K·RESIN®
Styrene-Butadiene Copolymers

Plastics Technical Center Report #413

Effect of Orientation on Impact Strength of Sheet and Thermoformed Parts Made from K-Resin® SB Copolymer/GPPS Blends

INTRODUCTION. Most thermoformed K-Resin styrene-butadiene copolymer parts contain general purpose polystyrene (GPPS) resin to reduce material costs and improve part rigidity. The K-Resin content is usually adjusted to the minimum amount possible to achieve the required toughness for each application. Since that toughness is greatly influenced by a few critical process variables, best economics are achieved when these variables are optimized. This study evaluates the effect of one important variable, die drawdown, on the impact strength of K-Resin/GPPS sheet and thermoformed parts.

PROCEDURE. Blends containing 60% K-Resin and 40% Nova 3500 GPPS resin were extruded into 20 mil sheet for this study. The first run was made from a die opening of approximately 1:1, die opening to sheet gauge ratio. The actual die opening for this run was 22 mils, to provide enough material to fill the polish roll nip. The second run (2:1 drawdown) had a die opening of 40 mils and so forth.

Our initial experiment was conducted by setting the selected die opening while the screw was stationary. Subsequent measurements taken at process conditions showed the die (EDI flex lip type) opened up under pressure. At 50 rpm, a 20 mil opening grew to 40 mils in the center of the die. This problem was countered by setting all die openings as the material was being extruded.

The sheet samples were thermoformed on a roll-fed machine, with a 16 oz. deli container and lid mold. Sheet and part toughness were analyzed using a modified Gardner impact test.

RESULTS. Figure 1 shows thermoformed deli containers were much tougher at each drawdown ratio than the lids, and lids were stronger than the sheet they originated from. This demonstrated that biaxial orientation is beneficial for part toughness. It also shows why thermoformed lids usually contain about 10% more K-Resin than cups.

Mono-axial orientation from extrusion, however, is detrimental to part strength. As the drawdown ratio from the die increased, sheet and part impact strength plummeted. Orienting the sheet in the direction of extrusion causes it to be increasingly brittle across its width. This tendency for K-Resin sheet to be tougher in the direction of extrusion suggests that thermoformed hinges should always be aligned in that direction.

Most K-Resin/GPPS sheet will perform well if the initial die opening is set approximately 10% larger than the required sheet gauge. This ensures enough material to fill the polish roll nip, without casing excessive drawdown. When extrusion begins, the center of the sheet die will open under pressure. This causes the center of the sheet to be thick. One gauge adjusting method is to open up the die for thin areas in the sheet. Adjustments are also made by closing the die where the sheet is thick. The second technique will provide a much smaller average die gap (and lower sheet orientation) than the first. As a result, sheet and part toughness will be improved.

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SUMMARY. Drawing K-Resin sheet from a large die opening will diminish impact strength in the sheet and thermoformed parts. This is especially significant, in K-Resin/GPPS blend applications. Biaxial orientation during the thermoforming operation, however, promotes sheet and part toughness.

As a general rule, initial die openings should be set about 10% larger than the required sheet gauge. Subsequent die adjustments should consist of tightening down thick areas, instead of opening up thin ones. Since the sheet will always be strongest in the direction of extrusion, any hinges or other critical design features should be aligned accordingly.

Figure 1

K-Resin/GPPS Blend 60/40 Ratio