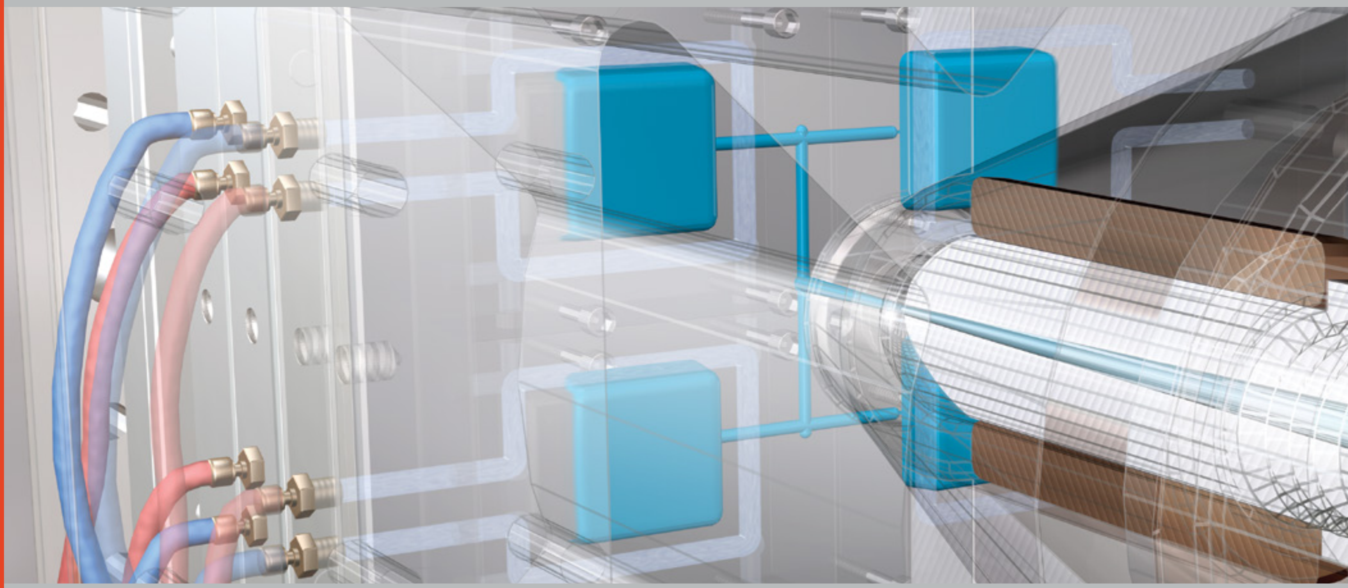
REFERENCE SERIES: DESIGN

Shear Rate & Orientation in Plastics Processing



nexeo plastics

Created exclusively for **Nexeo Plastics** by Routsis Training, this free guide contains excerpts from Routsis's ***Mold & Part Design Courses***.

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SHEAR RATE & ORIENTATION

Since the Viscosity of polymers change with Shear Rate, it is important to calculate the Shear Rate during filling. The Shear Rate is a function of the Material Flow Rate and the cross sectional area of flow.

In this formula, **Q** represents the flow rate, **W** is the flow width, and **H** is the thickness. As the thickness decreases (or flow increases), the shear rate increases.

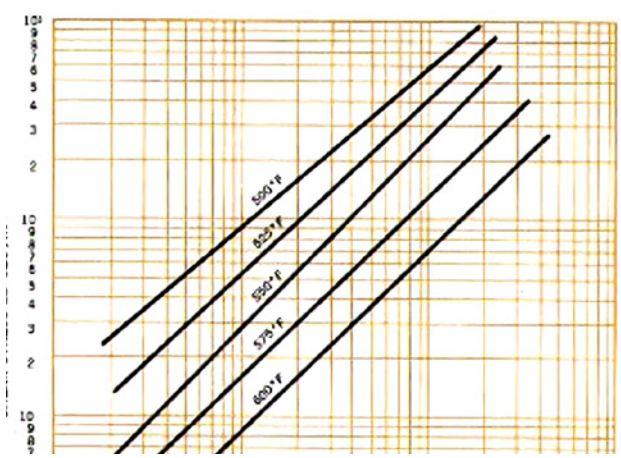
Apparent Shear Rate
(for Simplified Flow through Rectangular Cavity)

$$E_S = \frac{6 \cdot Q}{W \cdot H^2}$$

Shear Rate calculations can be useful for many reasons. For example, a Shear Rate calculation should be made in order to use a Viscosity Curve to determine the material's viscosity.

It is also possible to determine the Shear Rate in the process. Many material suppliers provide the maximum allowable Shear Rate for the process. Exceeding the maximum rate can lead to filling problems such as Jetting, Burning, and premature part failure.

SHEAR RATE vs SHEAR STRESS



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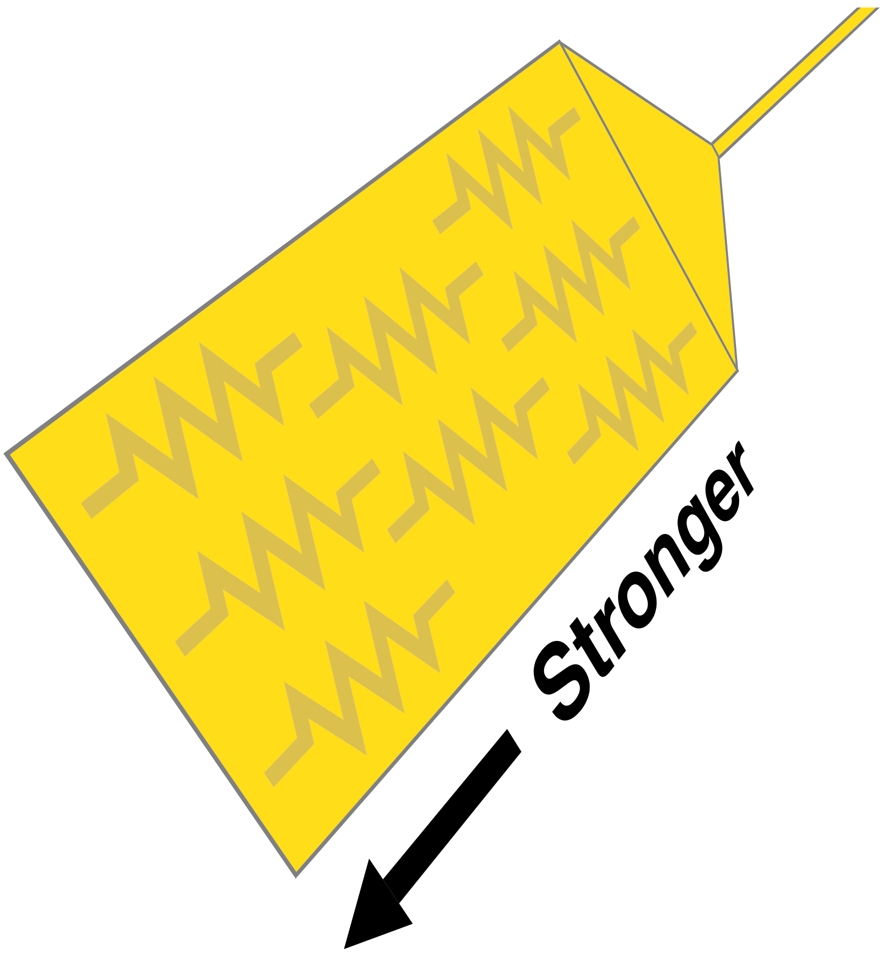
Furthermore, areas with high Shear Stress are likely to have high Polymer Chain Orientation. Polymer behavior during fill can be shown using a spring analogy. As the polymer fills this plaque, many of the polymer chains are being oriented in the direction of flow. Since polymer chains tend to be arranged in random order, aligning the chains causes stress in the polymer.

When the polymer is allowed to cool slowly, many of the polymer chains recoil and reduce the stress level. Increased Orientation in one direction can reduce the physical properties in the other direction. The plaque in this example has a higher tensile strength in the direction of flow than in the direction perpendicular to flow.

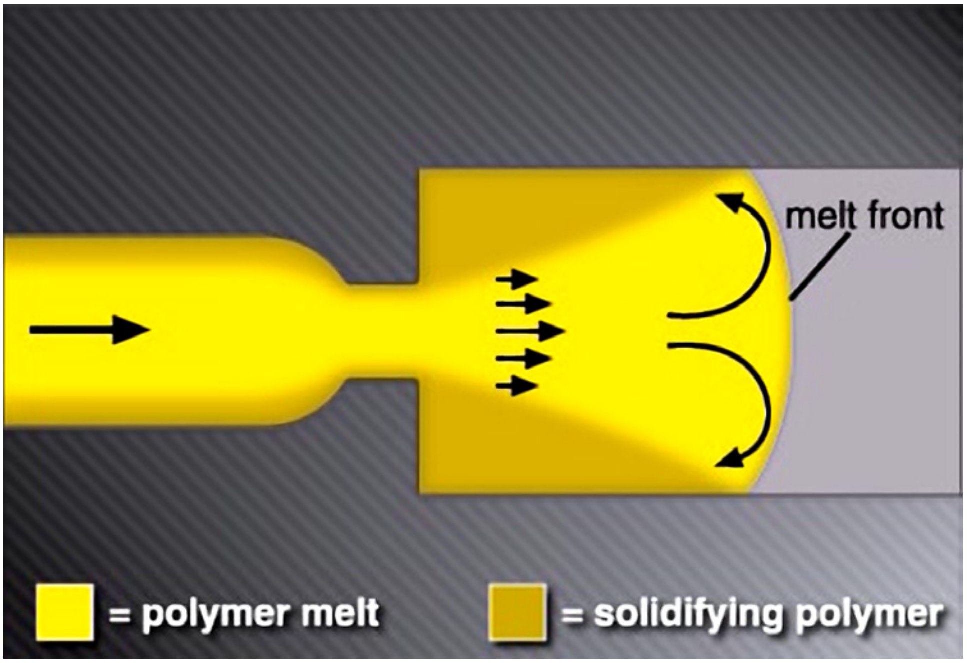


Mold Filling Simulations

The previously mentioned calculations all assume a simplified, Isothermal Flow. This assumes that heat is neither dissipated nor generated during fill.

Realistically, both Cooling and Shear Heating take place during filling. This means that the mold filling process is actually Non-isotropic.

As the melted polymer flows into the cavity, the material close to the wall cools and solidifies. The polymer is now required to flow between the frozen walls. This thins the material flow and increases the Shear Rate. Increased shear causes the polymer melt to heat up.



The calculations for these and other effects are virtually impossible to calculate by hand. Although hand calculation can be useful in making initial determinations early in the design process, computer simulations should be used to aid in the final design.

Computer filling simulations are capable of dividing the flow into various layers and quickly calculating both the cooling and heating effects simultaneously. Designers can either draw or import a drawing into the mold filling software and then run simulations on the part.

Most mold filling programs allow the designer to choose from a wide array of materials and material suppliers — to test various materials and design changes to help improve the fill.

Information such as Shear Stress, Shear Rate, Melt Temperature, and Material Viscosity is calculated and provided throughout the part. Mold filling software can be used to test various gating techniques — and to help detect weld line location and strength.