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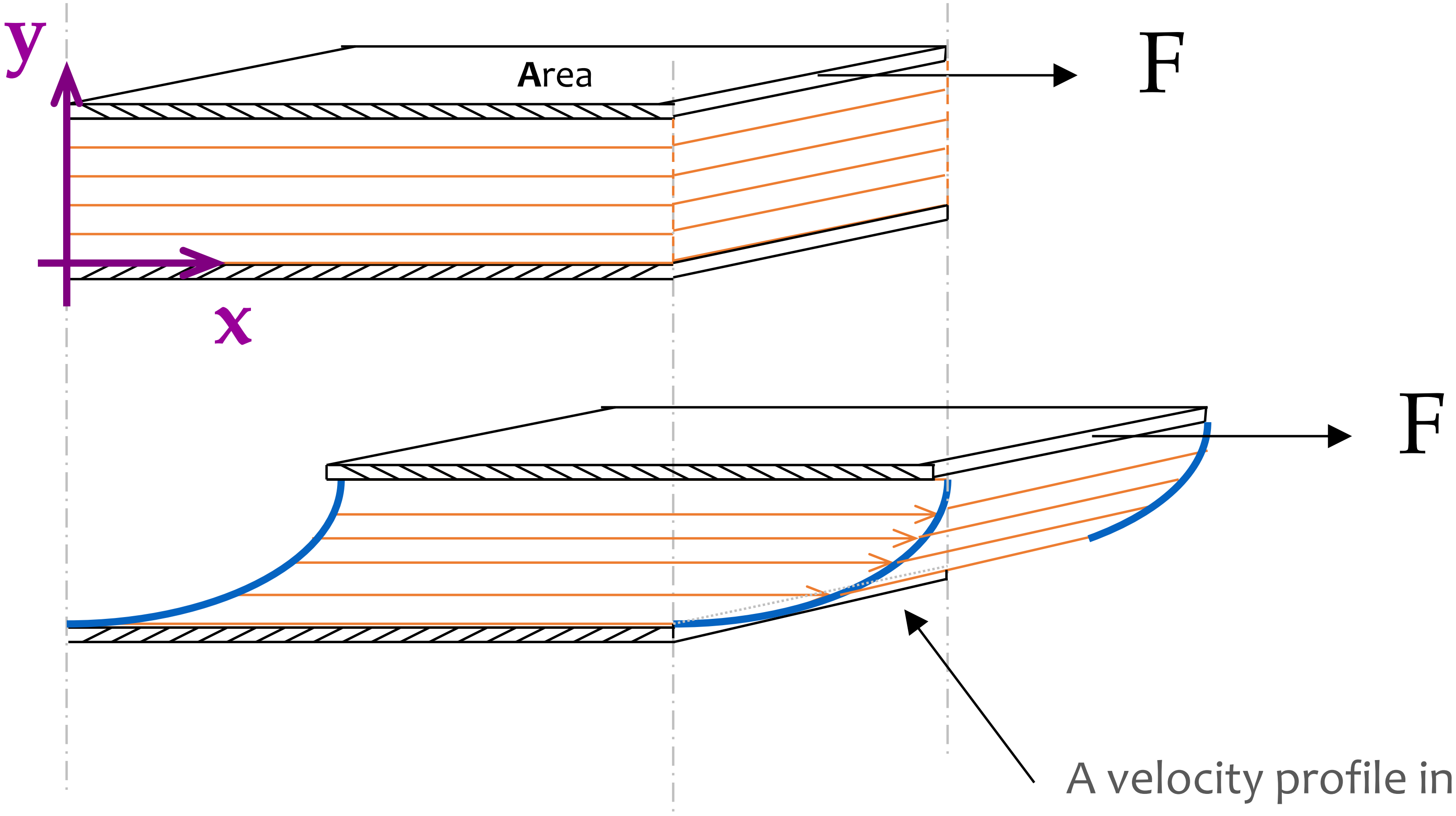
Shear Viscosity

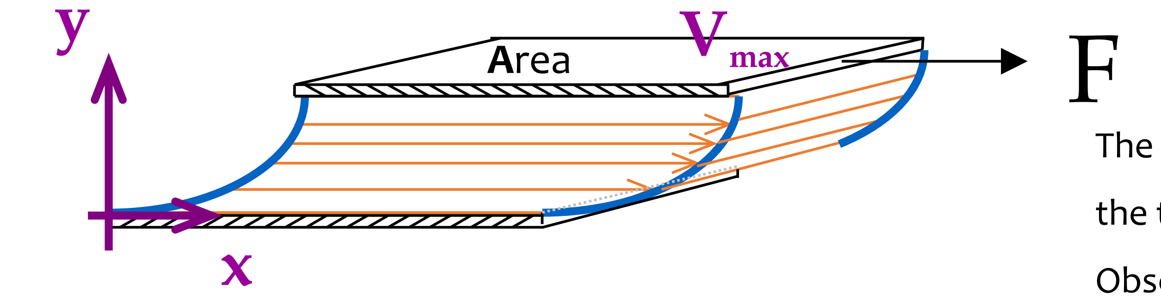
The shear phenomenon

Pictorial model: A set of parallel sheets, an imposed Force, an Area, a Velocity, a "new" concept.



A velocity profile in the x direction is developed

The shear phenomenon



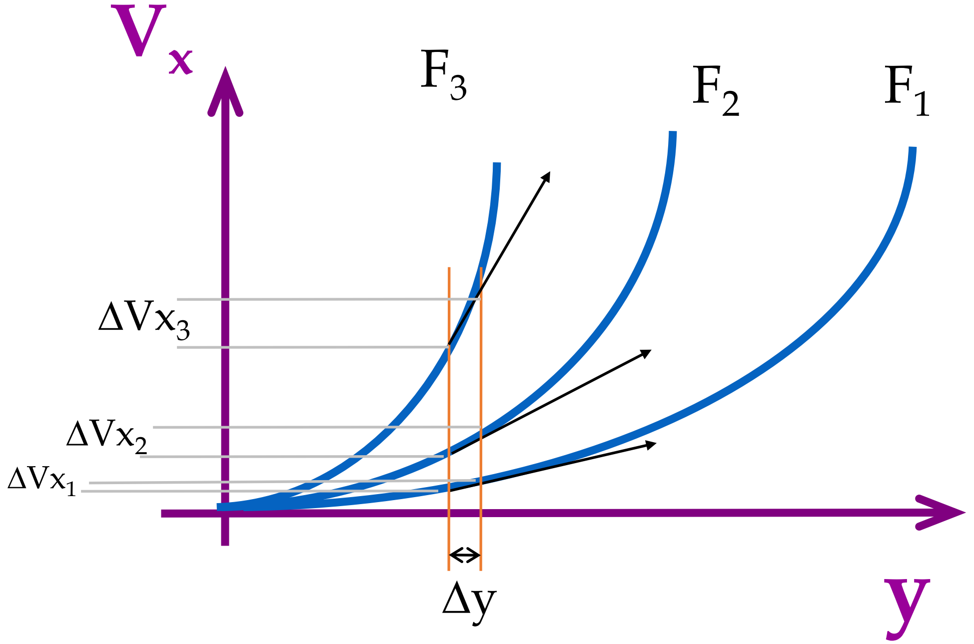


Figure 4. Velocity versus distance inthe direction of the transfer of momentum

The shearing force (F) has to be exerted all the time to maintain de motion (V_{max})

Observations:

1) The bigger the area the bigger the force:

$$F \ \alpha \ A \qquad (0)$$

2) The bigger the force:

   a) the bigger the final velocity in the upper sheet, and

   b) the greater the difference in velocity between two consecutive sheets that is:

$$\frac{\Delta V\mathbf{x}}{\Delta \mathbf{y}} \ \alpha \ F \qquad (1)$$

3) Combining 0 and 1:

$$F \ \alpha \ A \frac{\Delta V\mathbf{x}}{\Delta \mathbf{y}} \qquad (2)$$

$$\frac{F}{A} \ \alpha \ \frac{\Delta V\mathbf{x}}{\Delta \mathbf{y}} \qquad (3)$$

If we take ΔVx and Δy to be very small then we have the derivative of Vx with respect to y: , which is the slope given in Figure 4.

Well… this derivative is what is known as the

and it means how fast the velocity changes due to the shearing force imposed to the system. Or how fast a material can be sheared.

The shear rate is typically represented by the symbol:

On the other hand, the left side of equation 3 is equal to

$$\frac{F}{A}$$

Notice that the Force is parallel to the Area

Well… this relation is what is known as the

The shear stress is typically represented by the symbol:

Therefore equation (3):

Can be expressed as:

A proportionality constant can be included to get:

Where constant h is the viscosity and is equal to η_o in the *Newtonian region*

How is the equation for the non-Newtonian region

The proportionality constant has to change since η is shear dependent (remember the "typical viscosity curve" ?) :

$$\eta = f(\dot{\gamma})$$

There are many functions to show such dependency

Empirical functions (fitting) for the viscosity data

$\eta = K \gamma^{n-1}$	Power Law,
$\eta = \eta_o \; [(1 + \lvert \lambda_c \gamma \rvert^{m})]^{-1}$	Cross Model,
$\eta = \eta_o \; [(1 + \lvert \lambda \gamma \rvert^{2})]^{-p}$	Carreau Model,
$\eta = \eta_o \; [(1 + \lvert \lambda \gamma \rvert a)]^{(n-1)/a}$	Yasuda Model,
$\eta = \eta_o \; [(1 + 0.6 (\lambda \gamma)^{0.75})]^{-1}$	Bueche-Harding Model,
$\eta = \eta_o \; [(1 + \lvert \sigma / \sigma_{1/2} \rvert^{\alpha -1})]^{-1}$	Ellis model

where $\sigma_{1/2}$ is the stress at which $\eta = \eta_o /2$.

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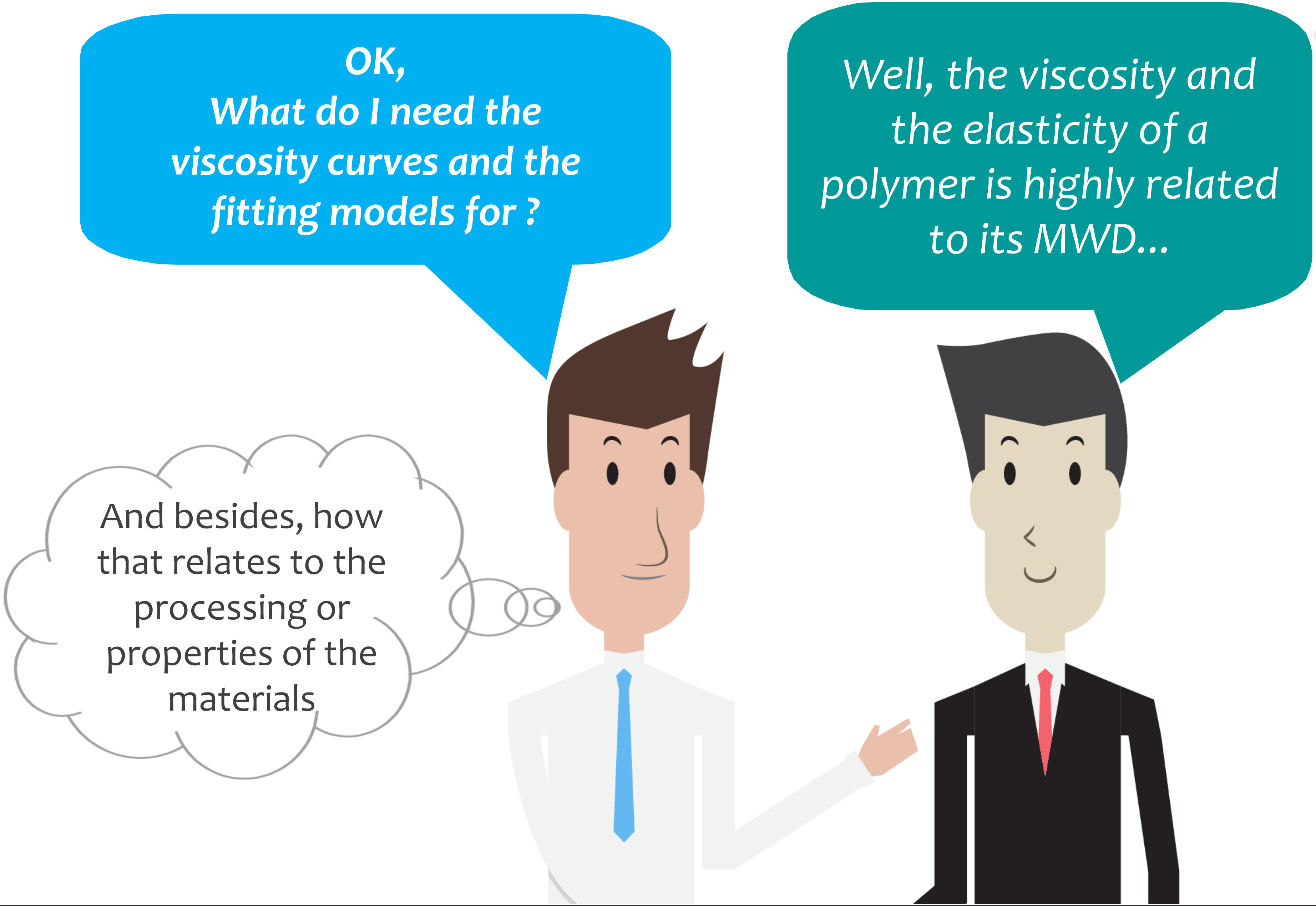
Homework

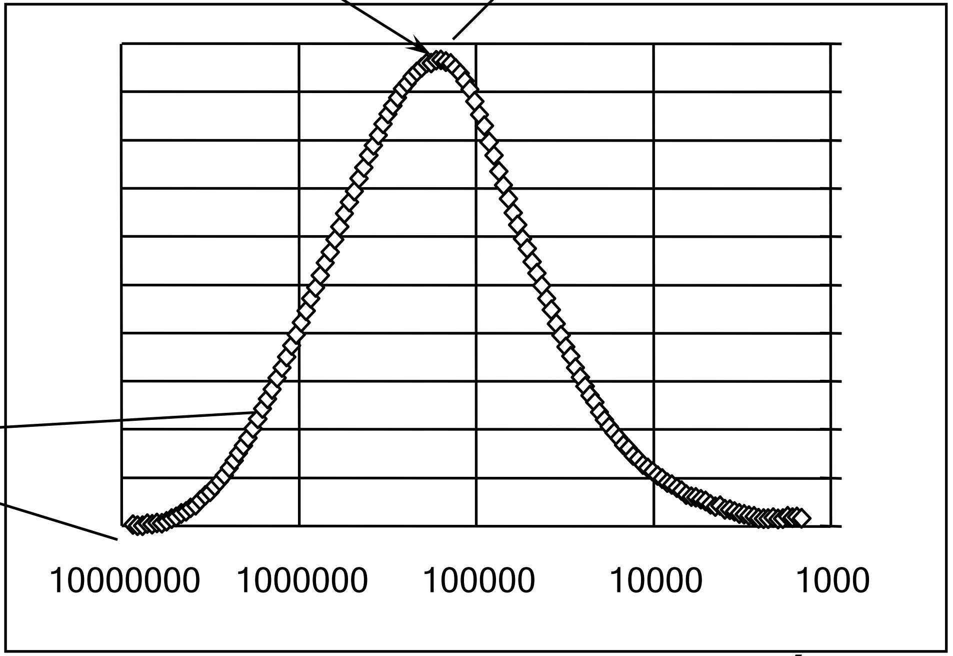
(Fitting two similar resins with the Cross Model)


OK,
What do I need the viscosity curves and the fitting models for ?
Well, the viscosity and the elasticity of a polymer is highly related to its MWD...
And besides, how that relates to the processing or properties of the materials

Creep:
short time response
Oscillatory Data
Gx
First normal stress
Zero die length
Steady shear viscosity

Average molecular weight: Mw

Viscosity at low shear rate (zero shear viscosity): η_o

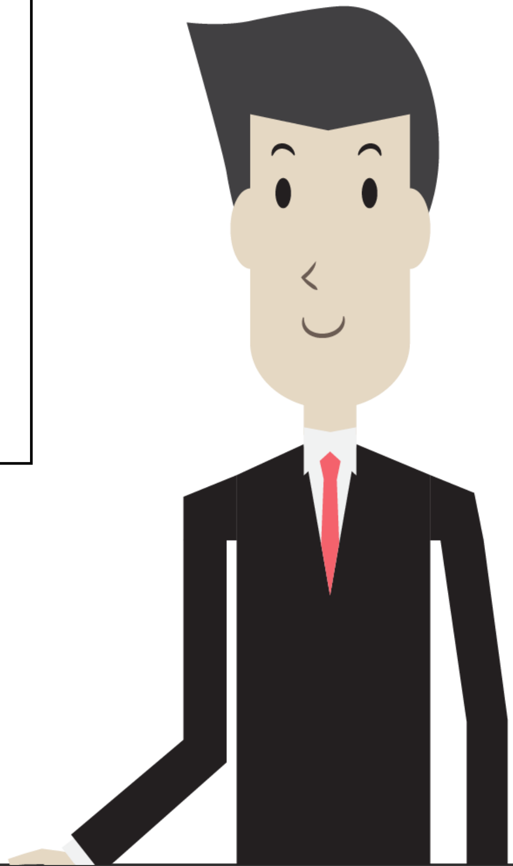


Distribution breath

Mz
Related to the content of high molecular weight chains

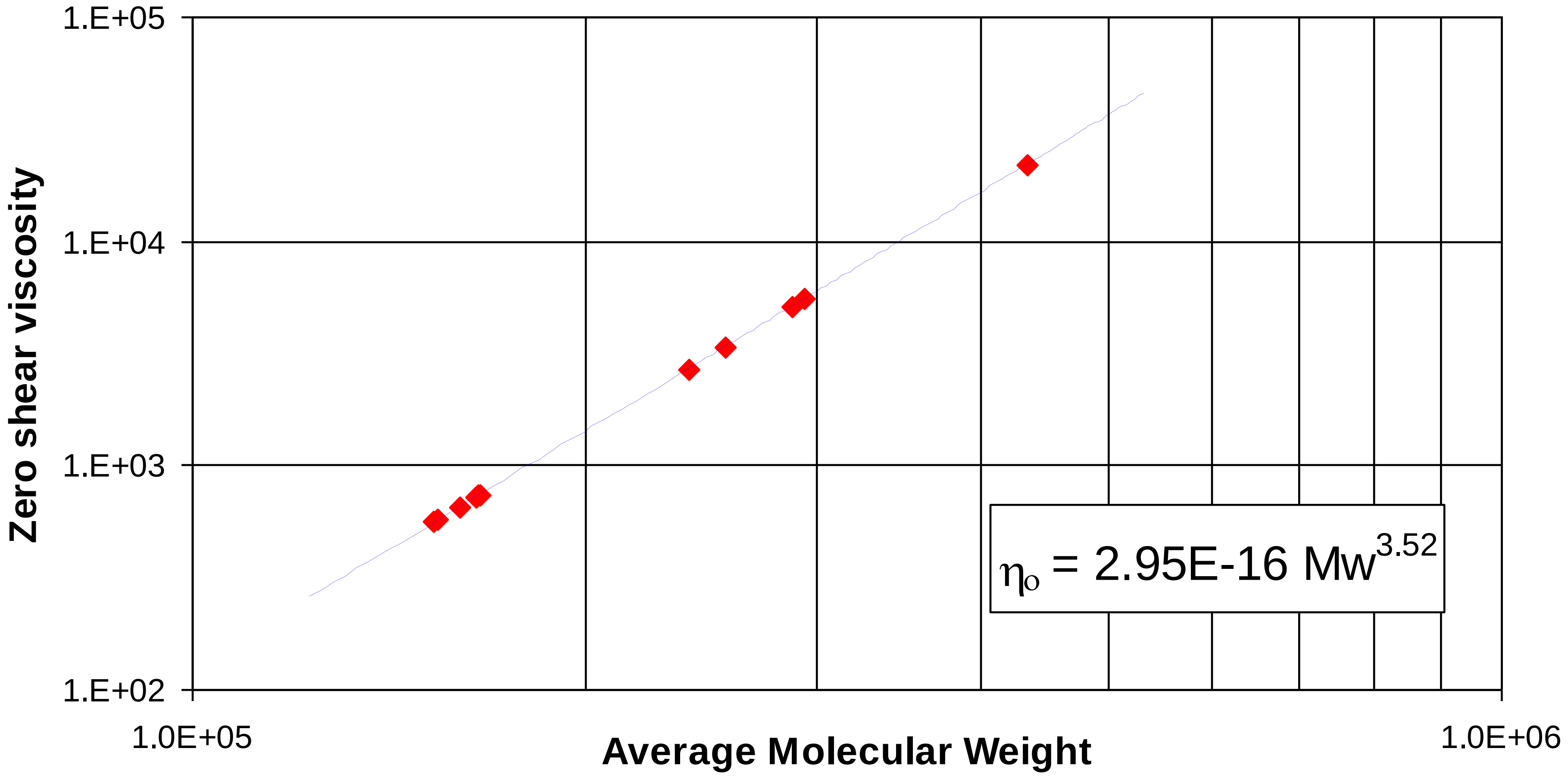
Mw/Mn

Slope of the viscosity curve, MFI

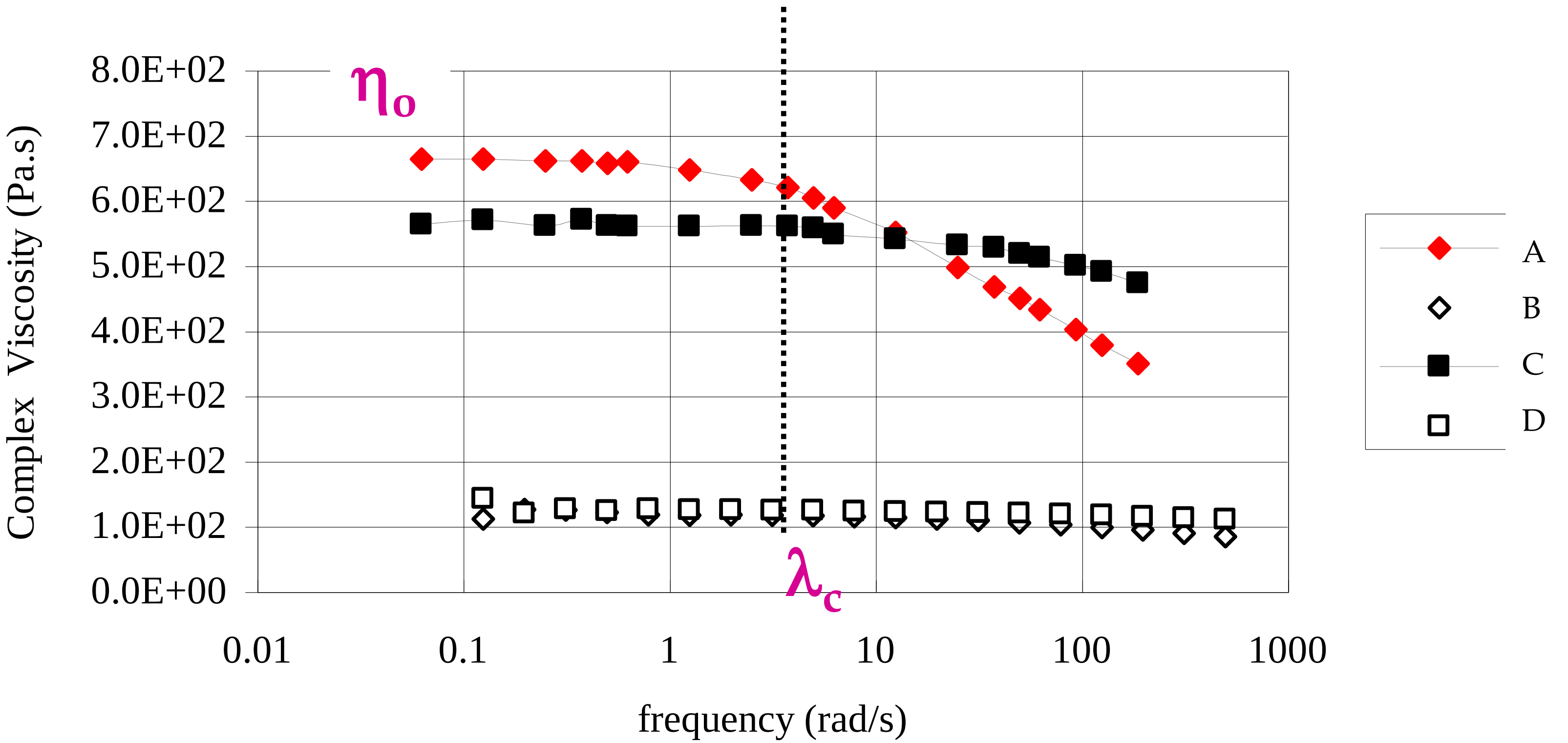


Relation between η_O and Mw

(Polypropylene resins)

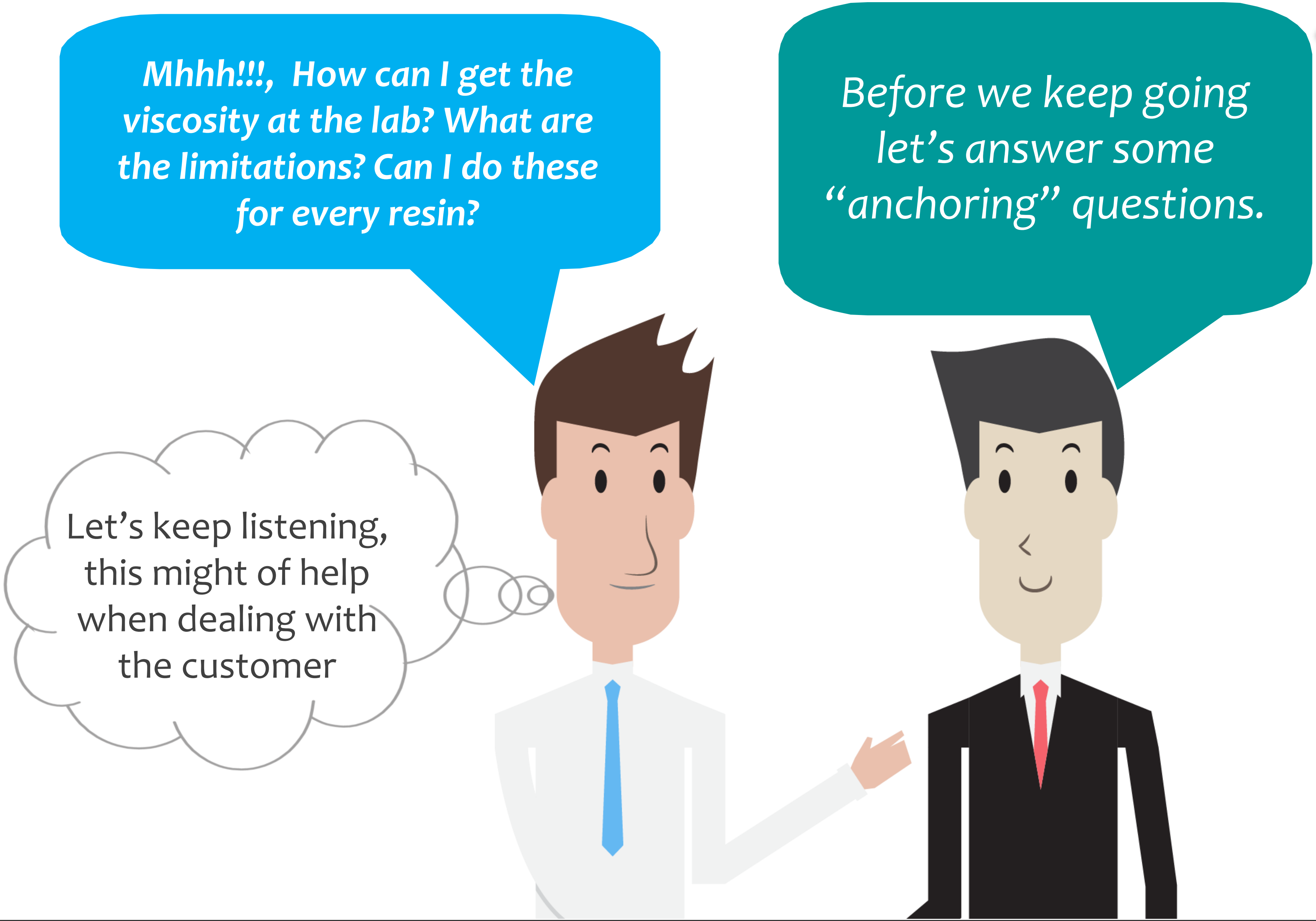


Viscosity data and GPC data (Asphalts)



Sample	Mn	Mw	Mz	PDI
A	80	2270	26800	28.4
B	130	840	14400	6.5
C	80	1630	21200	20.4
D	140	540	8450	3.9

GPC data from (Viscotek)


Mhhh!!!, How can I get the viscosity at the lab? What are the limitations? Can I do these for every resin?
Before we keep going let's answer some "anchoring" questions.
Let's keep listening, this might of help when dealing with the customer

Dr. Jaime Bonilla Ríos

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