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PR

From "Single Screw Extruder Experiment" on Integrated Experience Website

$$Q = \left(\frac{m\pi R^3}{1+3m}\right)\left(\frac{\Delta P}{2m}\frac{R}{L}\right)^{1/n}$$

PROBLEMS BASED ON THE RHEOLOGY DEMO *eq. 2 of extrusion manual*
(SOME USING EXTRUDE2.XLS)

$$\Rightarrow \ln Q = \ln\left(\frac{m\pi R^3}{1+3m}\right) + \frac{1}{m}\ln\left(\frac{\Delta P R}{L}\frac{1}{2m}\right)$$

(1) Using your data for flow rate Q vs. pressure drop, compute (at constant temperature) the power law parameters m and n for the HDPE at this temperature. Employ linear regression, working with the correct relation between Q and △P. Compute the viscosities from the ratios of shear stress and shear rate (at the wall). Follow the instructions in the spreadsheet for how to perform the linear regression.

$$\Rightarrow \ln Q = \ln\left(\frac{m\pi R^3}{1+3m}\right) + \frac{1}{m}\ln\frac{\Delta P}{L}\cdot\frac{R}{2} + \frac{1}{n}\ln\frac{1}{m}$$

I dunno, but
$$\dot\gamma = \tau/\eta$$
and $\dot\gamma = \left(\dfrac{Power}{\eta}\right)^{1/2}$

where Power
The energy dissipation rate, which Dr. Pooley sometimes calls Q, not to be confused with volumetric flow rate.

(2) Note that I have used the equations derived in class to compute the shear ① *Plot $\ln Q$ vs.* rate in two different ways, both of which should give almost the same result. $\ln\frac{\Delta P}{L}$. What are the 2 equations? Try to compare the viscosity or m,n data from either the *Polymer Handbook* or the *Encyclopedia of Polymer Science and* ② *slope = $\frac{1}{n}$* *Technology* (under "Olefin Polymers"). Both may be found in the reference ③ *Now you know n.* section of Middleton Library, and elsewhere.

Then intercept = $\ln(m\pi R^3/(1+3m)) + \frac{1}{n}\ln\frac{1}{m}$.

(3) Assuming that the initial slope of the Q vs. RPM curve is correct, determine ④ *Insert the* the % slippage or leakage of the extruder at higher Q's. This should *known n* increase with shear rate. Also examine your extrudate diameter data. *and solve* Assuming the primary or first normal stress coefficient ψ varies similar to *for m.* viscosity itself, and the die swell is directly proportional to ψ, what should be the functional relationship between die swell and shear rate?

I guess......
$$Power = \eta\dot\gamma^2$$
$$Power \cdot time = Work = C_p\Delta T$$

(4) Estimate the temperature rise in the die at the wall assuming C_p for HDPE is 2300 J/(kg·K). Remember, the relevant volume is cylindrical. The actual temperature rise would only be about 20% of this number. Why?

$$So\ \Delta T = Power\cdot time/C_p = (\eta\dot\gamma^2)\left(\frac{L\pi R^2}{Q}\right)\frac{1}{C_p}$$

I'll guess 20% less due to acceleration of plug.

(5) Recent work on extrusion and injection molding has shown that the magnitude of die swell (extrusion) or warpage (injection molding) is affected by the material of the die or mold. In particular, very smooth, polished surfaces tend to give less swell. List some possible reasons for this phenomenon.

We split this out as another problem.

(6) What are the chief rheological differences between Hair Conditioner (a suspension of PEG-100, PEG-5, PVA, PVP, guar, lecithin, long-chain alcohols, some cationic surfactants (quats), and some other low MW materials) and vinyl-terminated PDMS, as suggested by their behavior under oscillatory shear? How might some of the rheological properties of the Hair Conditioner contribute to its successful use? What about for the PDMS? NOTE: PDMS is used as biomedical implants, as heat transfer fluids, and as a component in personal care products such as body lotions.

X not graded

In general terms, we expect relatively greater loss modulus (more phase lag in sinusoidal shear) for things that lack great physical extent (entanglements).