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Shear Sensitivity

Melt index and density are two properties that help describe whether a polyethylene is useful for a given application. Density is the weight of the polymer per a given volume. Melt index (MI) is an indicator of the average molecular weight of a polyethylene and relates to both the processing and finished part performance of the polymer.

Melt index however, does not tell the entire performance story. Grades of polyethylene with the same melt index may perform quite differently during the blow molding process. A third property – shear sensitivity – provides additional information essential to understanding the polyethylene grade's behavior.

To see how important shear sensitivity is, you must first understand how the melt index alone affects production rates.

Extrusion data for three high density polyethylene grades (HDPE) are given in Table 1. The data show the effect of melt index on the best possible performance of three resins run on the same blow molding machine under a constant extrusion pressure. The higher MI resins have an advantage in both cycle time and power usage. In fact, the 0.8 MI resin has a cycle time 6.2 percent shorter than that of the resin with a 0.3 MI. The power draw was reduced by 7.5 percent, as well. As a result, more than 200 additional machine cycles can occur during an eight-hour shift if resin C is used instead of resin A.

Resin	Melt Index g/10 min.	Cycle Time Seconds	Extrusion Time seconds	Power amp	Temp. °F
A	0.3	9.8	1.8	92	386
B	0.6	9.3	1.8	87	375
C	0.8	9.0	1.2	85	365

However, while higher MI resins lead to shorter cycle times as illustrated in Table 1, for reasons concerning both processing (parison melt strength) and bottle properties (drop impact strength), polyethylene grades with high melt indices are not always the best resins for a given application.

Polyethylene grades exhibit a phenomenon called shear sensitivity. The resins in Table 1 have different melt indices, but the same level of shear sensitivity. The resins in Table 2 all have the same melt index but differ in shear sensitivity.

Resin	Shear Sensitivity	Extrusion Pressure psi	Extrusion Rate lb/hr	Extrusion Rate lb/hr/tp	Temp. °F
D	Low	2,300	324	3.7	435
E	Medium	1,800	390	4.8	412
F	High	1,500	406	5.8	390

According to the data in Table 2, the resin with high shear sensitivity produced less head pressure while extruding 25 percent more material per hour at a lower melt temperature than the other two resins. If the operator had chosen a resin simply based on MI, he might have overlooked this highly productive grade.

■ WHAT IS SHEAR SENSITIVITY?

The viscosity of a HDPE melt appears to change depending on how rapidly it is undergoing shear, i.e., how hard the resin is being pushed through processing equipment. The higher the shear rate, the lower the apparent viscosity. An extruder generally produces a moderate rate of shear and the polymer shows a moderate decrease in apparent viscosity. Forced at high speed through a narrow die gap, the molten polymer experiences high shear and a correspondingly large decrease in apparent viscosity. Once outside the die (in the form of a hanging parison) the melt experiences practically no shear and appears very viscous (Figure 1).



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Shear Sensitivity (Continued)

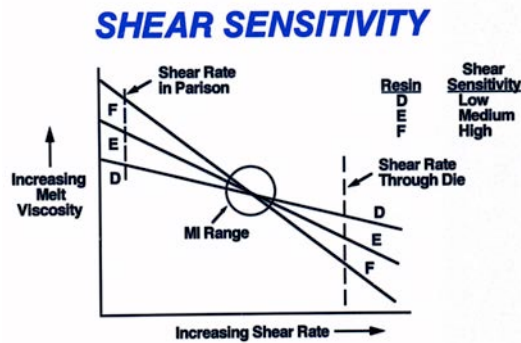


Fig. 1: The importance of good shear sensitivity – high viscosity in the parison, low viscosity through the die.

Depending largely upon the molecular weight distribution of the resin, different HDPE grades exhibit different levels of shear sensitivity. **Figure 1** shows that good shear sensitivity gives the best extrusion performance (lowest viscosity through the die) and best parison melt strength (highest viscosity at low shear). Some of the problems associated with low shear sensitivity are shown in **Figure 2**.

A resin with poor shear sensitivity may require higher melt temperatures, resulting in longer cycles because of the extra cooling time needed. This resin may also exhibit low parison strength, leading to “pleated” parisons and webbing in the blown handle.

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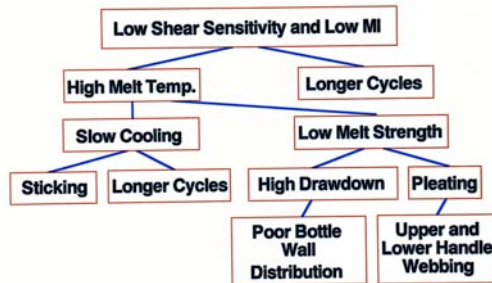


Fig. 2: Low shear sensitivity with low MI is bad news for the molder - the cures are even worse.

Consistent shear sensitivity is critical for consistent performance. At LyondellBasell, our resins are constantly checked for consistently high shear sensitivity for successful blow molding.

If you would like to learn more about shear sensitivity, please contact your LyondellBasell sales or technical service representative.