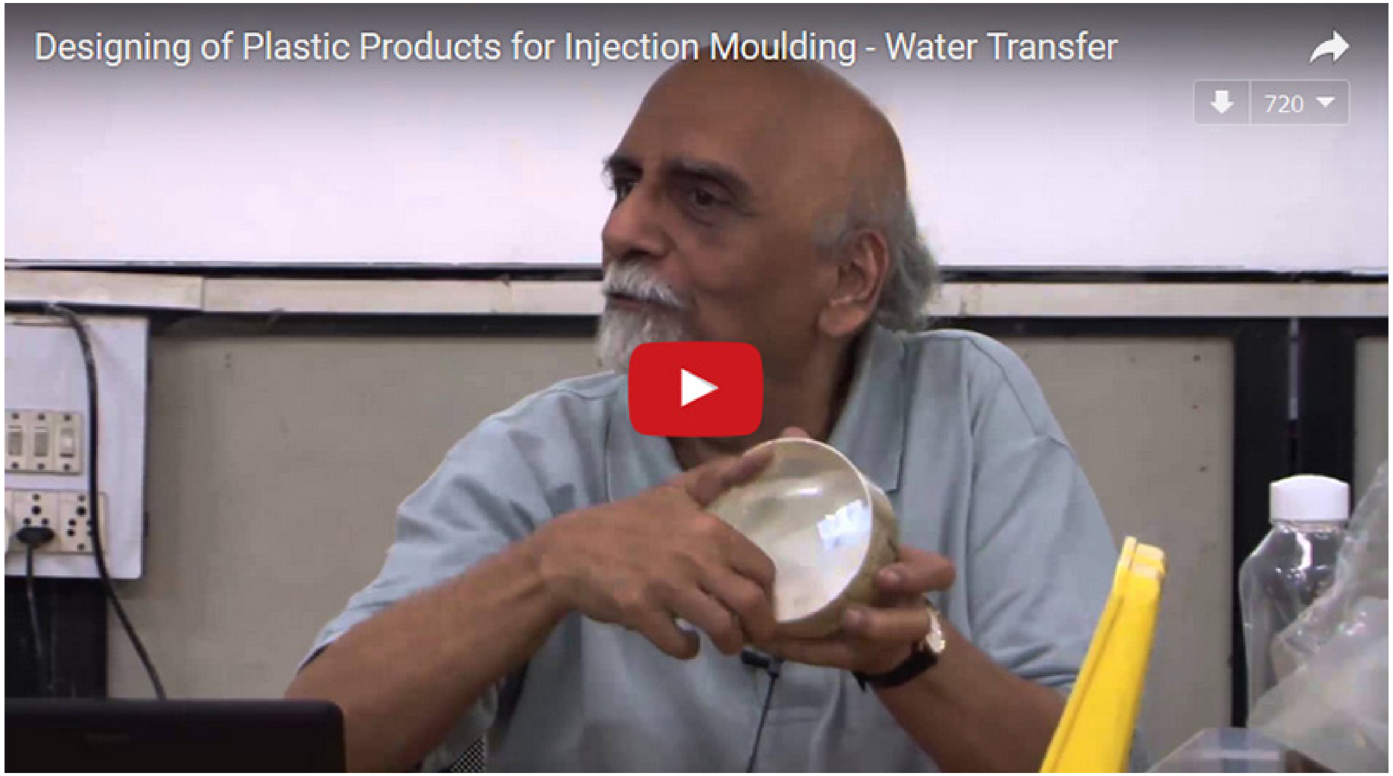
Water Transfer



Water transfer printing or hydrographics is a surface decorating technique for three dimensional objects. The process consists of five steps. First one is film printing in which the desired design is printed over a water soluble film. Second step involves the ink rewetting in which an activator is applied to the film due to which the film gets dissolved and leaves ink on surface of water. Third stage is the transfer of the ink on to the part. In this stage the part is dipped into the container containing film and water. Since film act as a medium for print transfer after the transfer process its role is finished and it is washed off in the fourth stage. The final stage involves drying and top coating in which excess water is dried off and transparent top coat is applied to protect printed surface.

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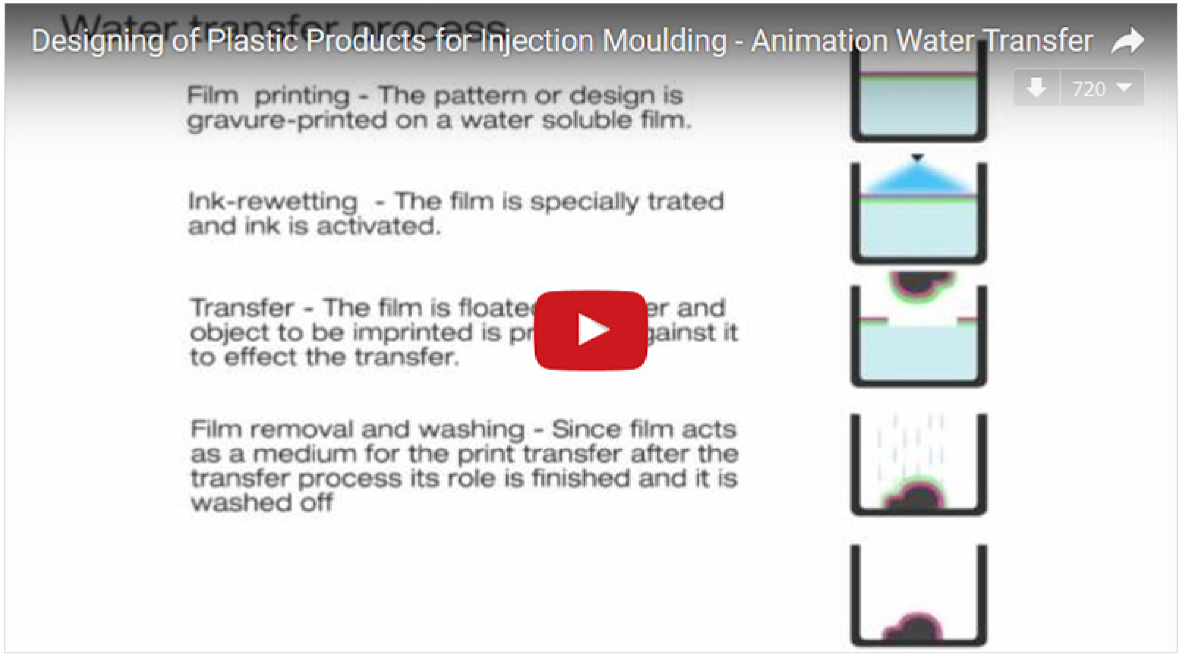

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Flocking

The flocking process involves the deposition of monofilament fibers of nylon, rayon or polyester on anadhesive coated surface using a potential difference created by high voltage electric field. The length of a fibre ranges from 0.25 to 5 mm. Flocking can be applied to plastics, glass, metal or textiles. Natural or synthetic materials can be used to make flock. Flock is categorized as milled flock and cut flock. Milled flock is produced from cotton or synthetic textile waste material. Cut flock is produced by a cutting process that produces a uniform length flock. The flock adhesives can be single or two component system. There are plastisols as well as water based adhesives.

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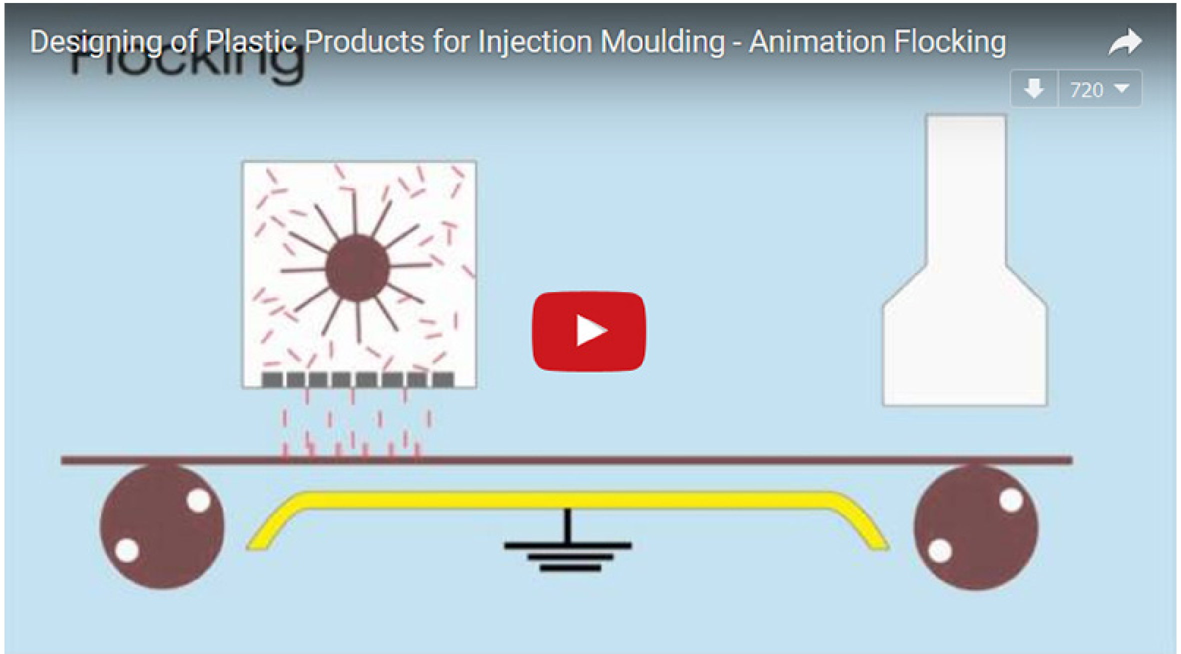

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Masking

Masking is a technique used to cover, hide or mask certain areas on plastic parts before painting. It is a complicated and labor intensive process. There must be a tight tolerance between mask and stencils to prevent leakage. Masks and stencils must be cleaned periodically for a good fit. There must be sufficient number of masks for an operation to avoid any interruption due to cleaning.

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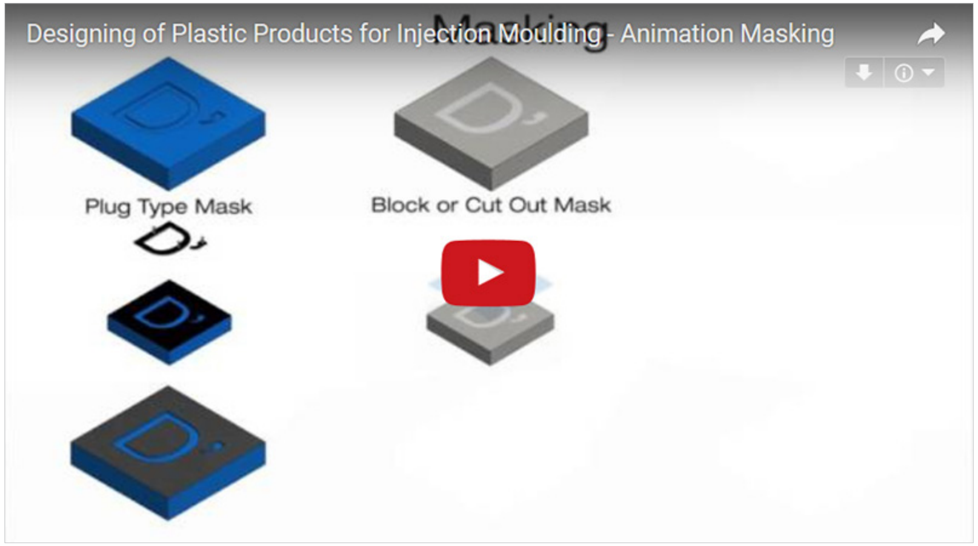

Masking considerations

- Try to simplify the masking process if can't be avoided.
- Avoid transition between masked and painted feature like fillet or irregular surfaces.
- Allow at least 1/8 inch between masked area and part edge.
- Avoid thin masking.

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Metallization

Metallizing is a technique of depositing or coating the plastic parts with metals. Metal coatings are applied for decoration as well as for functional reasons. Metal coated plastic parts are economical lightweight alternatives for various automotive applications like grills. Functional coating provides electromagnetic shielding, circuit paths or reflective surfaces for lightening applications.

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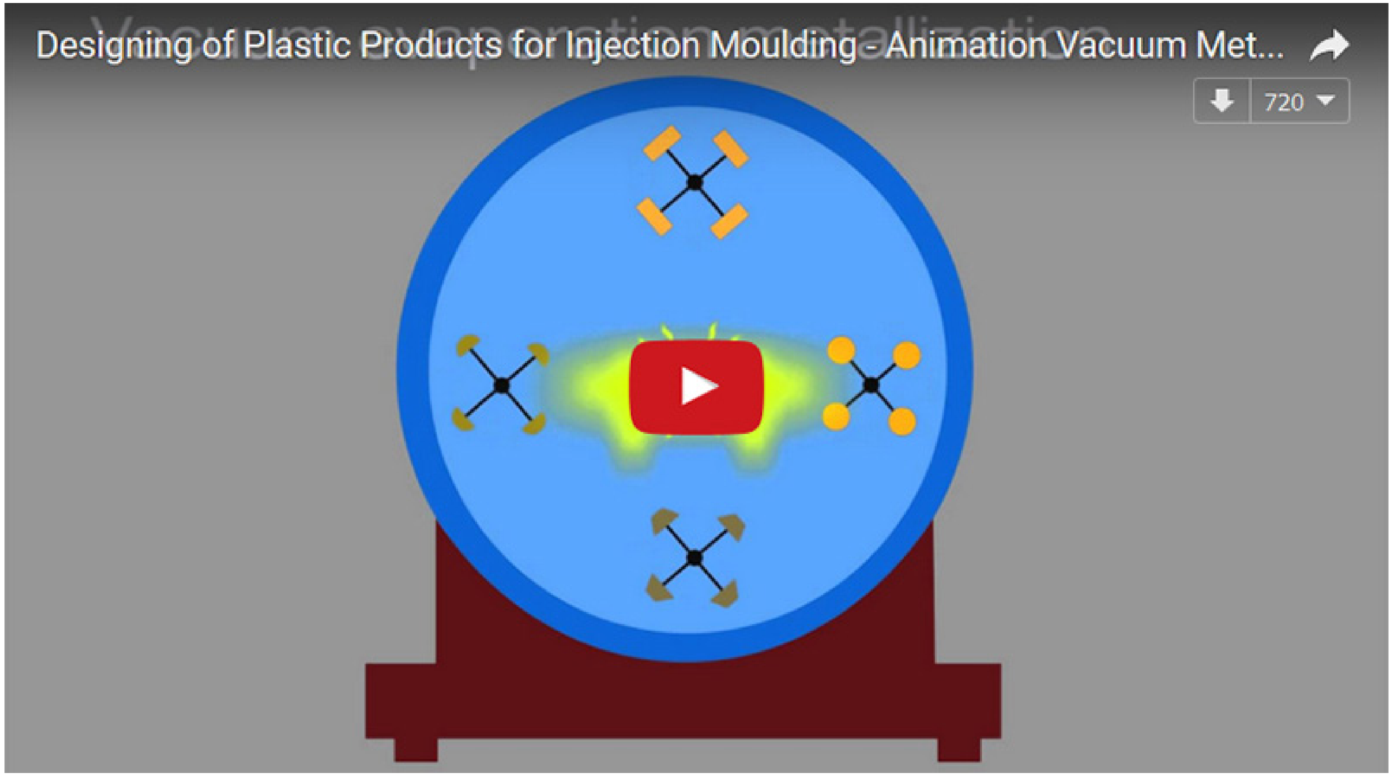

The processes for applying metallic coating on plastics are:

• Electroplating – In this process the plastic part first undergoes an electroless chemical process to deposit a conductive metallic layer. In electroless process part is immersed in a series of aqueous baths to clean, etch and activate part surface. Then a metallic film layer such as copper is chemically deposited on the part through conventional electroplating process.

• Vacuum Metallization – In this process a very thin film of about 1.5 microns is deposited on to plastic part in a vacuum chamber. The first stage of the process involves the application of a base coat to the parts to improve metal adhesion to the surface. Then the parts are moved on to a rack which rotates in the vacuum chamber for uniform deposition of the metal over the surface. Deposition take place by vaporizing the metal using tungsten filaments or electron beams. The final step involves the application of a clear top coat to protect thin metal film from abrasion.

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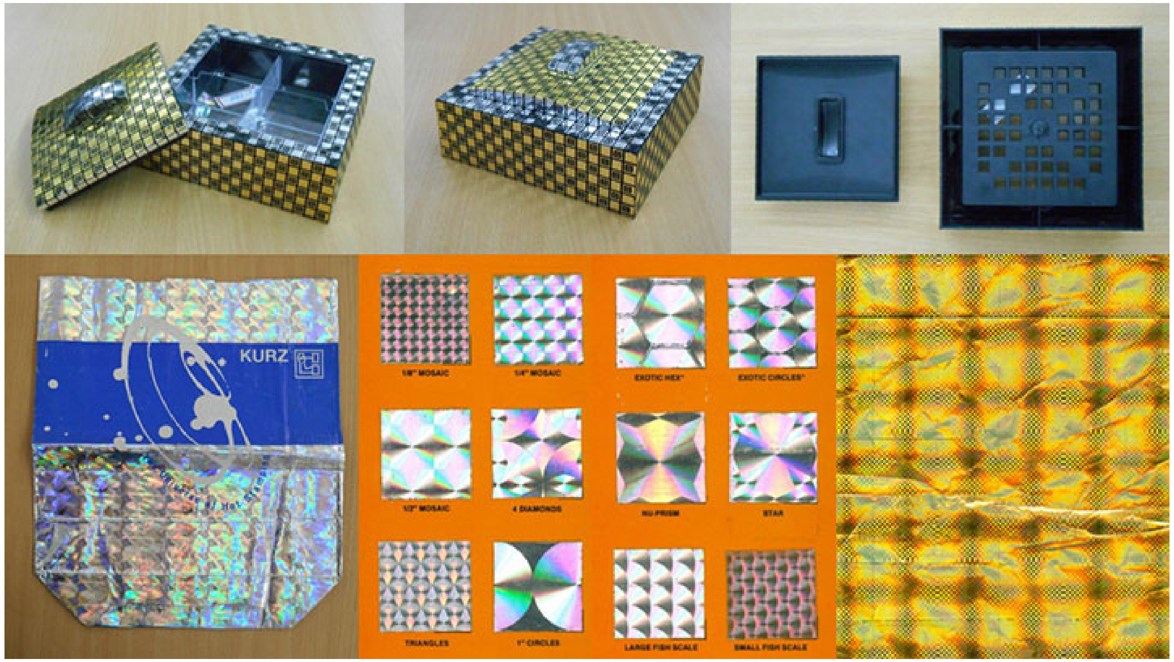

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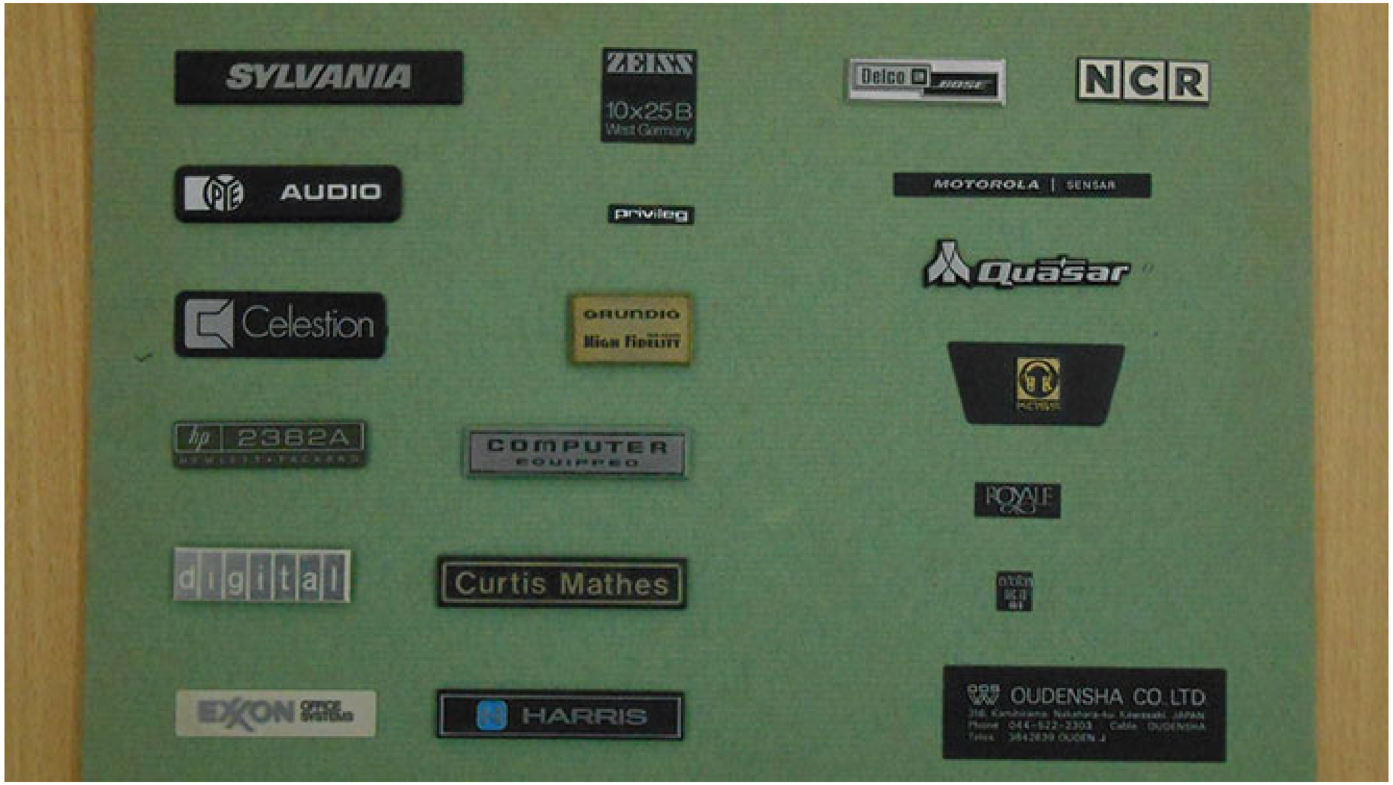

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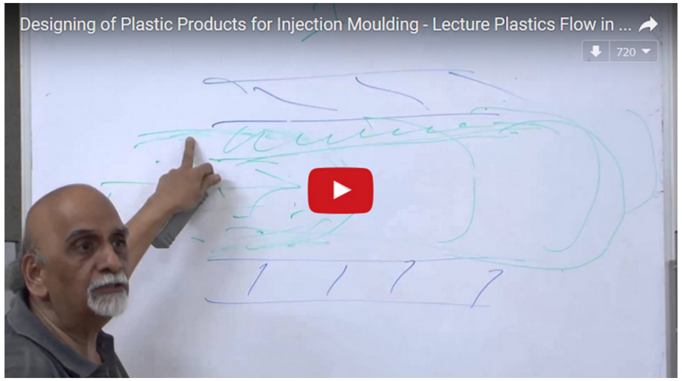
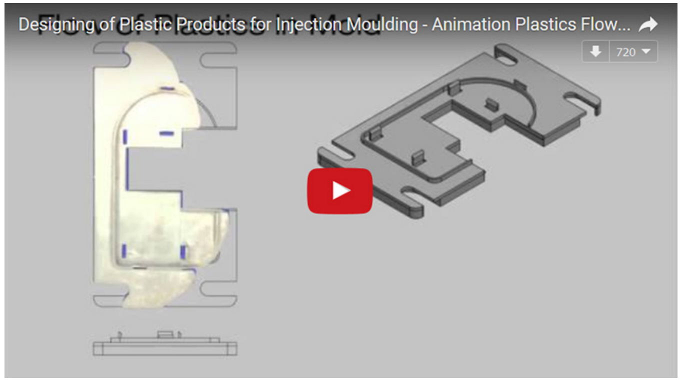
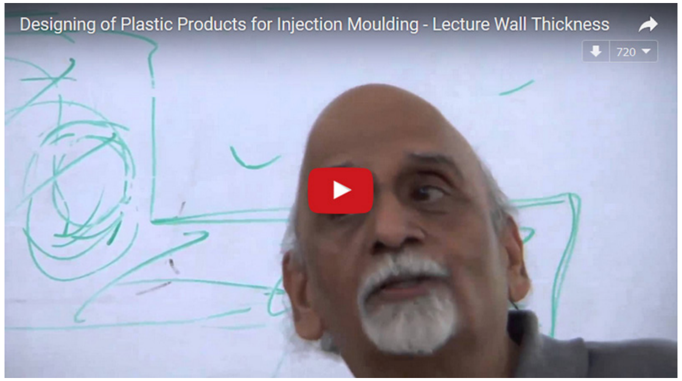
Video



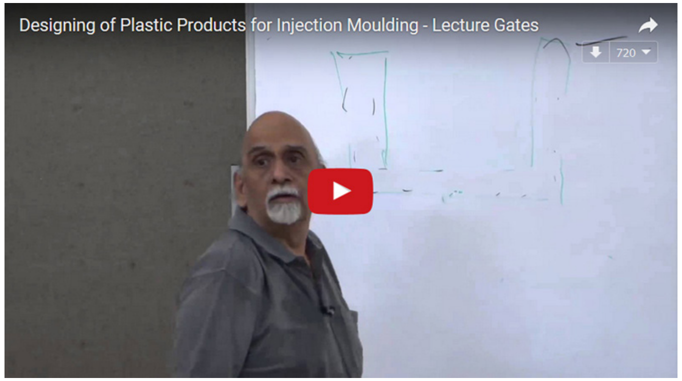
Lecture Plastics Flow in Mold



Animation Plastics Flow in Mold



Lecture Wall Thickness



Lecture Gates

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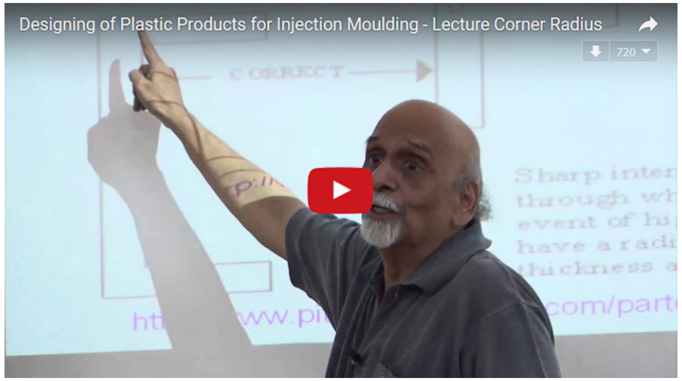
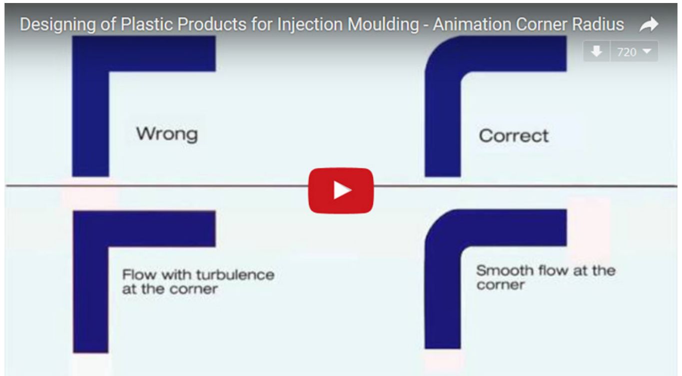
Lecture Air Vents



Lecture Corner Radius



Animation Corner Radius

Rib Combined

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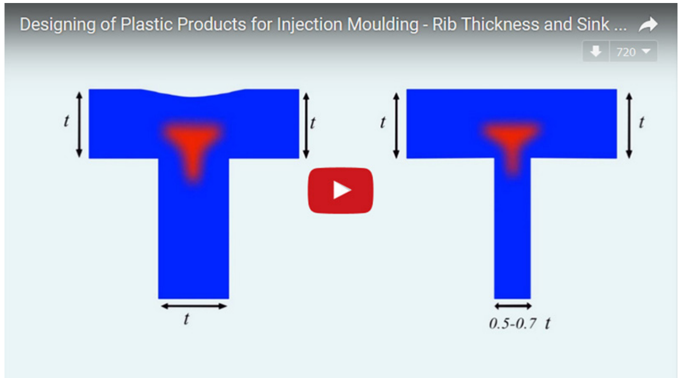
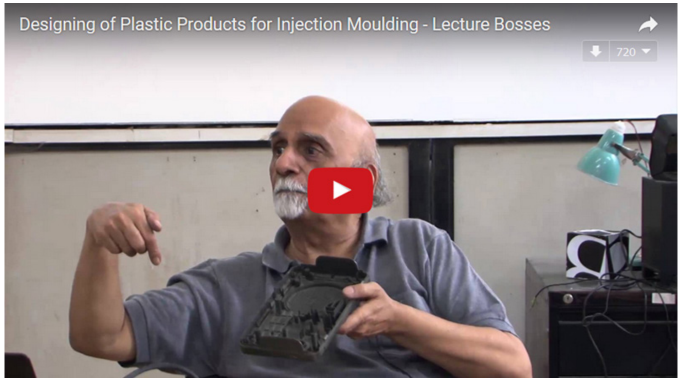
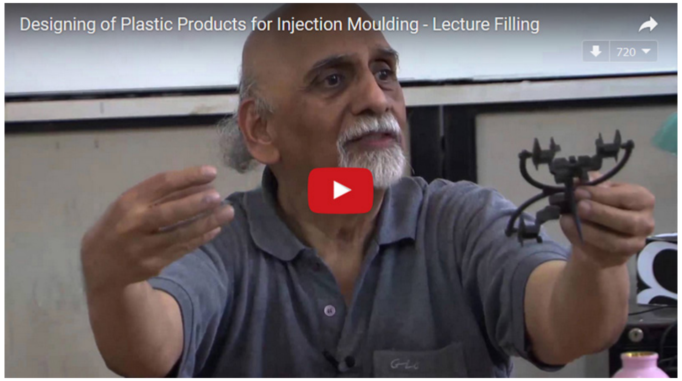


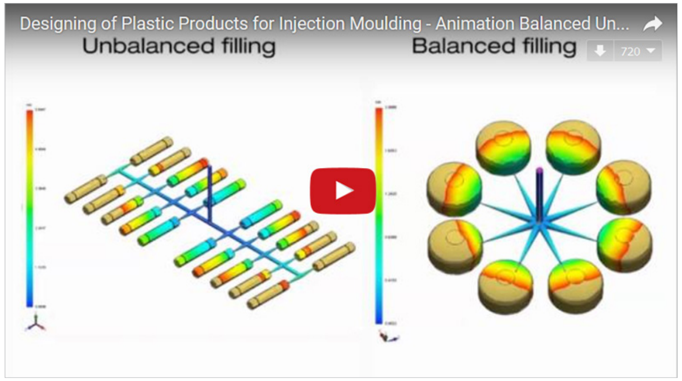
Rib Thickness and Sink Mark



Lecture Bosses



Lecture Filling



Animation Balanced Unbalanced

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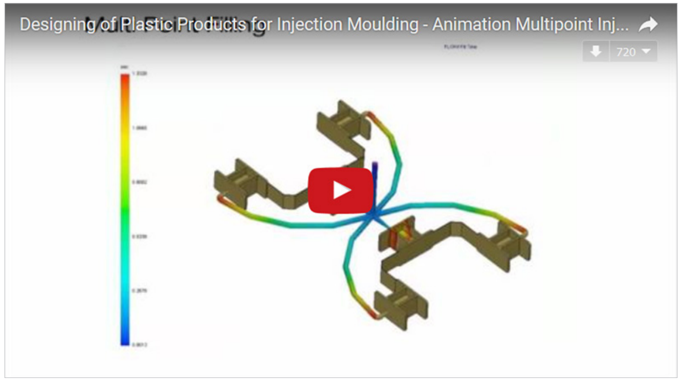
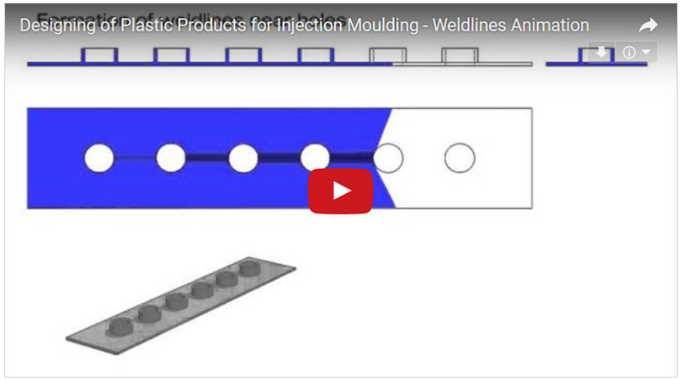
1. Design Considerations
2. Assembly Techniques for Plastics
3. Decorative Techniques for Plastics
4. Video
5. Contact Details

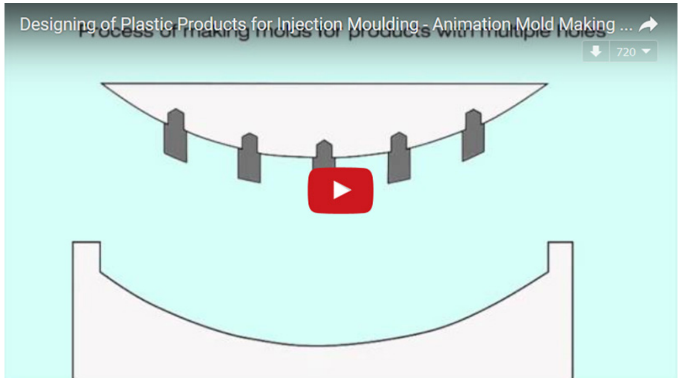


Animation Multipoint Injection

Lecture Weldlines



Weldlines Animation



Animation Mold Making for Holes

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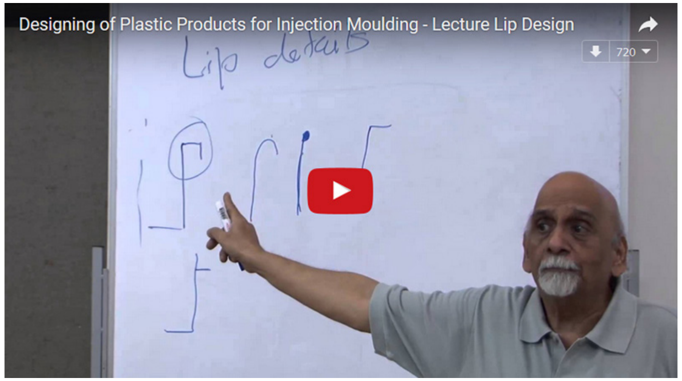
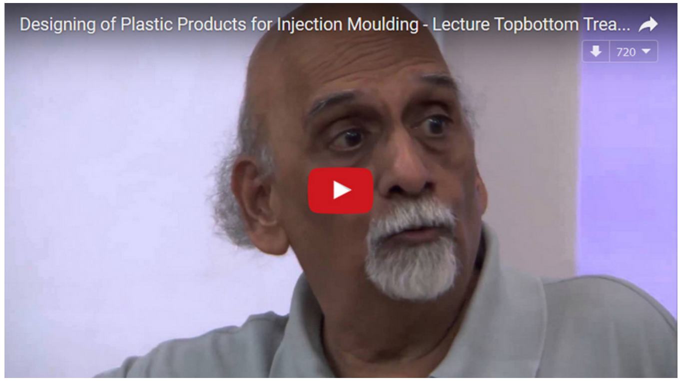
Lecture Draft

Lecture Undercut



Lip Design



Lecture Topbottom Treatment

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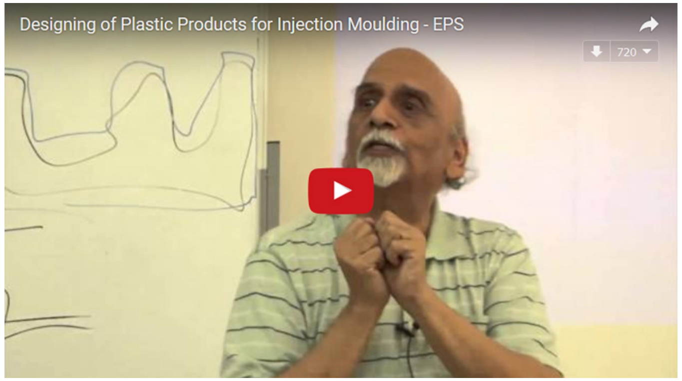
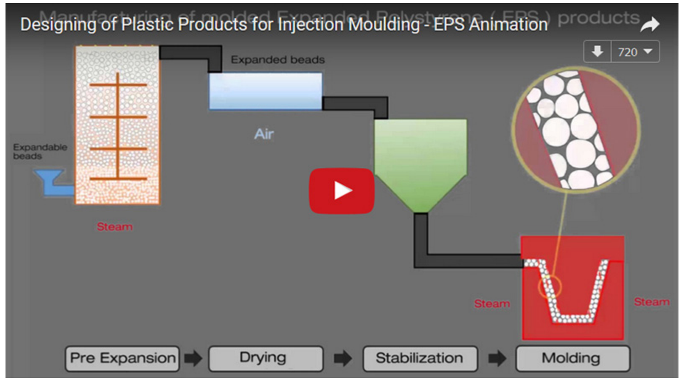
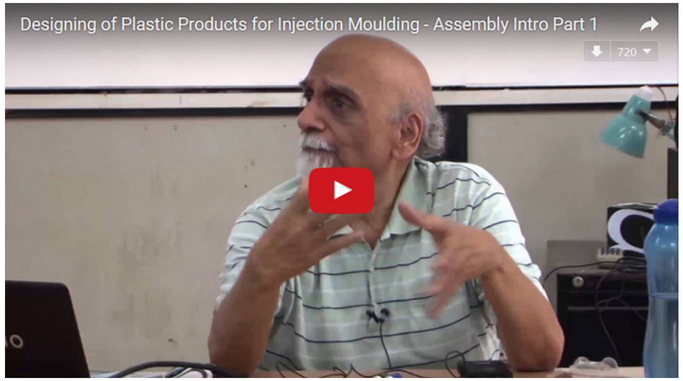


EPS



EPS Animation

Polyurethane



Assembly Intro Part1

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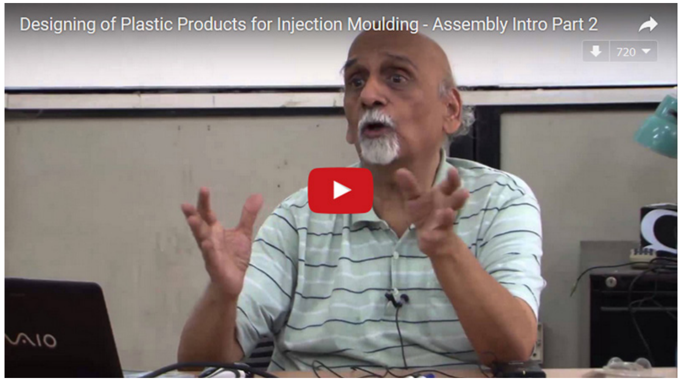
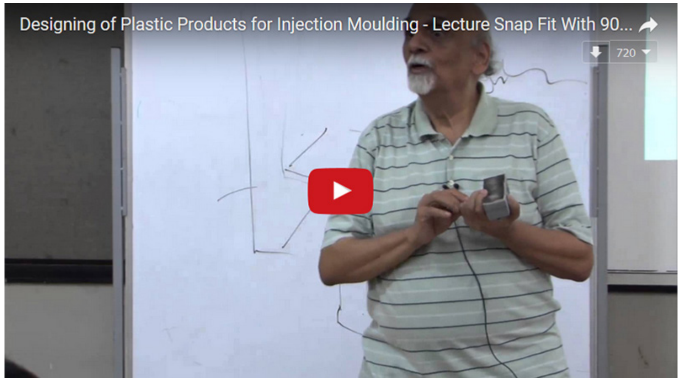


Assembly Intro Part2

Snap Fits

Hinges



Lecture Snap Fit With 90 Retaining Angle

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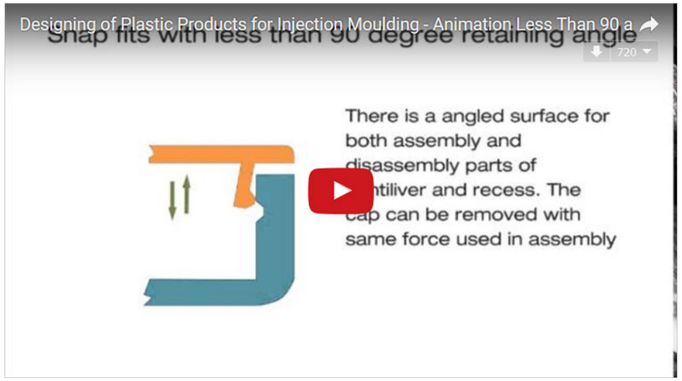
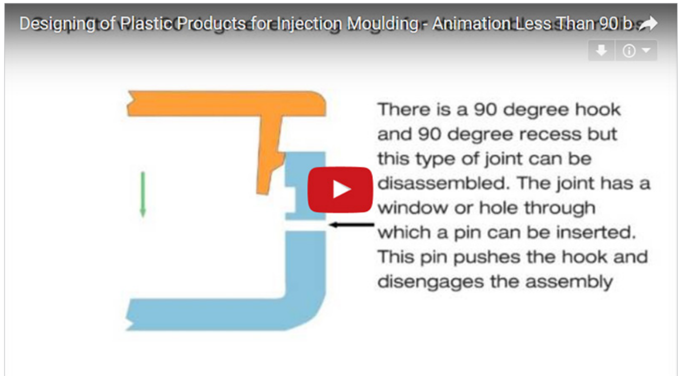


Animation Less Than 90 a



Animation Less Than 90 b

Animation Less Than 90 c

Mechanical Fasteners

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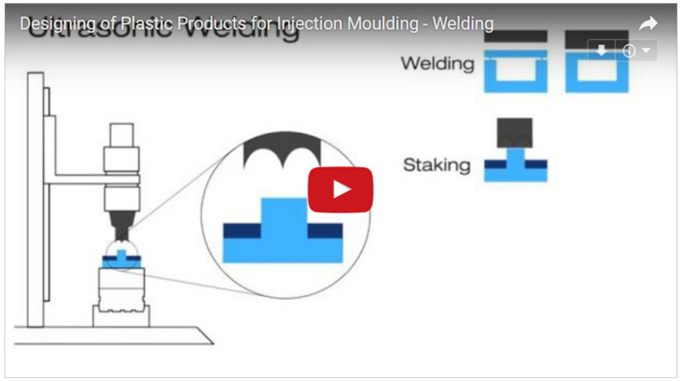
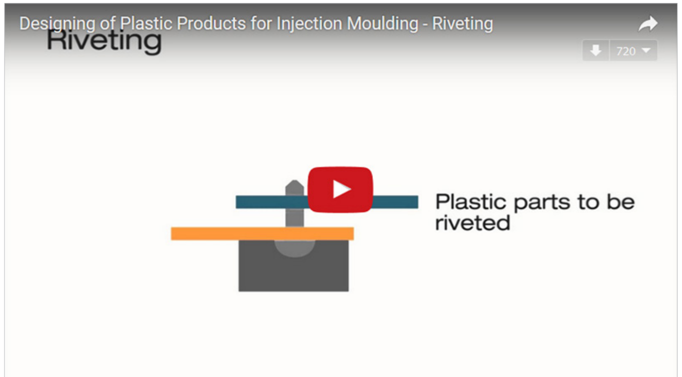
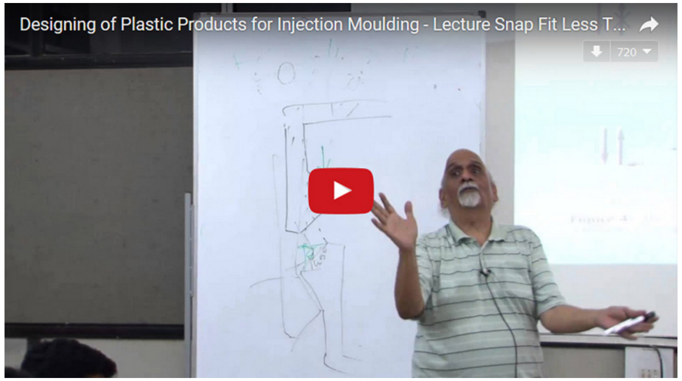


Welding



Riveting

Adhesives



Lecture Snap Fit Less Than 90

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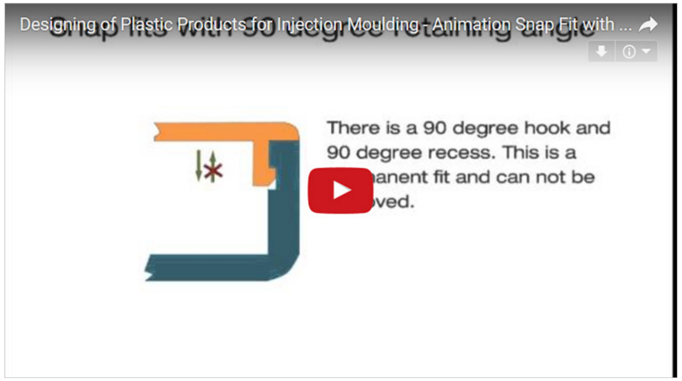
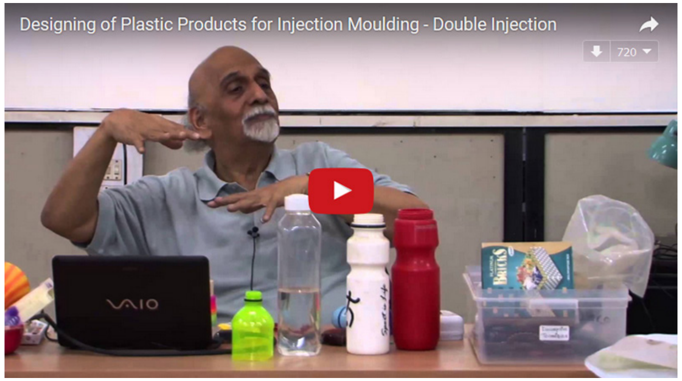
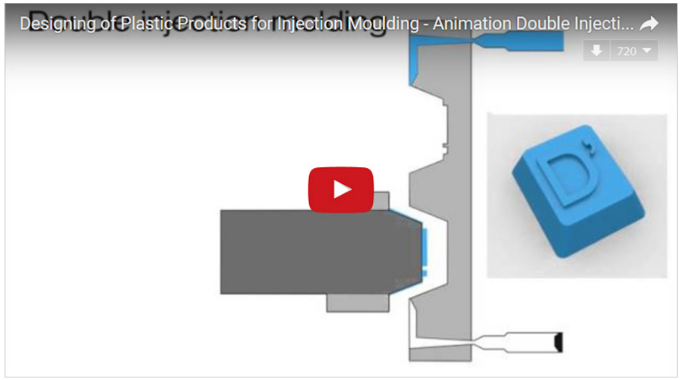


Animation Snap Fit with 90

Intro to Decorative



Double Injection



Animation Double Injection

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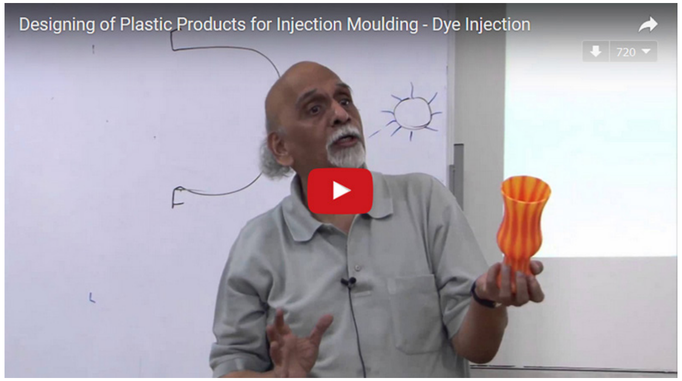
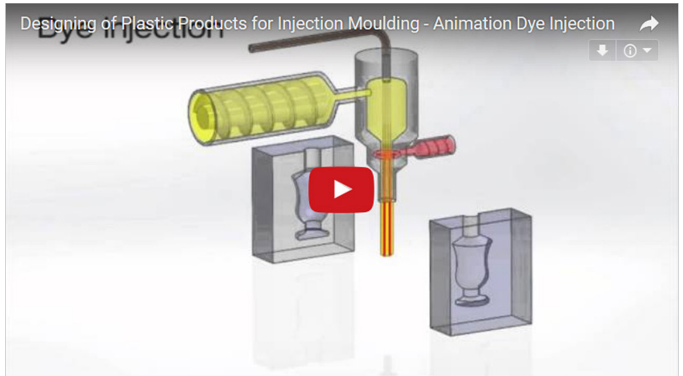
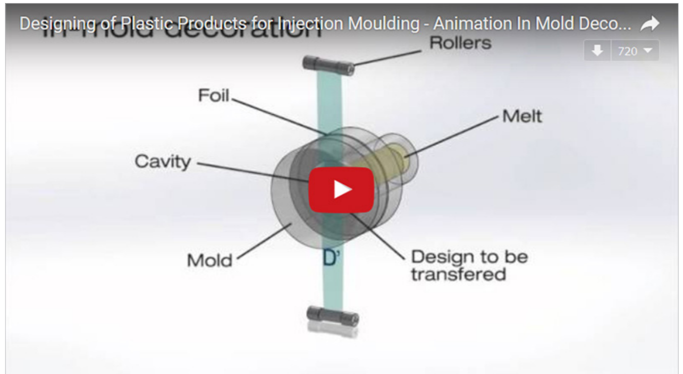


Dye Injection



Animation Dye Injection

In Mold Decoration



Animation In Mold Decoration

Design Course

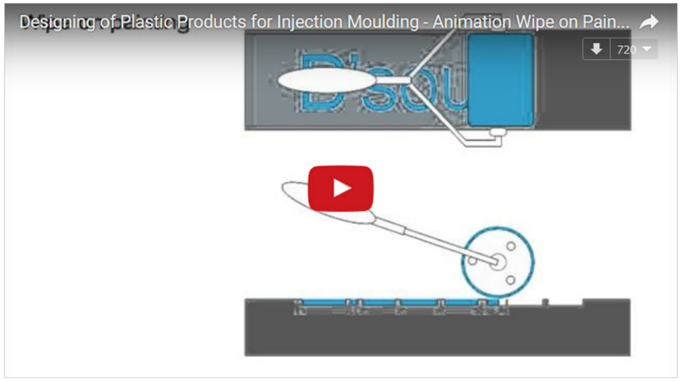
Designing of Plastic Products for Injection Moulding

Manufacturing Methods and Technologies

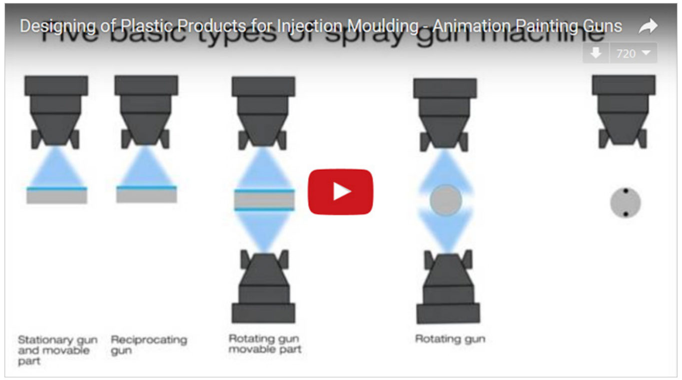
by
Prof. Vijay. P. Bapat and Shiv Kumar Verma
IDC, IIT Bombay

Source:
http://www.dsource.in/course/designing-plastic-products-injection-moulding/video

Painting



Animation Wipe on Painting



Animation Painting Guns

Printing

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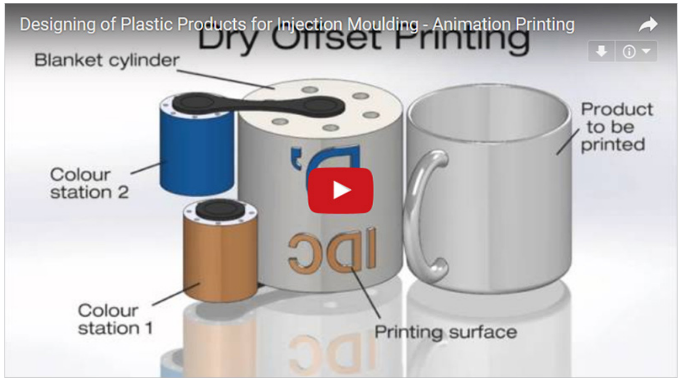
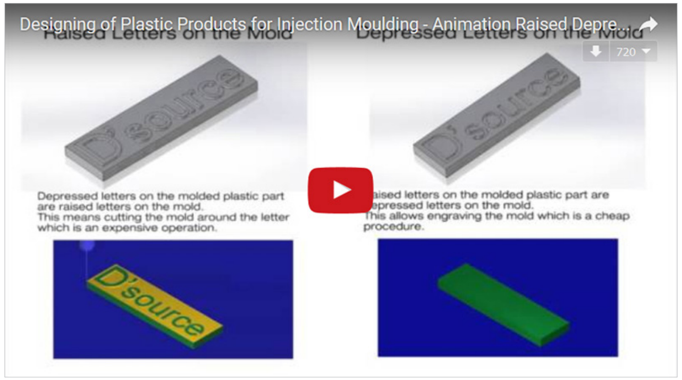


Animation Printing

Raised Depressed Letters



Animation Raised Depressed Letters

Screen Printing

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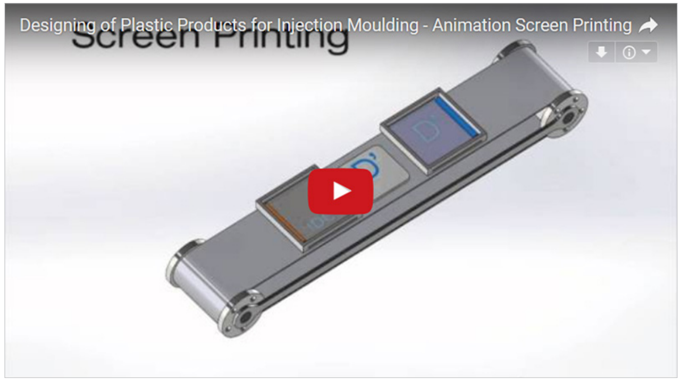
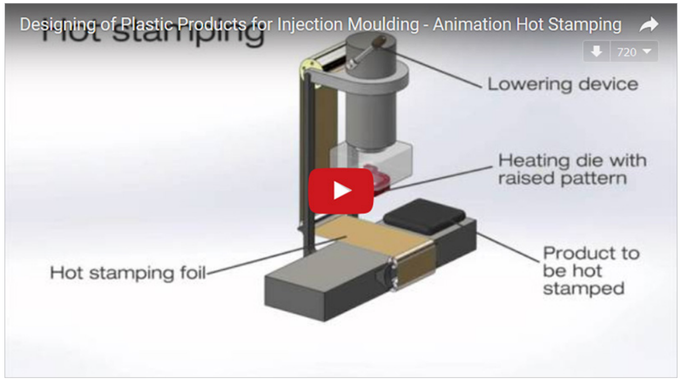


Animation Screen Printing

Hot Stamping



Animation Hot Stamping

Pad Printing

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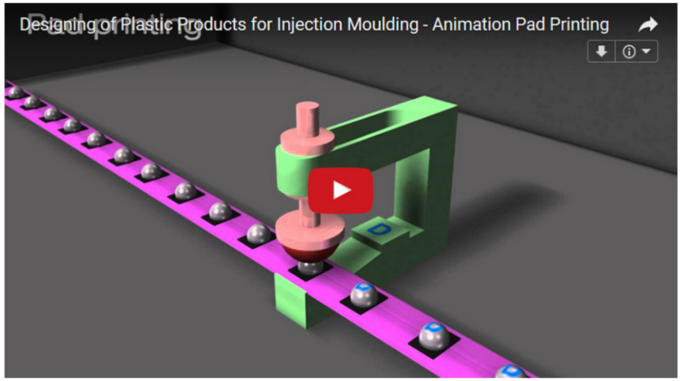
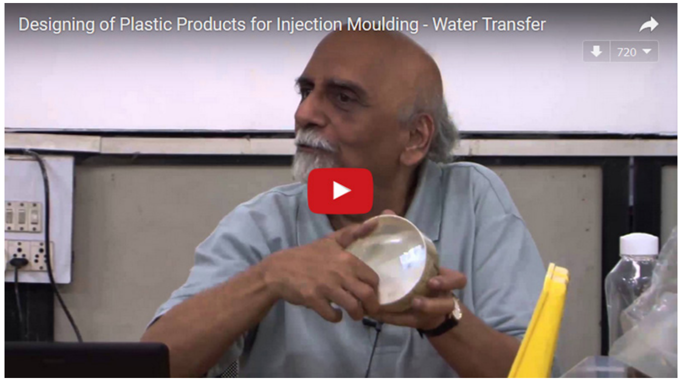
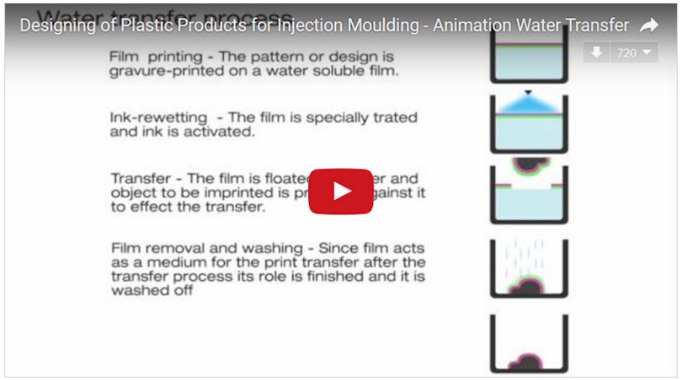


Animation Pad Printing



Water Transfer



Animation Water Transfer

Flocking

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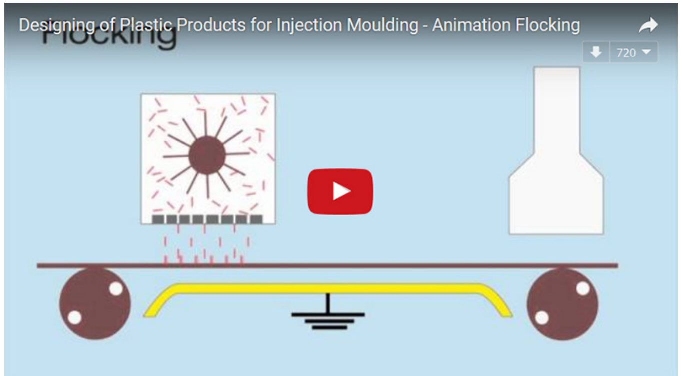

Animation Flocking

Masking

Animation Masking

Vacuum Metallization

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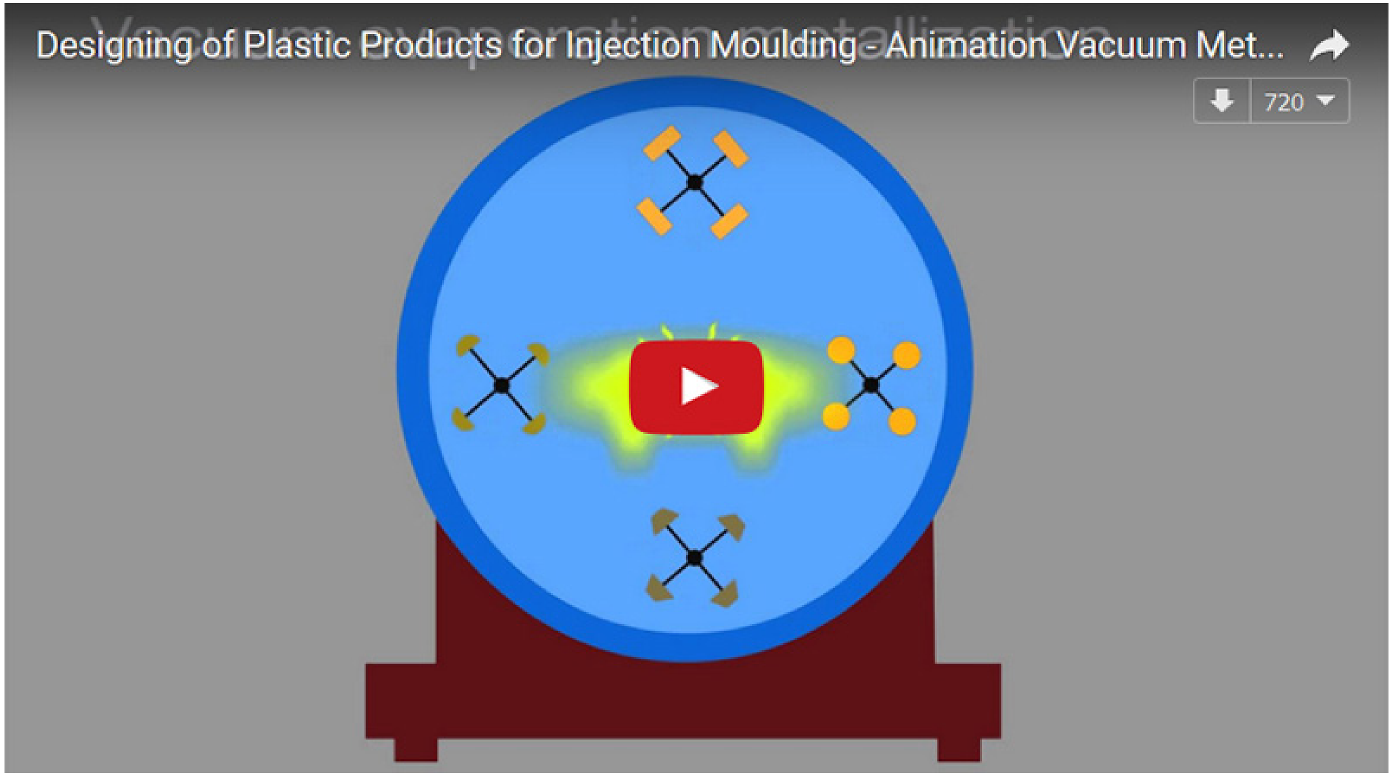

Animation Vacuum Metallization

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Source:
http://www.dsource.in/course/designing-plastic-products-injection-moulding/contact-details

Contact Details

This documentation for the course was done by Professor Vijay. P. Bapat and Mr. Shiv Kumar Verma at IDC, IIT Bombay.

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