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Thermoset Injection Molding

Injection molding of thermoset materials is the most automatic method of processing these materials and has become the most common.

An **injection molding press** consists of two major sections: the **clamp** and the **injection unit**. The **clamping section**, which is similar to a compression press, uses either a hydraulic cylinder (hydraulic clamp) or a hydraulic cylinder and linkage mechanism (toggle clamp) to close the mold halves and hold them together under pressure. This section of the press also contains the main ejection system for part removal from the mold.

The injection unit includes the injection barrel, reciprocating screw or sometimes a plunger for BMC materials, the injection screw motor, the material hopper for granular materials and a stuffer when molding BMC. A reciprocating screw is always used to process phenolics, melamine-phenolics and granular polyesters. BMC molding compounds are mostly processed using a reciprocating screw but they can also be processed using a plunger injection unit.

The reciprocating screw aids in the processing of thermoset materials in a number of ways. The rotational motion advances the material down the screw to where it is plasticized (changed from a solid to a semi-viscous state) and then injected into the mold. At the same time that the screw rotation is advancing the material, the screw is being forced backward. This "backing up" of the screw allows the plasticized material to move in front of the screw so it can then be injected into the mold. Once the pre-determined amount of material is plasticized in front of the screw, the screw is pushed forward, forcing the material out of the barrel and into the mold. In instances where a Check Ring is used to process BMC materials the material is pushed through the Check Ring and into the mold.

A typical injection mold consists of a cavity side with one or more cavities and a force side. The sprue bushing is the channel that connects the nozzle of the injection cylinder with the runner system of the mold. It is tapered to facilitate the removal of the sprue from the mold. The cavities are connected to the sprue by way of runners and gates. The minimum press size is determined by the pressure required to clamp the mold during the molding cycle. PLENCO typically suggests that the clamping force equal 2 – 3 T/in^2 of projected area at the parting line. The processing of a thermoset molding compound is controlled by three items which are Time, Temperature - [both stock (material) temperature and mold temperature], and Pressure. In injection molding, each of these is affected by a number of variables that need to be controlled.

Pressure - The pressure on the material is controlled by the primary pressure, which moves the screw forward at a rapid speed to fill the cavities. The secondary pressure (holding pressure) finishes the filling of the cavities and maintains pressure on the material until it is sufficiently cured to allow the screw to return and plasticize the next shot.

Time – There are 4 major times in a molding cycle; Overall Cycle Time, Injection time, Cure time, and Open time.
Overall Cycle Time is the complete molding cycle from clamp to clamp. The Injection time has two elements – Primary (fill) and Secondary (packing and hold). The Cure Time encompasses the entire molding cycle when the clamp is closed. The Open Time is the time from clamp open until the clamp is locked up for next cycle.

Stock Temperature - The melt temperature of the molding material (stock temperature) is controlled by the barrel temperatures, screw speed, injection speed and back pressure. The greatest influence comes from back pressure and barrel temperatures. The water jackets around the barrel regulate the point at which the material will start to plasticize. The screw speed, injection speed and back pressure create frictional heat. To maintain a consistent and workable stock temperature, all of these variables must be adjusted properly. The stock temperature cannot be too hot that the material cures before it is able to fill the parts. Likewise it should not be so cold that it cannot be injected into the mold or require additional cycle time to cure the molded parts.

Mold Temperature - The mold is heated by either electric cartridge heaters, steam or hot oil to typical temperature ranges of 330°F - 360°F (165°C - 182°C) for phenolic molding compounds, 300°F - 350°F (150°C - 177°C) for melamine-phenolic molding compounds, 310°F - 350°F (154°C - 177°C) for PLENCO granular polyester molding compounds, or 290°F - 340°F (143°C - 171°C) for PLENCO BMC polyester molding compounds.

What are the advantages of Injection Molding?

- Material handling is reduced because the press hopper will usually hold sufficient material to mold parts for an extended period of time.

- Longer and smaller diameter core pins may be used because they can be supported on both ends.

- With the mold being closed before any material is injected into it, parts containing metal inserts can be molded without having material flash the inserts.

- Relatively tighter tolerances across parting lines are possible.

- Parting line flash can be held to a minimal thickness if the mold is designed properly and well maintained.

- Injection molding of thermoset materials lends itself to automating the process which can result in lower piece costs.

What are the disadvantages of Injection Molding?

- Injection molded parts may be more prone to warpage because of the softer flow of molding compound required and the higher shrink rates associated with them. In addition, forcing the molding compound through a sprue, runner and gates may orient or degrade the compound reinforcement causing non uniform shrinkage.

- The injection of molding compound into the parts through one or two gates may produce parts that have knit lines. These knit lines are usually the weakest areas of the part.

- The total amount of scrap being produced during injection molding will usually be higher than that for compression molding because of the additional material loss created by the sprue and runner. The use of cold manifolds and live sprues in the molding of granular and BMC polyesters can reduce scrap and have been very successful.

- Injection molding is generally more cost effective when molding larger quantities of parts.

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