# *MTT 552: Polymer Characterization and Analysis (Rheological Tests)*

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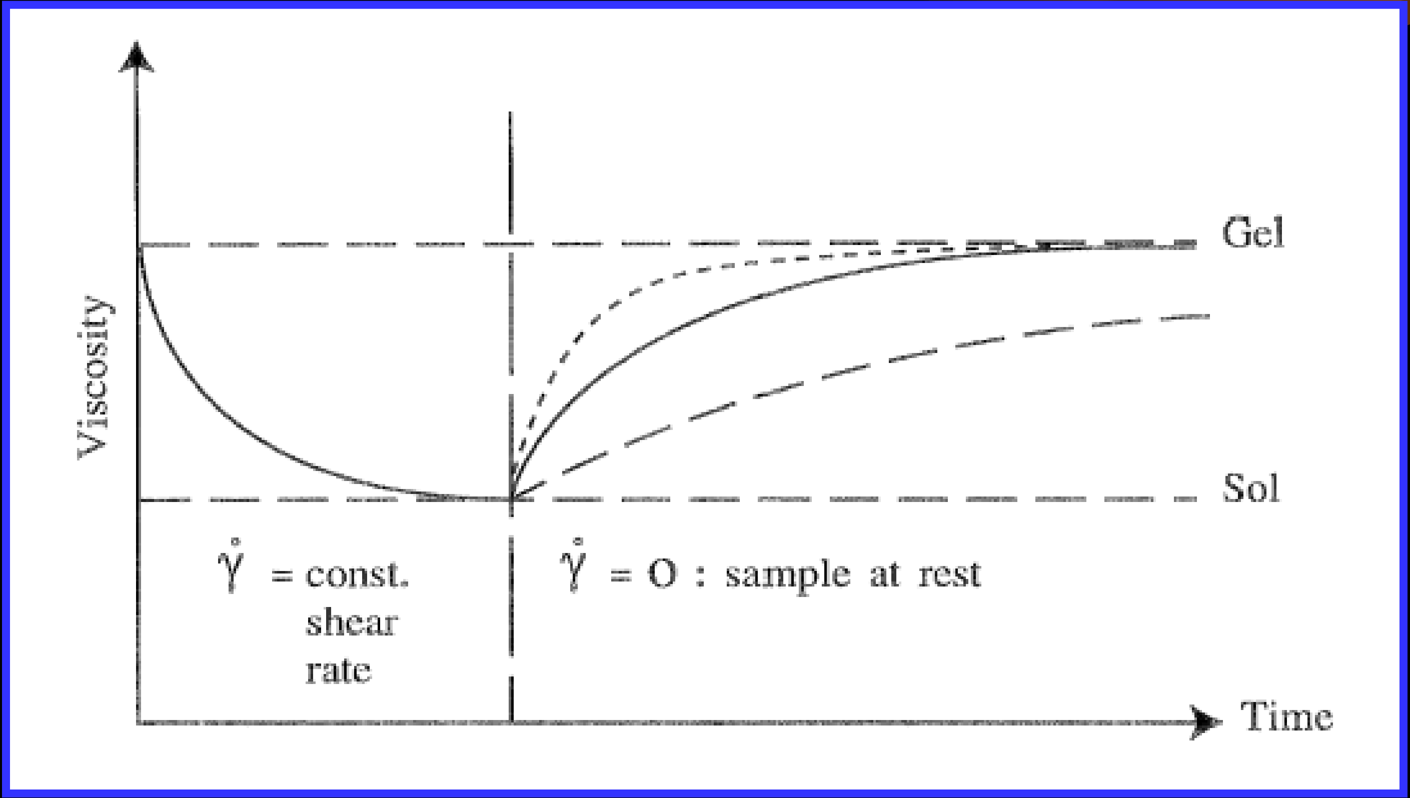
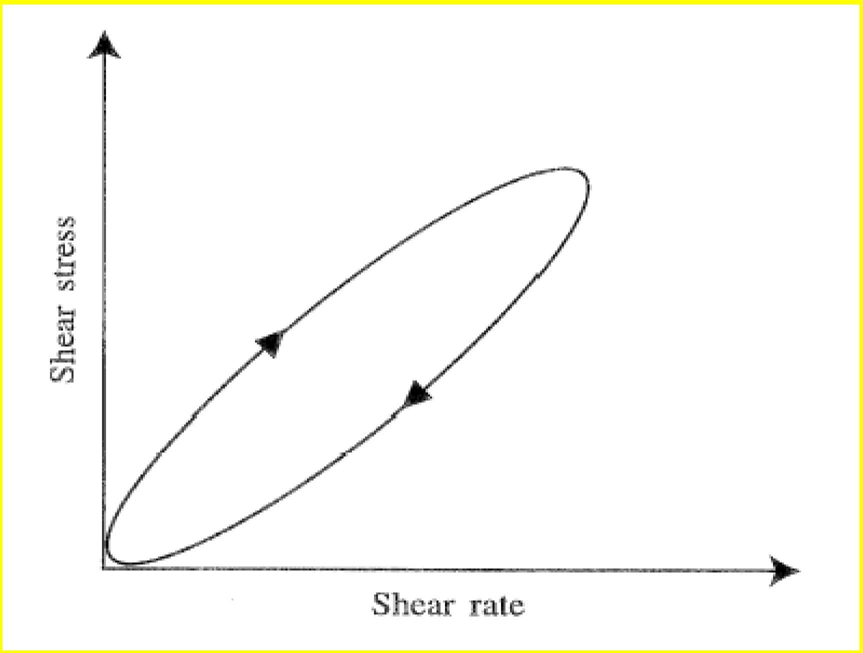
# Time dependent fluids

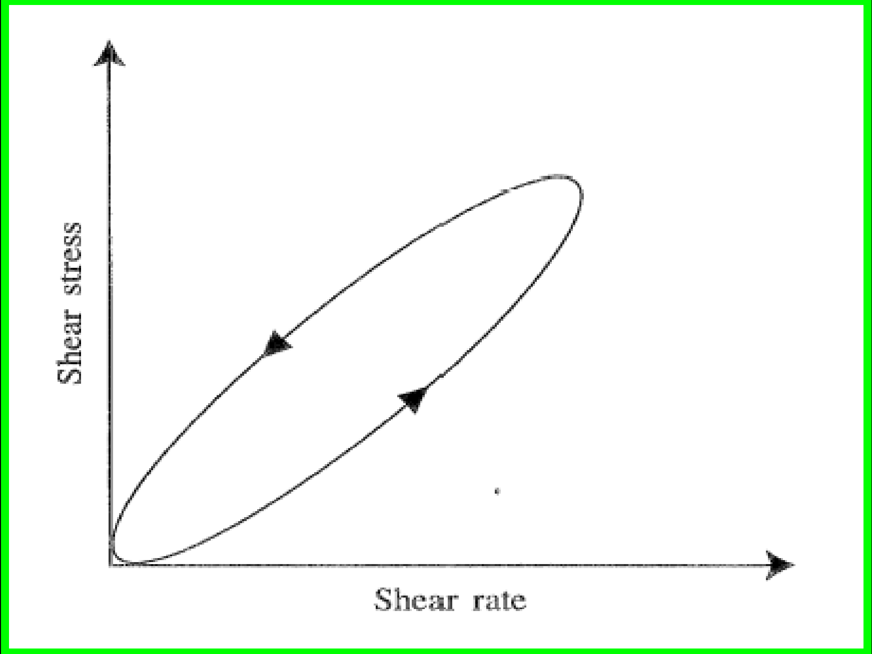
- Thixotropic fluids - Shear stress decreases with time for a given shear rate. (yogurt, salad dressing)
- Rheopectic fluids - Shear stress increases with time for a given shear rate. (suspended fluids, mud)

# Time and viscosity relationship for thixotropic fluids



# *Shear stress and shear rate for thixotropic*




# *Shear stress and shear rate for rheopectic*

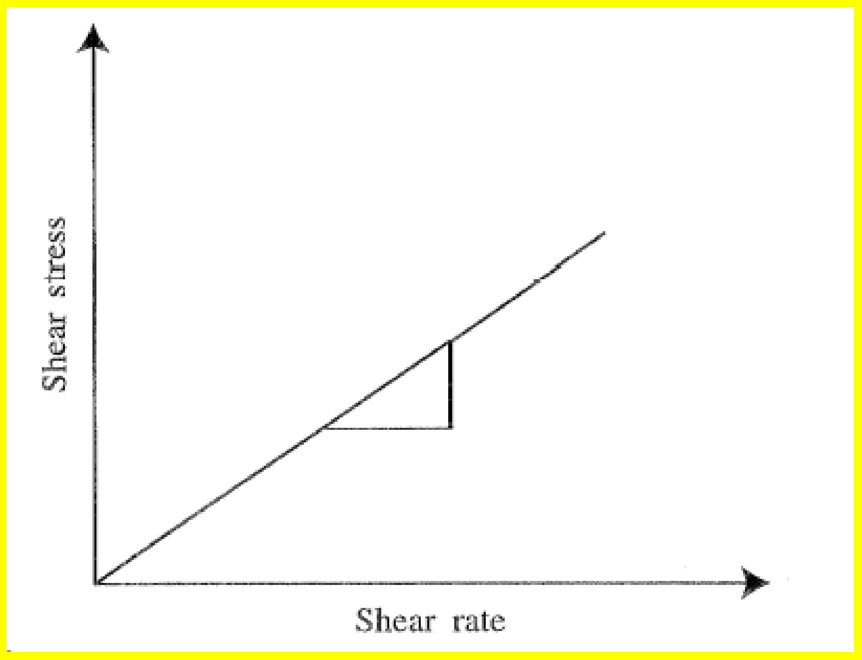
# Time independent fluids

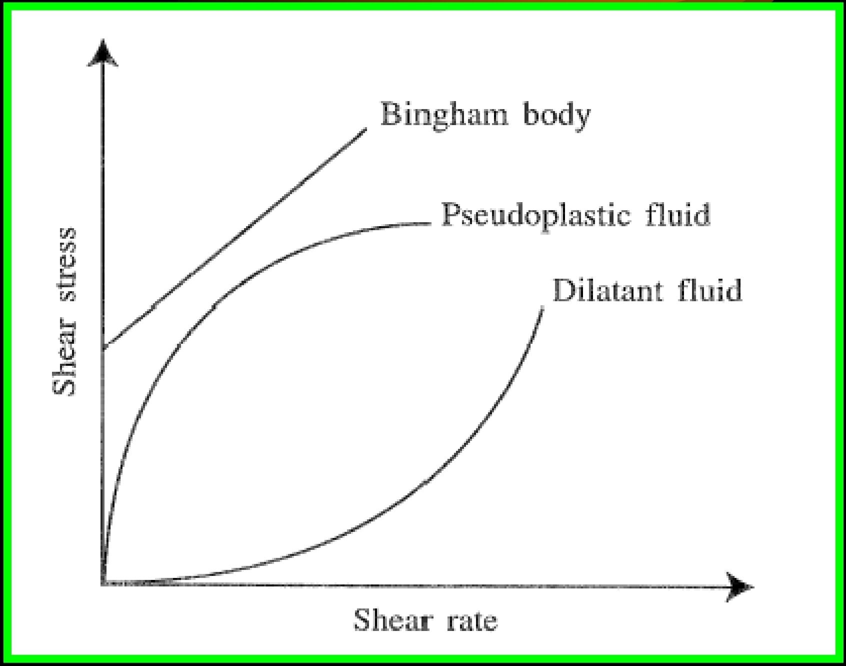
- Newtonian fluids: Viscosity is independent of shear rate. The ratio of shear stress and shear rate is constant.
- Non-Newtonian fluids: Viscosity is dependent on shear rate.

# Non-Newtonian fluids

- Pseudoplastics fluids (shear thinning fluids) such as polymer melts, rubber liquids, adhesives, biological fluids and grease.
- Dilatant fluids (shear thickening fluids) such as PVC pastes and flour in water.
- Bingham fluids such as paints, clays, pea slurry, magarine, soaps, paper pulp, sewage sludge.

## ความสัมพันธ์ระหว่างค่าความเค้นเฉือนและอัตราเค้นเฉือนของของไหลในกลุ่ม Newtonian




## ความสัมพันธ์ระหว่างค่าความเค้นเฉือนและอัตราเค้นเฉือนของของไหลในกลุ่ม non-Newtonian

## Power law index and Power law consistency

$$\tau = K\gamma^{n}$$

$$\log \tau = \log K + n \log \gamma$$

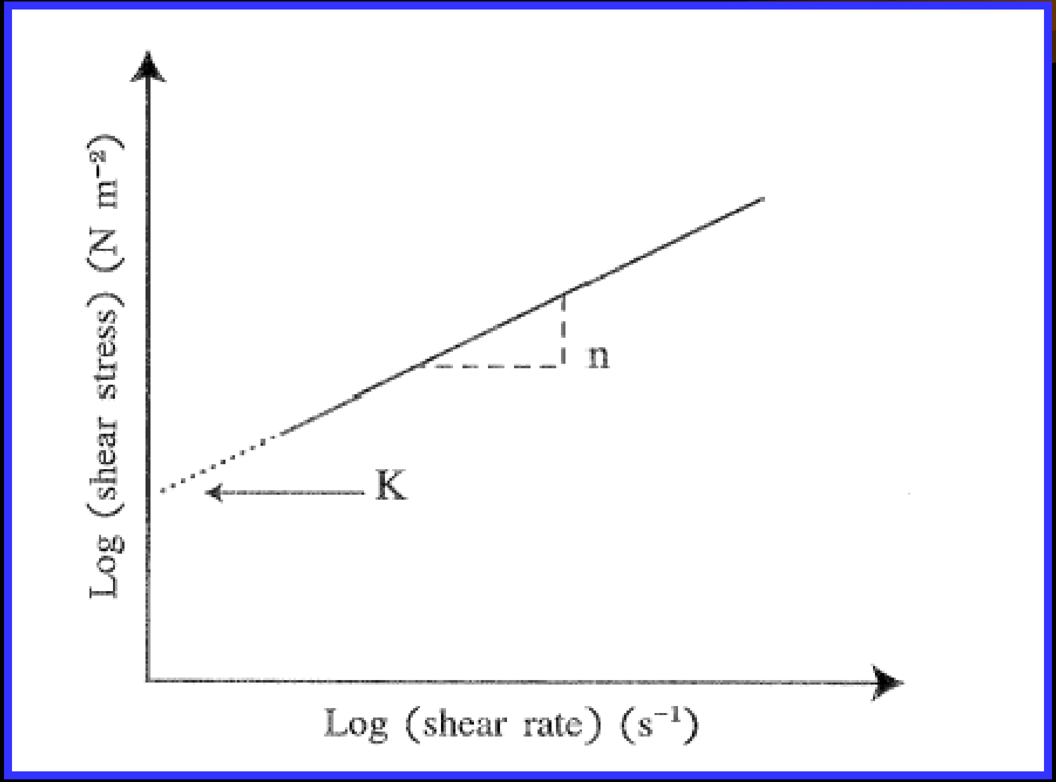
The n value indicates the type of fluids as follows:

Newtonian fluids n = 1

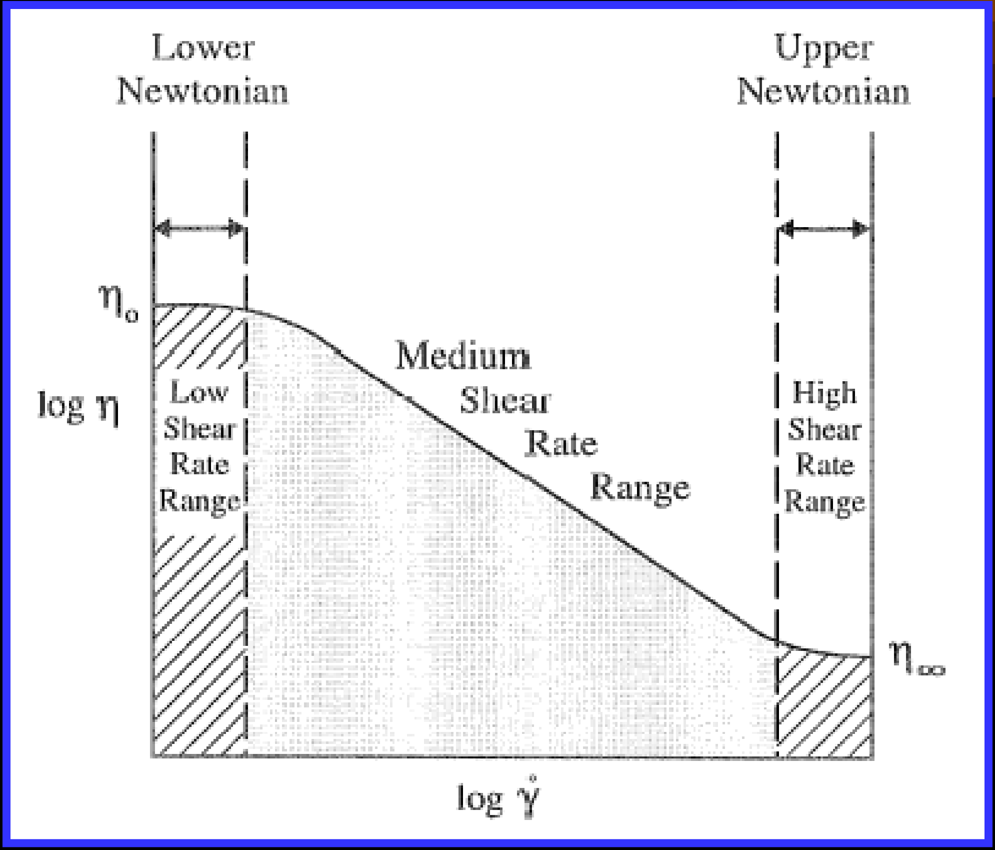
Non-Newtonian fluids $n \neq 1$

- Pseudoplastic fluids: n < 1
- Dilatant fluids: n > 1

# ความสัมพันธ์ระหว่าง Log (shear stress) กับ Log (shear rate)



# ความสัมพันธ์ระหว่าง shear viscosity กับ shear rate



# Examples of materials viscosities ($Nsm^{-2}$)

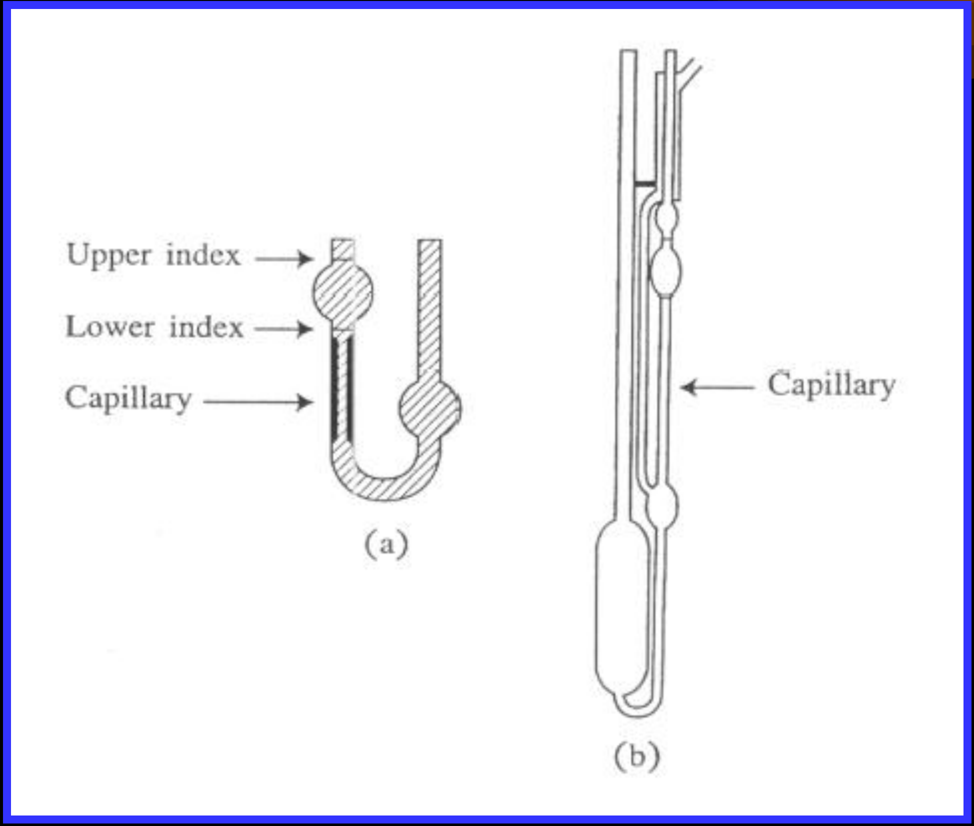
- 10 poise = 1 $Nsm^{-2}$

- Air (gaseous) = $10^{-5}$ (0.01 poise)
- Water = $10^{-3}$ (10 poise)
- Oil = $10^{-1}$
- Glycerine = 1
- Syrup = $10^{2}$
- Polymer melts = $10^{2}$ - $10^{6}$
- Glass = $10^{21}$

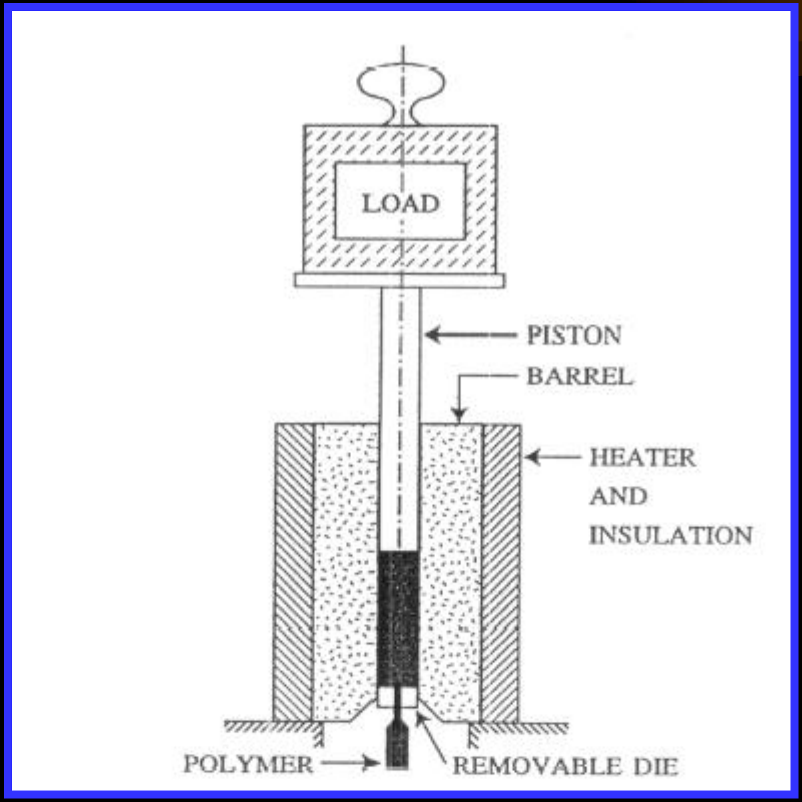
# Measurement of Rheological Properties

- Ostwald Glass Viscometer
- Melt Flow Rate (MFR)
- Falling Ball Viscometer
- Rolling Ball
- Capillary Rheometer

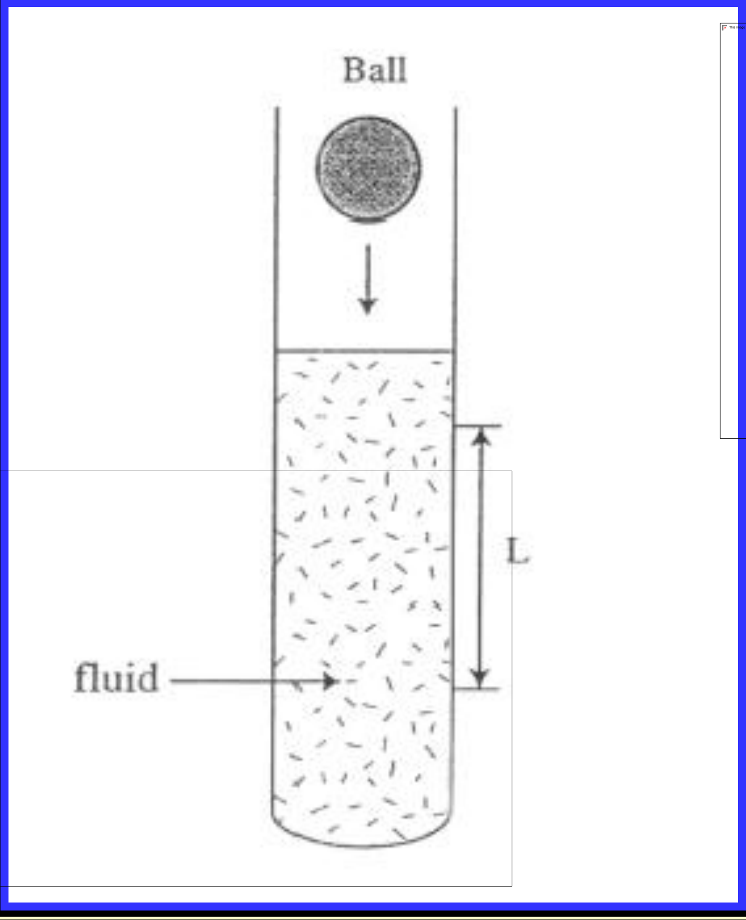
# Ostwald Glass Viscometer



# Melt Flow Rate (MFR)

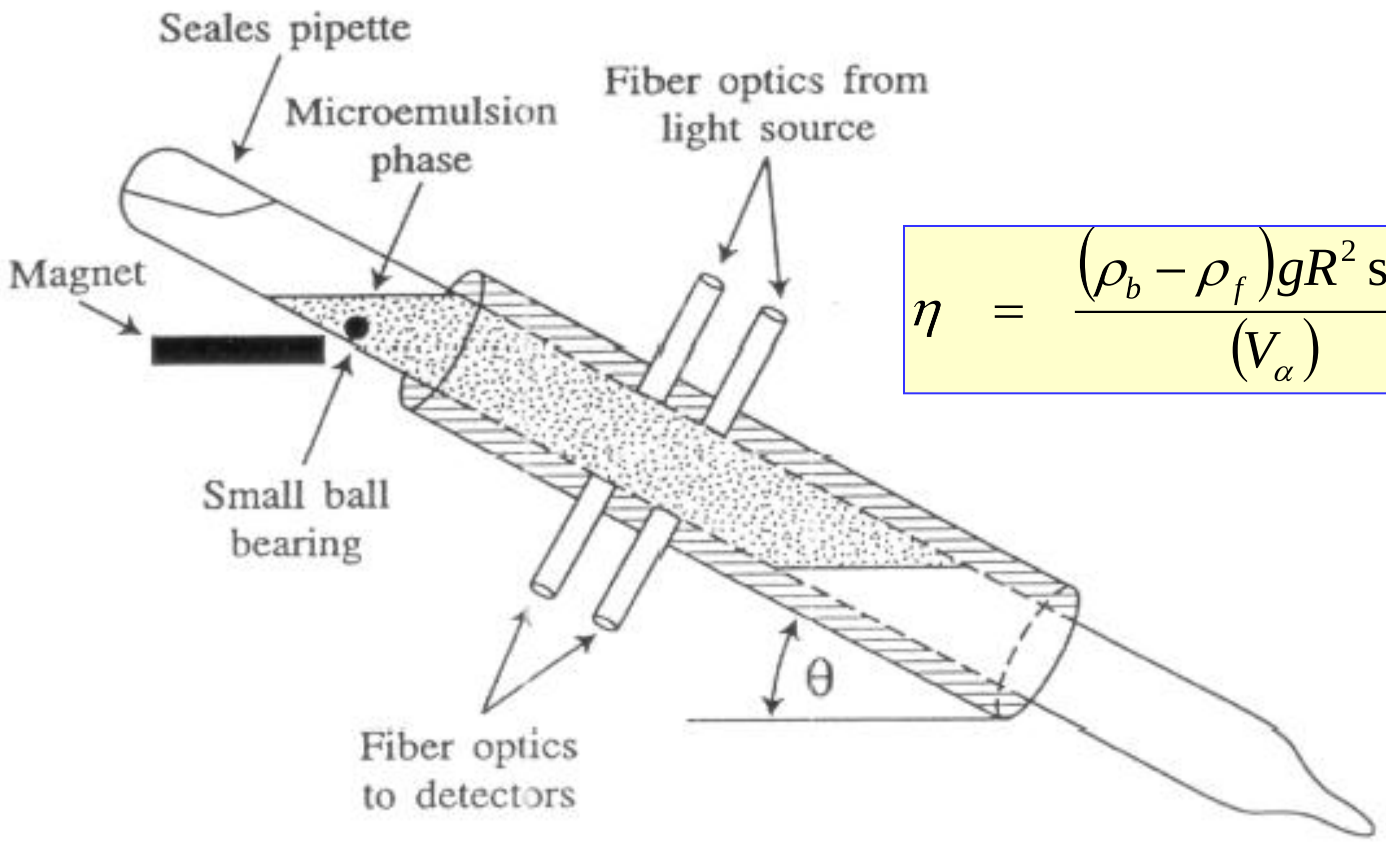


# Falling Ball Viscometer



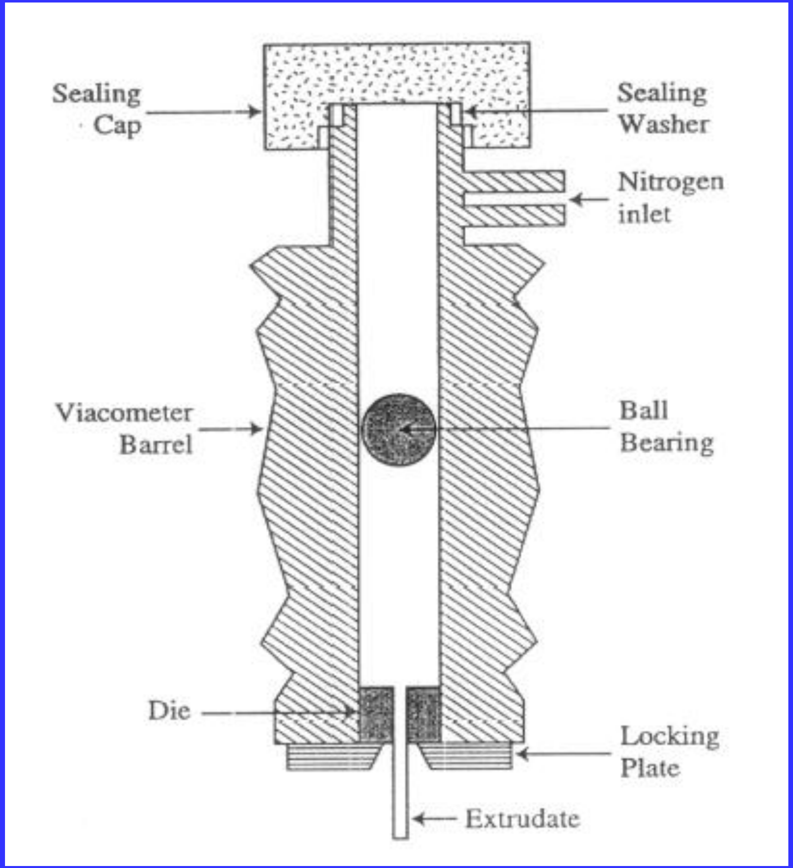

$$\eta = \frac{2(\rho_b - \rho_f)gR^2}{9\left(L/t\right)}$$

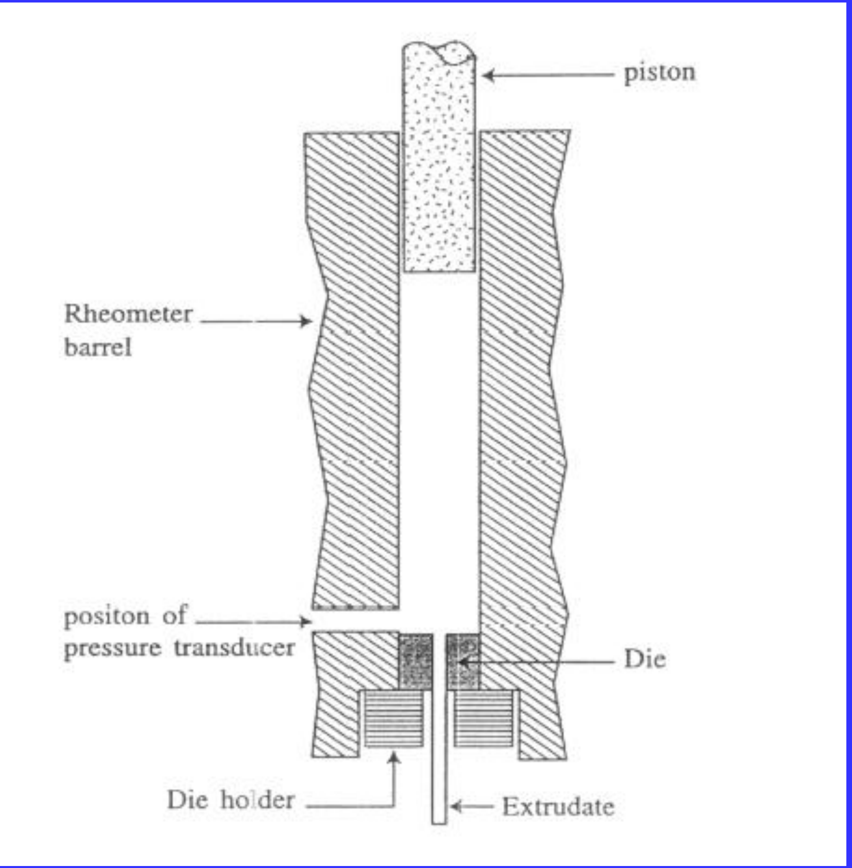
# Rolling Ball




$$\eta = \frac{(\rho_b - \rho_f)gR^2 \sin\theta}{(V_\alpha)}$$

# Capillary Rheometer



## Summary of wall shear stress and wall shear rate

For circular die

$$\tau_w = \frac{RP}{2L}$$

$$\gamma_w = \frac{4Q}{\pi R^3} \quad \text{and} \quad \gamma_w = \left(\frac{3n+1}{4n}\right)\frac{4Q}{\pi R^3}$$

For slit die

$$\tau_w = \frac{HP}{2L}$$

$$\gamma_w = \frac{6Q}{WH^2} \quad \text{and} \quad \gamma_w = \left(\frac{2n+1}{3n}\right)\frac{6Q}{WH^2}$$

where H and W are the die height (m) and the die width (m) respectively.