The standard Posi-Melt™ screw, patent # 7,652,528 and other patents pending, a general purpose replacement screw, has proven over the years to be more versatile than its GP predecessor that has been used for the last 65 years on Injection and Blow Molding Machines. We have proven that by altering the flight pitch and root of the screw through the metering section (see fig.1) and making them un-tangential with each other that we can increase the plastic exposure to the barrel wall by up to 55-60% for improved melting and achieve a homogenization by disrupting the laminar flow that is prevalent in GP designs. In addition, output is increased because the volumetric compression is low while achieving a high linear depth ratio (the ratio between the feed depth and the meter depth). These benefits are realized in the standard lengths of a conventional 20:1 L/D design.

**Reciprocating Screw Injection**

The nature of the Reciprocating Screw Injection Molding Machine means that as the shot capacity increases for the application, so does the stroke of the injection unit and hence the plasticating screw. The most widely used explanation of the melting apparatus is the Melt Model according to Maddock and others (see fig. 2), where the pellets are fed into the feed pocket of a rotating screw; a. Solids conveying moves the material downstream compacting the pellets to form a solids bed, b. Pellets are forced against the heated barrel wall at the end of the feed section and through the involute tapered transition section where melting occurs, forming a melt film on the barrel wall, c. The screw flights wipe the barrel wall clean depositing the molten material into the channel creating a separate melt channel, d. A separate solids bed and melt bed co-exist until further downstream where solids bed breakup occurs (see fig. 3). This melt model holds true for any compression screw Injection or Extrusion. When the melt is pumped forward on an Injection Machine however, volume is displaced in the barrel chamber which forces the screw to reciprocate backwards underneath the barrel/machine casting leaving the flight channel void of pellets. This action
The difference in residence time (see fig. 4), which is the time it takes the pellets to advance from the feed pocket to the molded part, becomes significantly different meaning a difference in shear heat and heat history for each pellet making it more difficult to deal with solids bed breakup and the final melting of the solids present in the channel. The GP compression technology falls short in melting capacity when the residence time decreases and or swept volume increases and in melt temperature homogeneity (see fig. 5) as a result of the laminar nature of the flow in the flight channel where no disruption or mixing takes place. In fact without applying a considerable amount of Back Pressure, melt homogeneity is very poor.
Designing a screw for thermoplastic processing should entail having an understanding of the properties of the polymer. Compression ratios, feed depths and section lengths are critical to achieve melt homogeneity for different polymer groups, a brief explanation of some properties are shown below.

**Resin Type**

- Thermoplastics can be divided into amorphous and semi-crystalline plastics.
- Amorphous plastics have a random, irregular molecular structure without crystalline regions. Some amorphous plastics are PS, PC, PMMA, ABS, and PVC.
- Semi-crystalline plastics can form highly regular regions where the molecules form crystals, called crystallites. Some semi-crystalline plastics are HDPE, POM, PA, PET, and PP.
- The crystalline regions in thermoplastics have different properties than the amorphous regions, such as density and optical properties.
- When amorphous plastics are heated, they soften gradually, while crystalline plastics soften more abruptly.
- Amorphous plastics tend to be more sensitive to Shear and Heat.

**Specific Heat**

- The specific heat is the amount of heat necessary to increase the temperature of a material by one degree.
- In most cases, the specific heat of semi-crystalline plastics is higher than amorphous plastics.
- The amount of heat necessary to raise the temperature of a material from a base temperature to a higher temperature is determined by the enthalpy difference between the two temperatures.
Posi-Melt™ Technology

When a screw design is considered for a particular polymeric family, the rule-of-thumb has been; Amorphous screws process better with low compression designs, while Semi-Crystalline materials prefer high compression designs. Since Semi-Crystalline materials have a sharp melting point and are either in the solid state or melt state, higher compression designs with shallower metering sections have done a better job of assuring that each pellet is melted. Whereas high compression designs with shallow metering sections have the tendency to overshear and heat Amorphous materials. The Industry Standard GP screw, is a square pitch design that has a compression between 2.3-2.7:1 and a 50/25/25 feed, transition, metering length ratio. The GP geometry does an adequate job at best with both polymer groups within a narrow process window (see fig. 6). Since Injection applications entail a broad range of polymer groups, residence times and swept volumes, a more advanced design is needed to assure more uniform melt homogeneity.

The Posi-Melt™ geometry is a core change to the geometry of a compression screw. We have separated the coordinate systems (see fig. 1) of the root and the flight pitch to force the pellets through a channel that changes pressure and velocity while exposing 55-60% more pellets to the heated barrel wall for increased conductive heat transfer. The “stepped” root geometry exposes the polymer to a change in velocity and extensional strain that enables us to lower the volumetric compression for low shear heating while establishing a high “linear depth ratio” between the feed depth and the metering depth. The lower volumetric compression works well with Amorphous polymers by lowering the shear between the pellets in the transition zone and the high “linear depth ratio” assures a shallow meter depth for efficient melting of the Semi-crystalline polymers. The Posi-Melt™ screw has won acclaim from resin suppliers, OEM’s and our customers/fabricators on both ends of the crystalline spectrum from LCP to Rigid PVC and the improved melt quality broadens the process window for custom molding shops that process a variety of materials. The Multi-Purpose Posi-Melt™ geometry delivers a more thoroughly melted polymer with a higher level of melt homogeneity (see fig. 6) that is able to produce higher quality parts over a broader spectrum of residence time and swept volumes.

fig. 6
Since every plasticating screw design has melt quality homogeneity limitations when the requirement for output increases, we have designed a family of advanced screws that incorporate the core Posi-Melt™ technology to meet the most demanding applications. If a high level of melt homogeneity is achieved, the polymer will flow more consistently into the mold assuring more evenly filled cavities with less part weight variance void of common defects such as warpage, short shots, color variance and weak weld lines.

In order to reach a high level of homogenization the polymer has to be melted first, then distributed or dispersed. When the swept volume is greater than three diameters and/or the residence time is under ninety seconds most OEM’s default to longer L/D’s because of the diminished melting capacity. We have proven that our technology is capable of delivering a quality melt under these conditions by first exposing the polymer to the core Posi-Melt™ technology for melting purposes then adding our proprietary mixing technology for additional melting and distribution using conventional length 20:1 L/D designs.

The “XL” dispersive or “XLA” distributive mixers are used to add a high level of melting and mixing to the melt pool by forcing the polymer to change direction numerous times over a short axial distance and exposure to extensional strain. A positive pumping angle and major flight OD wiping action assures a low pressure drop for high throughput yet pressurizes the channels for positive displacement for melt cleaning purposes. These mixers are used for virtually all resin groups when precise color matching is needed or the residence time and swept volume dictate.

The “MB-XL” design shown above is used in applications where the residence time < 90 seconds and or the swept volume is > two diameters or where there is a need for exact color matching. Our proprietary “MB” barrier forces the polymer between the barrier flight and the barrel ID for added extensional strain to assure complete melting. We couple the barrier to the “XL” mixer for PP, HDPE and PS resin groups for dispersion and the “XLA” mixer for PET, ABS and other shear sensitive materials for distribution. The output capability of these designs is extremely high to meet the most demanding melt quality and cycle times in the industry.
Posi-Melt™ Technology Comparison

Most of the research conducted and math models developed on processing of thermoplastic materials took place in the 60’s, 70’s, 80’s and 90’s where a frenzy of newly developed polymers were commercialized. Resin companies funded and universities tested processing techniques on extrusion equipment in the 60’s and 70’s and Injection Molding processing was tested in the 80’s and 90’s. The math models developed by such names as Z. Tadmor, I. Klein, Lindt, J.F. Ingen Hausz, B. Maddock, and others are still used today, and practical testing and analysis of designs by B. Maddock, G. Kruger, and H.E.H. Meijer are still used as reference materials. One of the most comprehensive analysis of the performance of Injection Screws was conducted by C.P.J.M. Verbraak DSM Research and H.E.H. Meijer Technical University of Eindhoven (Polymer Engineering and Science, Mid-April 1989, Vol. 29, No. 7) and has been used to reinforce our development efforts at Md Plastics Incorporated.

Analysis of the melt model (see fig. 2) led to the development of the first barrier screw by Geyer/Uniroyal and further parallel barrier design improvements by Dray/Lawrence, R. Barr, Chung, B. Willert and others. The purpose of the multi-channel barrier screw is to deliver a phase separation between the solids bed and melt bed and maximum use of contact surface for heat exchange with the barrel. In addition various mixing sections are coupled to compression and barrier screws to facilitate more exposure to the barrel wall and melt separation for melt homogeneity. The designs mentioned above come at an expense however, all of them cost more to manufacture and most of them are resin specific, therefore the staple in the industry is still the GP compression screw.

The Posi-Melt™ design is a development that was spawned from the digestion of many of these books and articles as well as testing and practical experience. We felt that there was a need to develop a design that increased the exposure to the barrel wall (fig. 7) while adding a degree of melt separation (velocity change, extensional strain) without the manufacturing expense of the previous technology. In our opinion, there has been no advancement in a design that brings melt quality value without a significant increase in the cost to manufacture…Until Now!
### Posi-Melt™ Multi-Purpose Design: Performance Case History

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screw</td>
<td>L/D</td>
<td>OEM</td>
</tr>
<tr>
<td>105</td>
<td>18</td>
<td>Van Dorn</td>
</tr>
<tr>
<td>71</td>
<td>22</td>
<td>Sumitomo</td>
</tr>
<tr>
<td>80</td>
<td>14</td>
<td>Krauss Maffei</td>
</tr>
<tr>
<td>18</td>
<td>20</td>
<td>Engel</td>
</tr>
<tr>
<td>120</td>
<td>20</td>
<td>UBE</td>
</tr>
<tr>
<td>130</td>
<td>22</td>
<td>Demag</td>
</tr>
<tr>
<td>50</td>
<td>25</td>
<td>Krauss Maffei</td>
</tr>
</tbody>
</table>

Our technology, a core change to the geometry of a compression screw, is the most versatile technology available in the industry today for delivering a high quality melt for the lowest manufacturing cost. We have been successful in processing resins from LCP to PC to Rigid PVC with diameters from 14mm through 240mm with good application engineering and an understanding of the melting process.

Whether you are running a custom shop or have dedicated machines with a specific application, chances are we have provided a solution with the Posi-Melt™ family of plasticating screw designs that has yielded less rejects, lower cycle times and improved melt temperature homogeneity for increased profits.