CASE STUDY 7 – Hose extrusion process

Brief

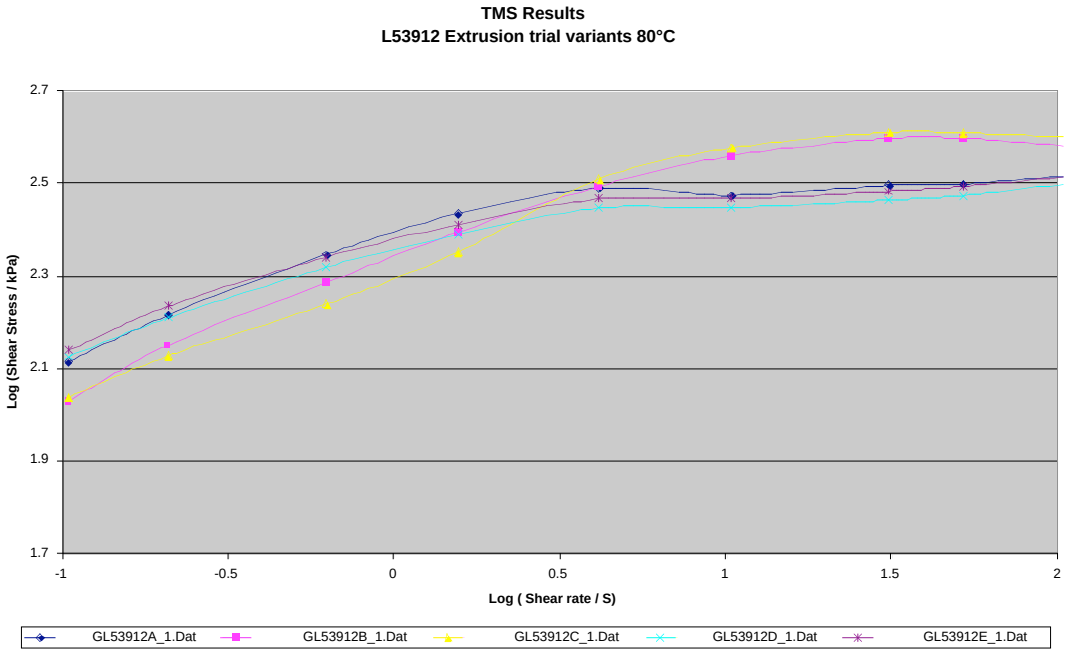
ARTIS were approached with a selection of very similar compounds. There were essentially three issues:

1) Inability of compounds A,D,&E to process under the same conditions as B & C during in-line extrusion i.e. it required a much higher screw speed to match the required output rate for a number of constructions.
2) Inability of A,D,&E to match the output rate of the B & C under any conditions during the crosshead extrusion for the same constructions.
3) Balling up of the A,D,&E compound in the feed pocket during crosshead extrusion for the same constructions.

Investigation

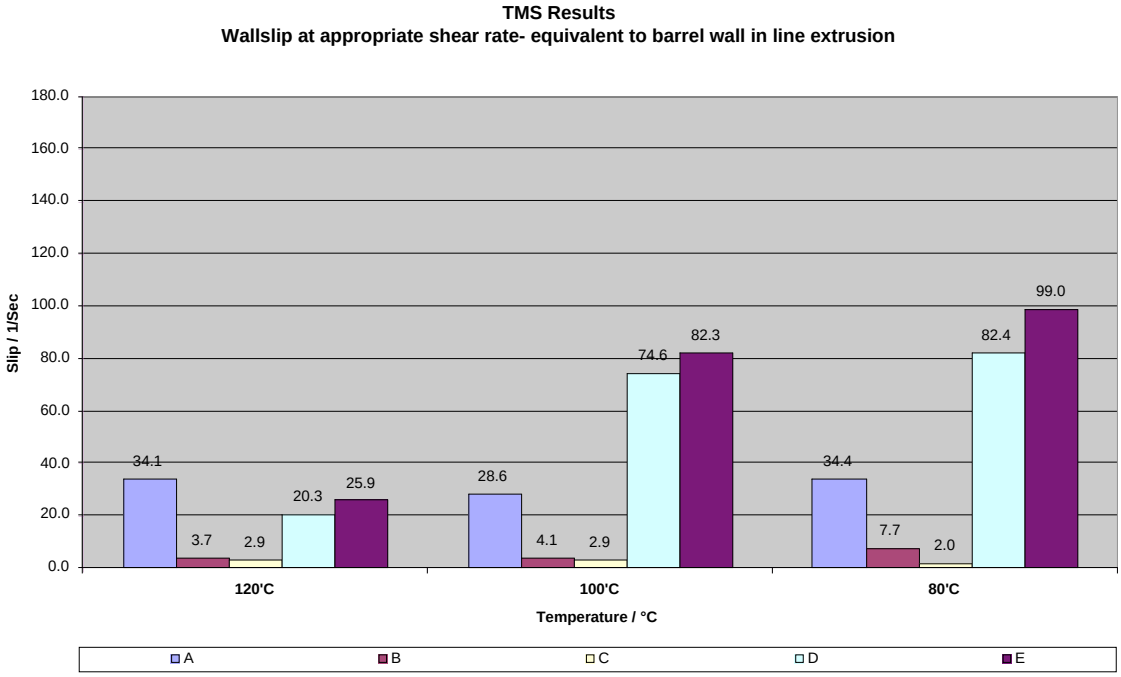
During the extrusion process the pressure generated in the head behind the die pushes the rubber through the die orifice, but also tries to push the rubber back along the screw flights. The net output of the extruder is governed by the relative impedance of the die and the screw channel. If the screw provides less resistance than the die, then the rubber will not flow out of the die but back up the screw, clearly it is a balance.

Using unique testing equipment, ARTIS investigated the rheological behaviour of each material. The TMS rheometer uses a bi-conical rotor geometry to give a uniform shear rate over the radius and allows us to measure shear rate dependence of elastomeric compounds and lubricated wallslip behaviour with ease.



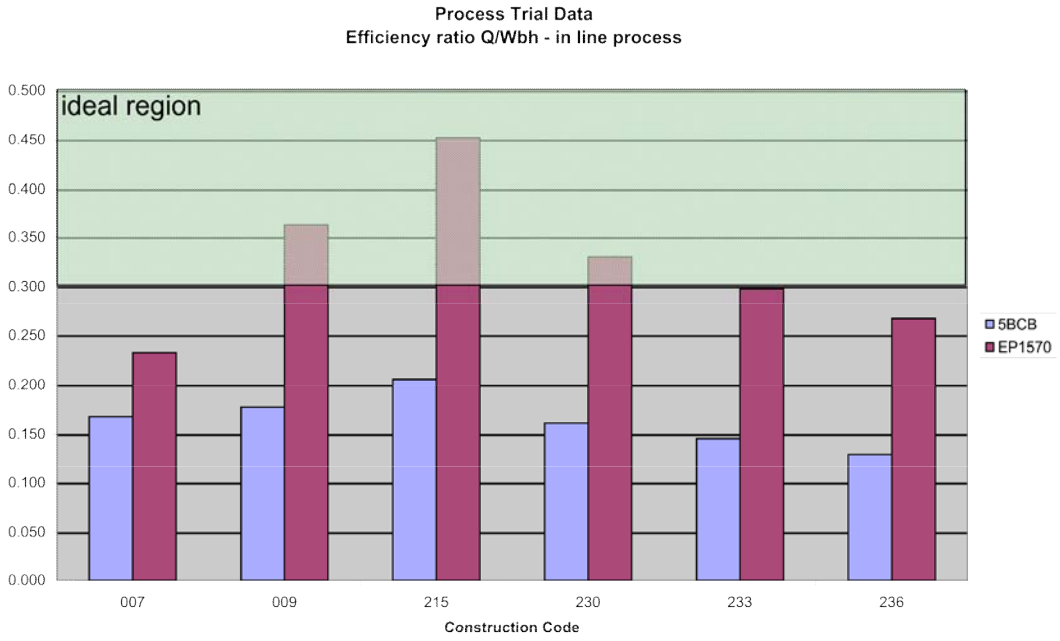
Shearflow behaviour of compounds

Comparing the flow curves above there is a clear discontinuity in the behaviour of the poorly performing compounds suggesting a critical fracture stress is reached disrupting the flow pattern.



Slippage results for in line extrusion

Calculating the shear stress and rates in the barrel and die from process data, and comparing the lubricating effect at these rates, it is clear that the well performing compounds have significantly less slippage and are more able to grip the barrel wall, hence give improved output rates.



Process efficiency ratio

Calculating the theoretical output from the screw and comparing to that achieved in the process, it is clear that with a ratio of less than 0.3, the die impedance is far too high for the extruder geometry under these conditions.

Conclusion

For the compounds that process inefficiently, this may be improved by reducing the slip at the wall relative to the screw, so increasing the screw temperature should help as would reducing the wall temperature of the barrel.

The efficiency calculations suggest that the current setup is not appropriate for these materials in these constructions, the die impedance relative to the transport capability of the screw is way too high. This could be improved by the use of a screw with reduced channel depth, given that a smaller extruder is not an option.