Chapter 5

Experiments

- Materials
- Observations
- Practical problems

Materials

Shear characterisation $\mu(\dot{\gamma})$, $N(\dot{\gamma})$, $G(\omega)$
no help with extensional behaviour.

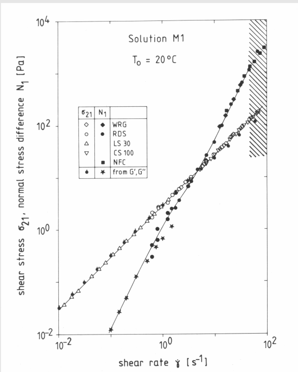
What is a complete rheological description? Use complex flows?

Must document many details of preparation, e.g. molecular weight distribution, for others to reproduce results.

Standard materials
i. IUPAC-LDPE – J.Meissner 1975 Pure & Applied Chemistry

Standard Materials – M1

ii. The M1 fluid T.Sridhar (1990) JNNFM 35
0.244% polyisobutylene ($M = 3.8\,10^6$) in polybutene + 7% kerosene
Cold solution easier to handle than hot melts



Steady shear

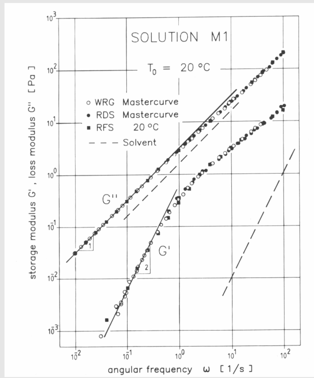
Laun & Hingham (1990) JNNFM 35

Boger fluid:
$\mu(\dot{\gamma}) \approx \text{const},$
$N_1 \propto \dot{\gamma}^2$

Standard Materials 2 – M1 continued

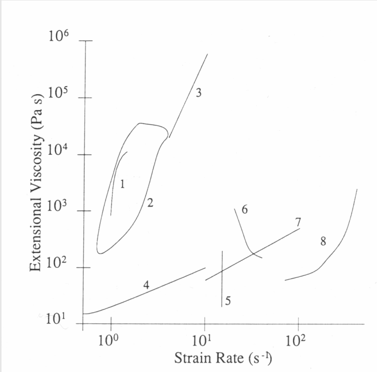
Oscillating shear

Laun & Hingham (1990) JNNFM 35



Standard Materials 3 – M1 continued

Extensional viscosity



M1 data collected by Keiller (1992) JNNFM 42

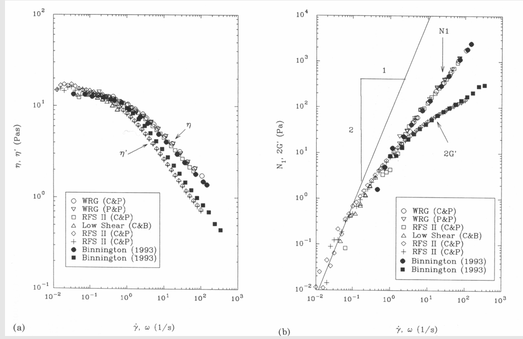
Confusion, but very large stresses

Standard Materials 4 – S1

iii. The S1 fluid N.Hudson (1994) JNNFM 52

5% polyisobutylene in decalin

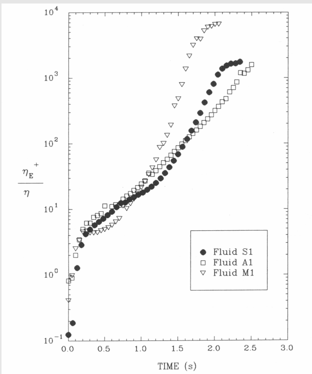
Shear Ooi & Sridhar (1994) JNNFM 52



Shear-thinning

Standard Materials 5 – S1 continued

Extension of S1, A1 & M1 Ooi & Sridhar (1994) JNNFM 52



as function of time

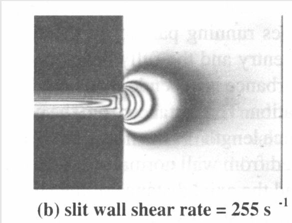
Observations

- Visualisation, LVA, PIV, volume flow, NMR
- Forces and couples
- Δp
  - but large entry loss
  - hole errors in pressure taps from N_1
- Birefringence: assume stress-optical law

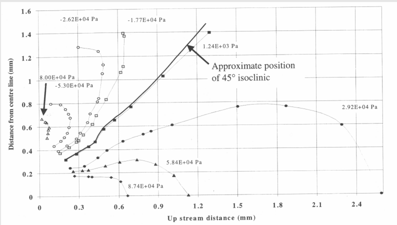
$$\sigma = C\Delta n$$

Birefringence

Observed birefringence   Martyn, Nakason & Coates (2000) JNNFM 91

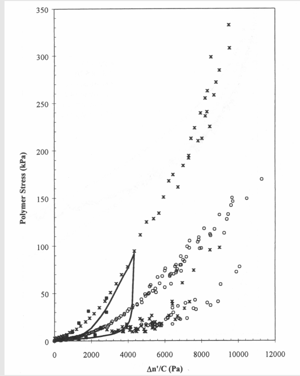


deduced stress contours



Birefringence 2

Start up of extensional flow at different strain-rates



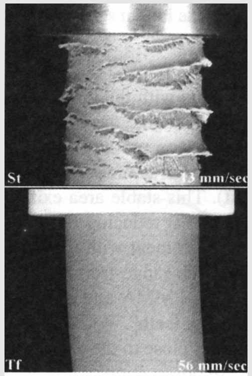
Sridhar (2000) JNNFM 90

Failure of stress-optical law

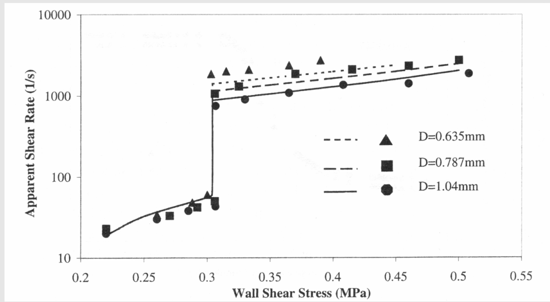
Practical problems

- Flow instabilities → apparent jumps in rheology
- Wall slip – pastes and polymer melts
- Shear-banding
- Viscous heating with $\mu(T, p, \dot{\gamma})$
- Phase separation/crystallisation
- Degradation – light, UV, bio, mechanical

Practical problems – wall slip

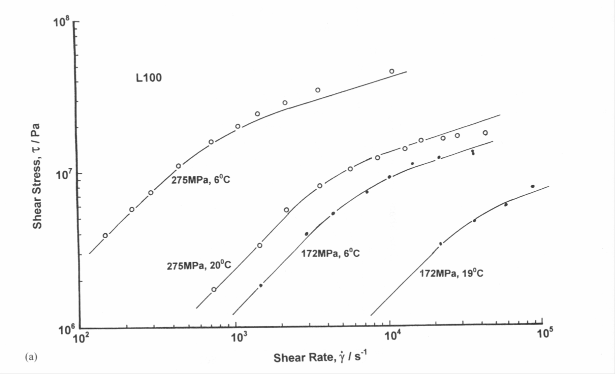


Kulikov (2001) JNNFM 98



Joshi (2000) JNNFM 94

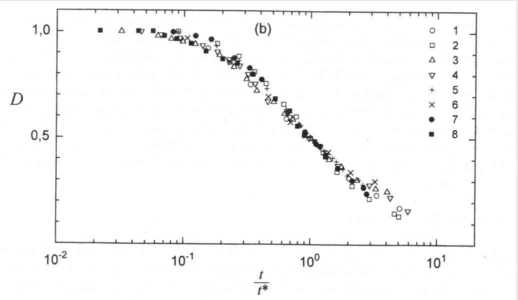
Practical problems – $\mu(T, p, \dot{\gamma})$



Blair (2001) JNNFM

Practical problems – mechanical degradation

Drag reduction decrease in time



Kalashnikov (2002) JNNFM 103

Theory: residence time in wall layer $t_*(Q, d, L, c, \mu_0)$.