Injection Unit Design Tips

The hopper, stuffer, barrel, water jackets, screw and nozzle are the key elements of the material processing section of a thermoset injection molding press. 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 on thermoset injection molding presses feed granular molding materials into the injection screw. The two basic hopper designs are **square** and **round**.

A **square hopper** is not recommended because it does not allow the full flow of the granular materials into the injection 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 causing variations in shot size.

A **round hopper** allows the full flow of the material into the injection screw and generally does not cause particle size segregation within the material.

Stuffer

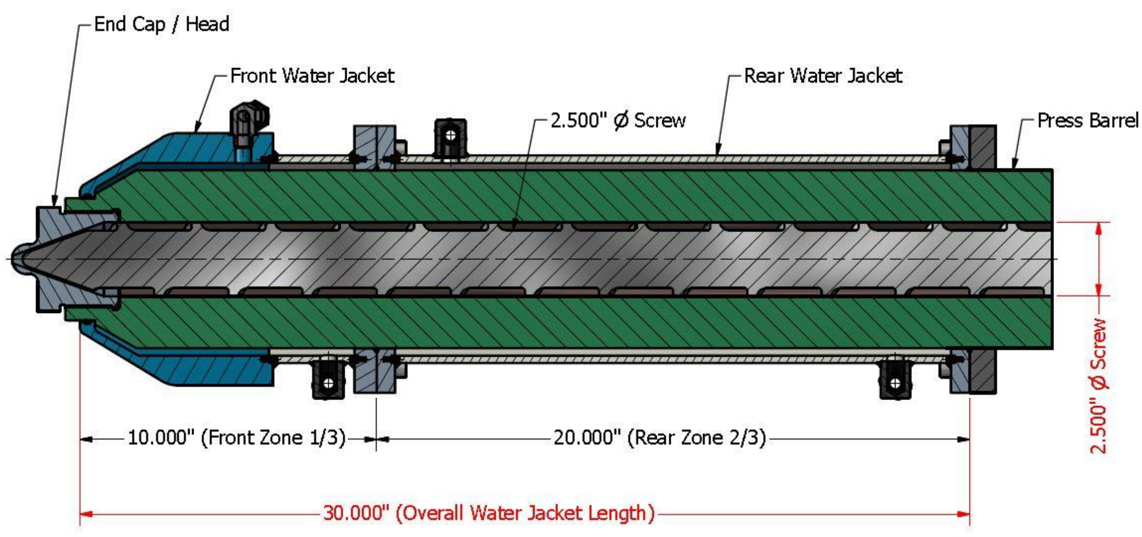
Hydraulic piston or screw stuffers, rather than hoppers, are used on thermoset injection molding presses processing bulk molding compounds (BMC).

A **piston stuffer** uses a hydraulic piston to push the BMC out of the stuffer's bore into the feed throat of the injection press, so the injection screw can pick up the BMC for processing.

A **screw stuffer** typically uses two screws: a horizontal screw and vertical screw. The horizontal screw conveys the BMC material from the stuffer's feed hopper into a vertical screw, which then conveys the material into the feed throat of the injection press so the injection screw can pick up the BMC for processing.

Injection Barrel

To process thermoset materials, the barrel temperature is typically controlled by **water jackets** that surround the outside diameter of the barrel. The best water jacket design uses two zones of temperature control. Some presses have 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 ⅓ of the effective length of the barrel and the **rear zone** should be the remaining ⅔'s of the effective length of the barrel. It should be mentioned that these zone lengths apply to a standard thermoset injection press with an 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.



L / D Ratio

L = Length Of Water Jacket
D = Screw Diameter

To get your Water Jacket Length multiply your required ratio by your screw diameter.

In this case we wanted a ratio of 12 so 2.500" (Dia) Screw x 12 (Required Ratio) Equals a Water Jacket Length of 30.000"

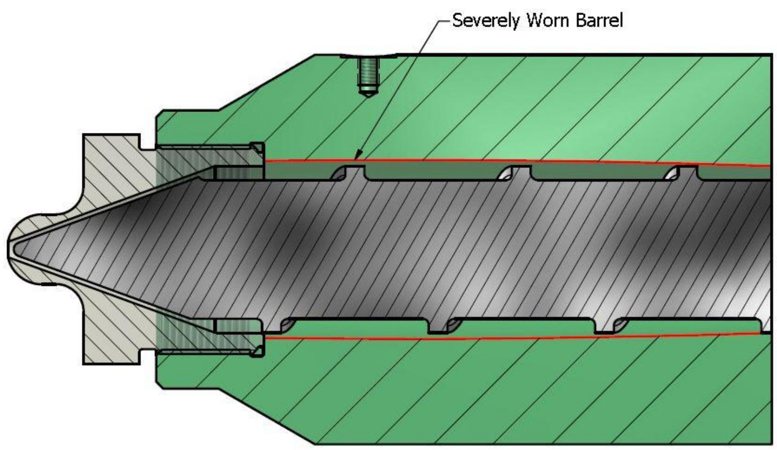
12 (Required Ratio) x 2.5" Dia (D) Screw

Equals

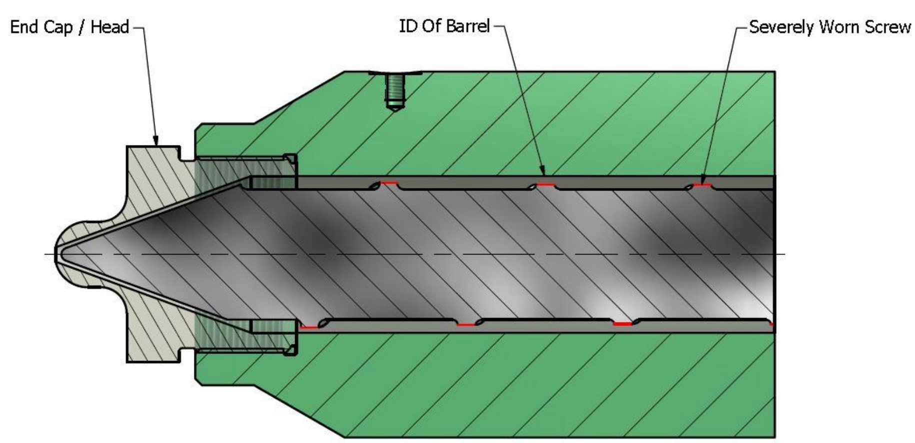
The Overall Water Jacket Length will be 30.000"

Severely Worn Barrel & Screw

Injection Barrels experience their greatest wear at a distance approximately equal to three times the diameter of the screw from the nozzle. 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 sleeve is CPM-10V, due to its excellent wear resistance. There are other materials and processes currently being evaluated but to date, none has demonstrated having better wear resistance than CPM-10V. The drawings below show an example of both a worn screw and barrel.



Severely Worn Barrel



Severely Worn Injection Screw

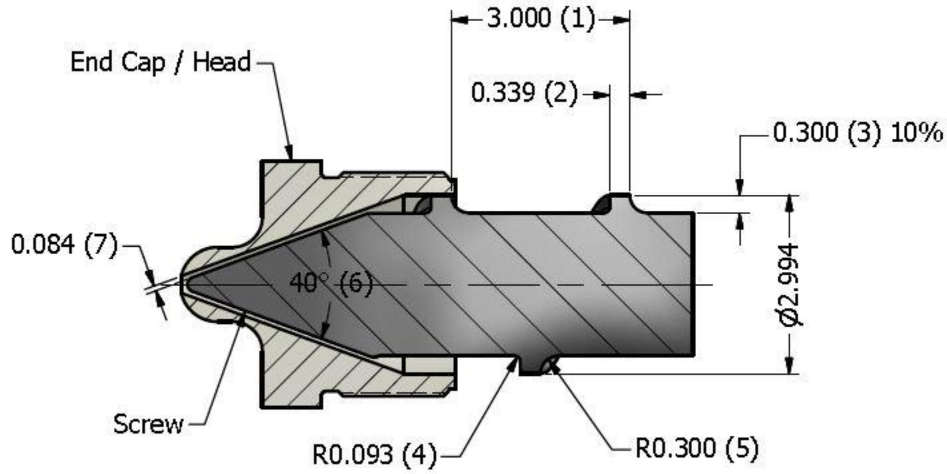
Injection Screw

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

- It should be made from a crucible steel such as CPM-9V 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 2.0" (50.8mm) diameter and larger, the flight depth should be equal to 10% - 11% of the screw diameter.
- For screws, under 2.0" (50.8mm) 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 $^{3}/_{32}$" or 0.093" (2.38mm) to minimize wear.
- The flight width should be 0.039" (1mm) 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 $^{1}/_{16}$" - $^{1}/_{8}$" or 0.0625" - 0.125" (1.59mm - 3.175 mm) 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.
- It is suggested that injection screws for processing BMC materials use a check ring to improve the materials process ability.

The drawing on the next page shows a 3.00" (76.2 mm) screw designed with these specifications.

Phenolic Screw



3.000" Ø Phenolic Screw

Note:

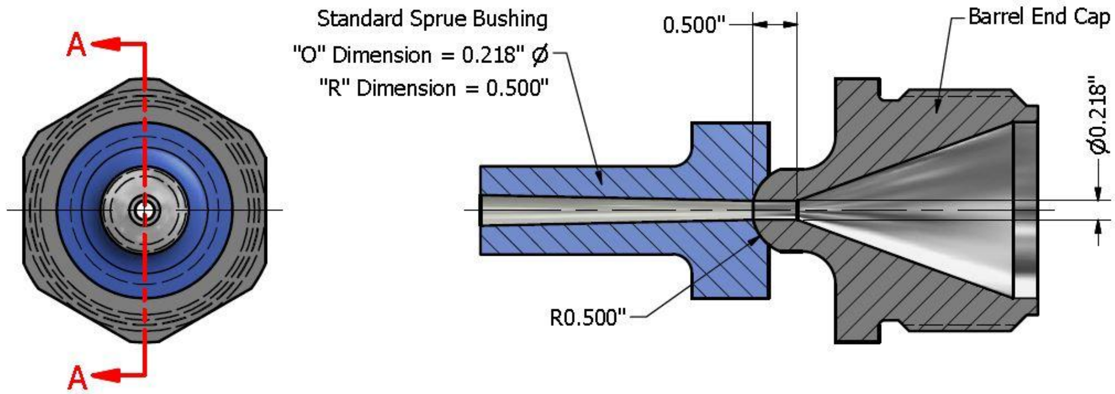
1. The length of the screw flight should be equal to the screw diameter when measured from the leading edge or in other words the screw should have a square pitch.
2. The flight width should be 0.039" (1 mm) more than the screw flight depth.
3. For screws 2.000" (50.8 mm) in diameter and larger, the flight depth should be equal to 10% - 11% of the screw diameter.
4. The base of the screw flight's leading edge should have a radius of 3/32" or 0.093" (2.38 mm) to minimize wear.
5. The base of the screw flight's the trailing edge should have a radius equal to the flight depth to minimize wear.
6. 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.
7. There should be a 1/16" – 1/8" or 0.0625" – 0.125 (1.59 mm – 3.175 mm) 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.
8. It should have an effective L/D of 12:1 or 13:1 to optimize the processing window.
9. It is suggested that injection screws for processing BMC material use a check ring to improve the materials process ability.

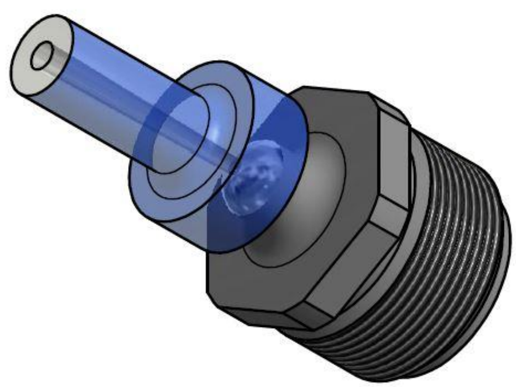
Screw and Barrel

New or rebuilt screws and barrels are typically designed with 0.001" - 0.002" (0.025mm - 0.051 mm) per side clearance. The screw and barrel should be periodically measured for wear. When either the screw or the barrel has 0.010" (0.254mm) per side or 0.020" (0.508mm) 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 $^{1}/_{2}$" (12.7mm) spherical radii. In addition, the orifice of the sprue should always be at least $^{1}/_{32}$" (1mm) larger than that of the nozzle.





Nozzles designed for thermoset materials should allow the screw tip to come forward to a point that is $^{1}/_{2}$" (12.7mm) 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 0.010" (0.25mm) 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, temperature controlled extended nozzles can be used for processing PLENCO granular polyester and BMC materials.