Technical Report #53

Lubricant Effects on Pipe Extrusion

Purpose

To demonstrate a scientific method to evaluate the effect of lubricant levels on the extrusion process and physical properties. It is meant to show the significant effect lubricant levels have on these properties.

All values were obtained on a Cincinnati-Milacron CM-55 twin screw extruder. The trends demonstrated in this study may vary with different equipment, formulations and processing conditions.

Procedure/Results

OxyVinyls™ 225PG was blended into four formulations for extrusion study: control, high external/low internal lubricant, low external/high internal lubricant and low external/high internal/impact modified. The exact levels of these formulations are found in Table 1.

The compounds were extruded on the CM-55 on two occasions under mostly similar conditions. (Two trials were run for reproductibility.) The extruder conditions are listed in Table 2. The compounds were checked for: extrusion amps, gloss (BYK-Gardner Glossmeter), impact resistance (ASTM D-2444), b color (Hunter Color/Difference meter), outside diameter appearance, vent appearance, and Brabender fusion. The results of those tests are in the graphs on the following pages. (For outside diameter and vent appearance, an arbitrary value was assigned to the observations so that a graph of the results could be made.)

Discussion

The two primary categories for lubricants are internal and external. Internal lubricants (e.g. calcium stearate) help to promote fusion by easing the movement of PVC molecules within the melt. External lubricants (e.g. paraffin wax) help the polymer melt release from metal surfaces of the extruder. In so doing they help to impede fusion.

Graph 1 below contains the Brabender fusion curves of three of the compounds studied and is the key to this study. The high internal lubricant compound had the highest fusion torque and the highest equilibrium torque. The high external compound was the opposite with the lowest fusion torque (the exact location of the peak is not even well defined) and the lowest equilibrium torque.

Because external lubricants retard earlier fusion, one group of properties that the lubricant levels effect are amps, vent appearance and b color. With high levels of external lubricant, fusion occurred later in the screw barrel and the material at the vent appeared more powdery and less ribbon-like. The lesser fused material was easier to convey and decreased amps were the result. Accompanying the lower amp level was less heat history and less yellowing (lower b color) was observed. High external lubricant levels also increased pipe gloss.

Another way of interpreting the results is looking at the internal lubricant's effect on amps, impact strength and outside diameter appearance. In contrast to external lubricants, the higher levels of internal lubricants resulted in earlier fusion and a smoother, more ribbon-like vent appearance was observed. Although the early fused material was more difficult to convey (higher amp), it produced pipe with a very smooth outside diameter. Here through, the pipe was over fused and had a lower impact strength.

Impact modifier recovered some of the impact lost with the higher internal lubricant levels, but it also increased amps and gloss and the compound was less fused at the vent. Color results were not consistent within the two trials.

Conclusion

The balance of all additives in pipe extrusion is key to producing good pipe and involves a tradeoff of properties. Lubricant systems are especially important to consider. In this study earlier fusion has the disadvantages of lower impact strength, higher b color, and a duller finish; the advantages include lower processing temperatures, a smoother ribbon at the vent and a smoother outside diameter. It should be re-emphasized that these results may be specific to this equipment, these formulations, or these conditions.

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Table 1

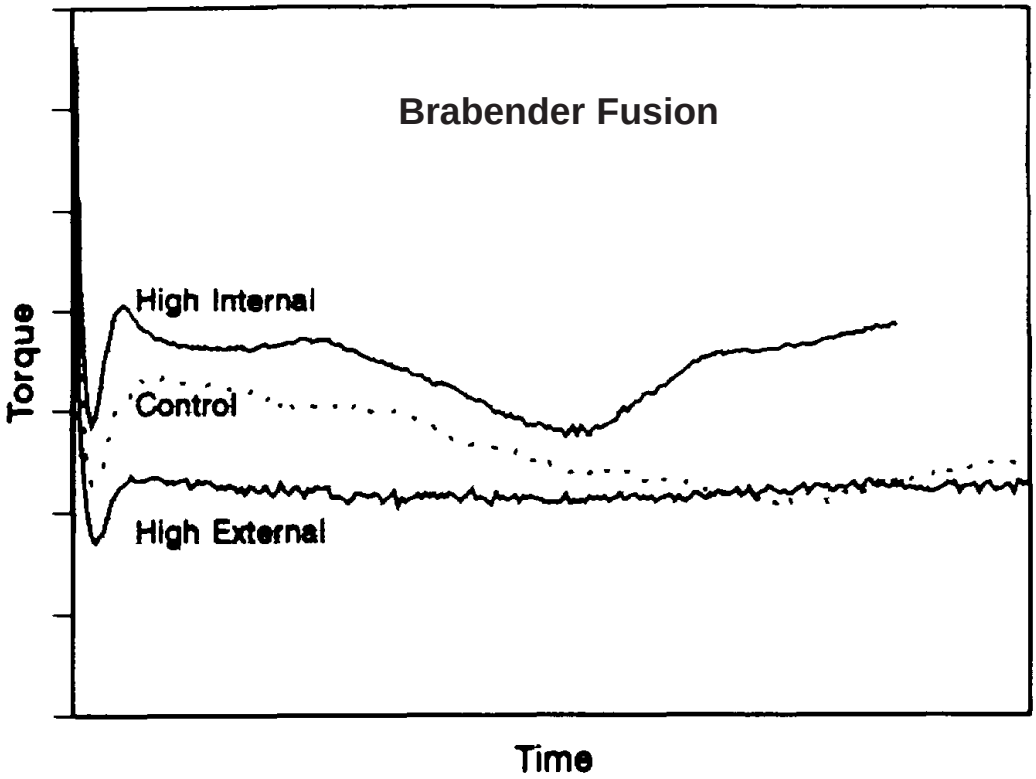
Pipe Compound Formulations

	Control	High External	High Internal	Impact Modified
OxyVinyls™ 225PG	----------100----------			
TM694	----------0.5----------			
Calcium stearate	0.8	0.4	1.0	1.0
XL165	1.2	1.5	0.9	0.9
AC629A	0.15	0.2	0.0	0.0
Titanium dioxide	----------1.0----------			
Hydrocarb 95T	----------3.0----------			
K120N	0.0	0.0	0.0	2.0

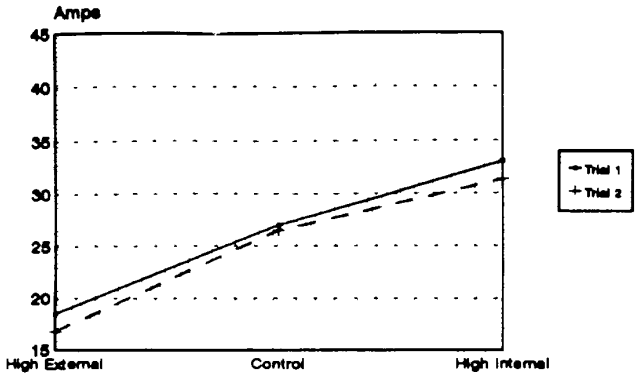
Table 2

Extrusion Conditions

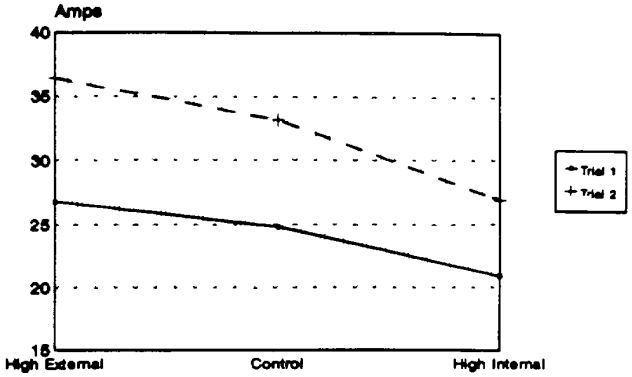
	Trial 1	Trial 2
Zone 1	360°	360°
Zone 2	355°	355°
Zone 3	355°	350°
Zone 4	350°	345°
Die 1	370°	370°
Die 2	380°	380°
Die 3	380°	380°
Screw Oil	360°	350°
Motor RPM	1600	1750



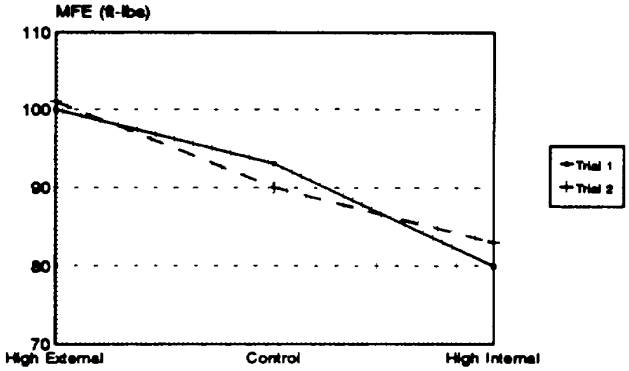
Extrusion Amps



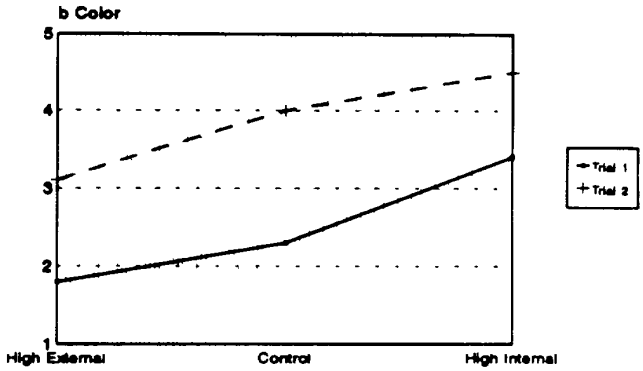
Gloss



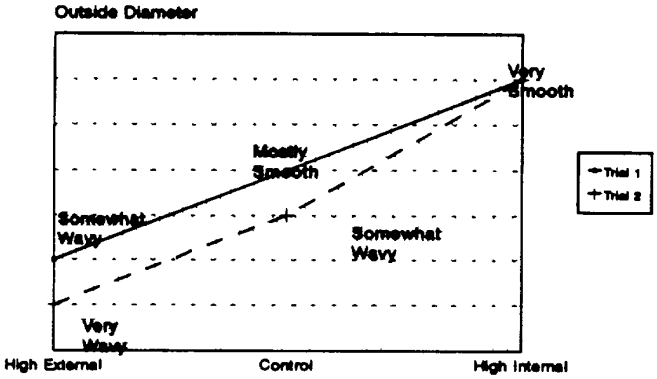
Pipe Impact



Pipe b Color



Outside Diameter



Vent Appearance