

Problem 2.69

[Difficulty: 4]

2.69 An insulation company is examining a new material for extruding into cavities. The experimental data is given below for the speed U of the upper plate, which is separated from a fixed lower plate by a 1-mm-thick sample of the material, when a given shear stress is applied. Determine the type of material. If a replacement material with a minimum yield stress of 250 Pa is needed, what viscosity will the material need to have the same behavior as the current material at a shear stress of 450 Pa?

τ (Pa)	50	100	150	163	171	170	202	246	349	444
U (m/s)	0	0	0	0.005	0.01	0.025	0.05	0.1	0.2	0.3

Given: Data on insulation material
Find: Type of material; replacement material
Solution:

The velocity gradient is

$du/dy = U/\delta$ where $\delta = 0.001$ m

Data and
computations

τ (Pa)	U (m/s)	du/dy (s ⁻¹)
50	0.000	0
100	0.000	0
150	0.000	0
163	0.005	5
171	0.01	10
170	0.03	25
202	0.05	50
246	0.1	100
349	0.2	200
444	0.3	300

Hence we have a Bingham plastic, with $\tau_y = 154$ Pa
 $\mu_p = 0.963$ N·s/m²

At $\tau = 450$ Pa, based on the linear fit $du/dy = 307$ s⁻¹

For a fluid with $\tau_y = 250$ Pa

we can use the Bingham plastic formula to solve for μ_p given τ , τ_y and du/dy from above

$\mu_p = 0.652$ N·s/m²

