



Injection Unit Design Tips

The hopper, stuffer, barrel, screw and nozzle are the key elements of the material processing section of a thermoset injection molding machine. Their design is critical to providing the optimum processing window. The following design suggestions are given to assist you in achieving the optimum processing window.

Hopper

Hoppers are used on thermoset injection molding machines that will be processing phenolic, melamine-phenolic and granular polyester materials. The two basic hopper designs are **square** and **round**.

A **square hopper** does not allow the full flow of the material to the screw due to the "dead" zones created by the corners. In addition, these corners can cause segregation of the coarse and fine particles in the material, which may result in erratic material pickup that will produce variations in shot size.

A **round hopper** allows the full flow of the material to the screw and generally will not cause particle size segregation in the material.

Stuffer

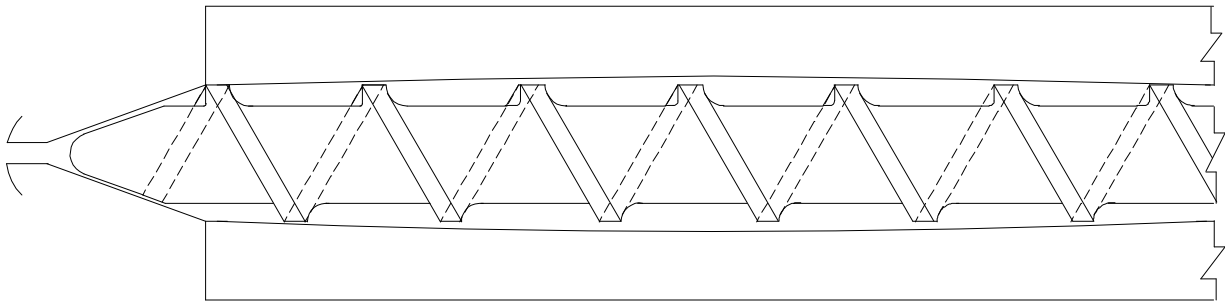
Stuffers rather than hoppers are used on thermoset injection molding machines that will be processing BMC materials. The two basic stuffer designs are **piston** and **screw**.

A **piston stuffer** uses a piston to push the BMC material out of the stuffer's bore into the throat of the injection machine so it can be picked up by its screw.

A **screw stuffer** typically uses two screws to convey the material into the injection screw. A horizontal screw conveys the BMC material from the stuffer's feed hopper into a vertical screw, which then conveys the material into the throat of the injection machine so it can be picked up by its screw.

Barrel

To process thermoset materials, the barrel temperature is typically controlled by **water jackets** that are placed around the barrel. Usually the barrel is set up with two zones of temperature control, but some presses provide the ability to setup as many as five or six zones, which is not recommended. In the two zone arrangement, the **front zone**, which can include the end cap and nozzle, should be $\frac{1}{3}$ of the effective length of the barrel and the **rear zone** should be the remaining $\frac{2}{3}$'s of the effective length of the barrel. It should be mentioned that these zone lengths apply to a standard thermoset machine with a L/D ratio of 12:1 or 13:1. If the L/D ratio is greater than 13:1, a third zone, using room temperature water, may be necessary to reduce the effective L/D ratio to 12:1 or 13:1.



Severely Worn Barrel

Barrels experience their greatest wear at a distance approximately equal to three times the diameter of the screw from the nozzle. (See Above Drawing) As a result, it is recommended that the barrel be sleeved for a length equal to 6 diameters of the screw. The material recommended for making the sleeves is CPM-10V, due to its excellent wear resistance. There are other materials and processes currently being evaluated but to date none have demonstrated having better wear resistance than CPM-10V.

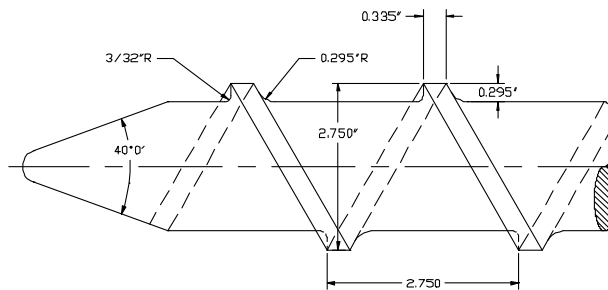
Screw

For processing thermosets, it is recommended that the screw have the following elements in its design:

- It should be made from CPM-9V steel to obtain the best wear resistance.
- The length of the screw flight should be equal to the screw diameter when measured from leading edge to leading edge or in other words the screw should have a square pitch.
- For screws 50.8 mm (2.0") diameter and larger, the flight depth should be equal to 10% - 11% of the screw diameter.
- For screws under 50.8 mm (2.0") in diameter the flight depth should be 15% of the screw diameter.
- The base of the screw flight's trailing edge should have a radius equal to the flight depth to minimize wear.

- The base of the screw flight's leading edge should have a radius of 2.38 mm ($3/32$ " or 0.093") to minimize wear.
- The flight width should be 1 mm (0.039") more than the screw flight depth.
- The end of the screw should taper down at an included angle of 40° to a rounded tip, to optimize the processing window.
- The screw flight should taper down and end at the transition to the 40° angle of the screw tip.
- There should be 1.59 mm - 3.175 mm ($1/16$ " - $1/8$ " or 0.0625" - 0.125") axial clearance between the screw tip and the end cap or head. This will help minimize the probability of nozzle freeze ups and damaging the end cap or head.
- It should have an effective L/D of 12:1 or 13:1 to optimize the processing window.
- Screws that process BMC require a check ring.

The drawing below shows a 70 mm (2.75") screw designed with these specifications.

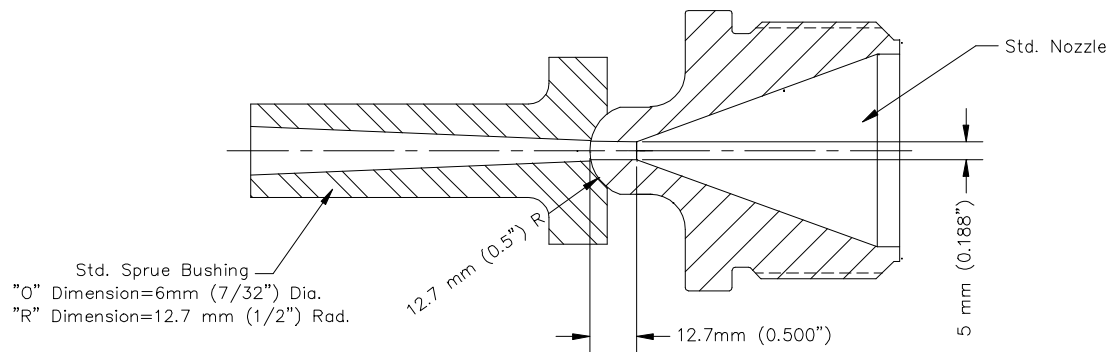


Screw and Barrel

New or rebuilt screws and barrels are typically designed with 0.025 mm - 0.051 mm (0.001" - 0.002") per side clearance. The screw and barrel should be periodically measured for wear. When either the screw or the barrel has 0.254mm per side (0.010") or 0.508mm (0.020") total wear, they should be rebuilt or replaced.

Nozzle

The nozzle and the sprue bushing should have the same radius. As illustrated in the drawing below, the sprue bushing and the nozzle have matching 12.7 mm ($1/2$ ") spherical radii. In addition, the orifice of the sprue should always be at least 1 mm ($1/32$ ") larger than that of the nozzle.



Nozzles designed for thermoset materials should allow the screw tip to come forward to a point that is 12.7 mm ($1/2$ ") from the end of the nozzle. The smallest diameter of the nozzle orifice should be located at this same point. The nozzle orifice should be tapered so the orifice diameter at the open end is 0.25 mm (0.010") larger than it started, as illustrated in the drawing above. Extended nozzles are not recommended for use with phenolic materials due to an increased probability of nozzle freeze-ups. However, they can be used with PLENCO's granular polyester and BMC materials.

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This information is suggested as a guide to those interested in processing Plenco Thermoset molding materials. The information presented is for your evaluation and may or may not be compatible for all mold designs, runner systems, press configurations, and material rheology. Please feel free to call Plenco with any questions about PLENCO molding materials or processing and a Technical Service Representative will assist you.