CM3215

Fundamentals of Chemical Engineering Laboratory

RTD Dynamics

Also, *Identifying Empirical Models for Laboratory Data*

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Department of Chemical Engineering
Michigan Technological University

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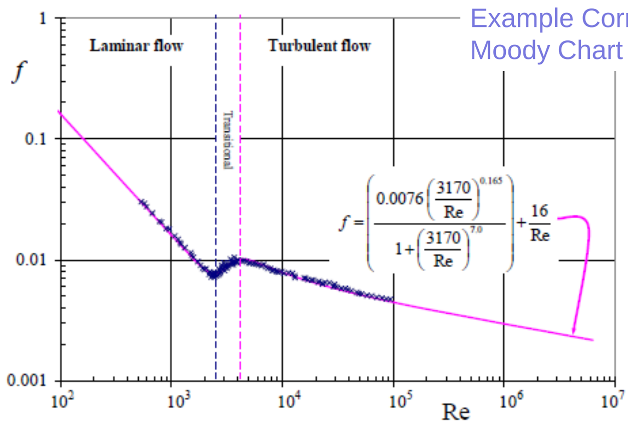
We often need to fit a model to data:

Example Correlation:
Moody Chart



Functions are easier to deal with than discrete data:
- Compact
- Smooth
- Easy to program

Faith Morrison, *An Introduction to Fluid Mechanics*, Cambridge University Press, 2013

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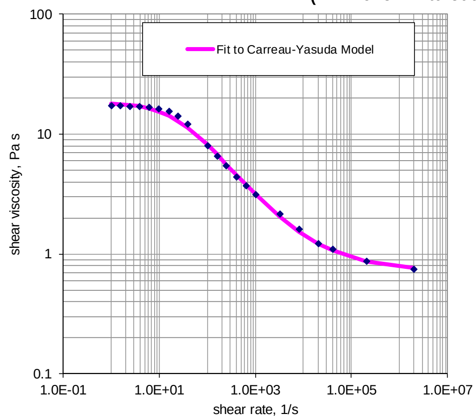
Carreau-Yasuda Model for Shear Viscosity of Polymer Solutions

$$\eta = \eta_\infty + (\eta_0 - \eta_\infty)\left[1 + (\dot{\gamma}\lambda)^a\right]^{\frac{n-1}{a}}$$

If we know the functional form, it's easy to find the parameters with ***Excel Solver***

(*www.chem.mtu.edu/~fmorriso/cm4650/Using_Solver_in_Excel.pdf*)



1. Plot data
2. Plot model
3. Construct error vector
4. Use Solver to minimize sum of error *(first guess must be reasonably close)*

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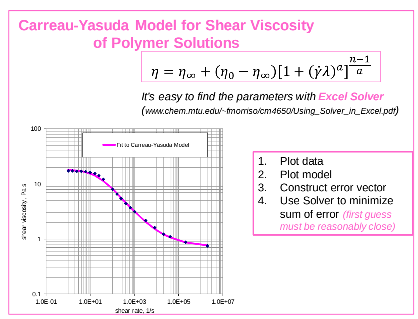

Let's try.

www.chem.mtu.edu/~fmorriso/cm3215/fittingCarreau2010blank.xlsx

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Fitting data to a model with Excel

- Need a model (an equation) whose shape mimics the data (see Table 2 for some ideas).
  www.chem.mtu.edu/~fmorriso/cm3215/AnalyticalFunctionsTable2.pdf
- Play with the model's parameters to see what they do to the shape of the model.
- *Solver* can determine the parameters; the first guess of parameters must be reasonably close, however.

This Lab:

- Find a model and parameters that best represent two sets of time-dependent data

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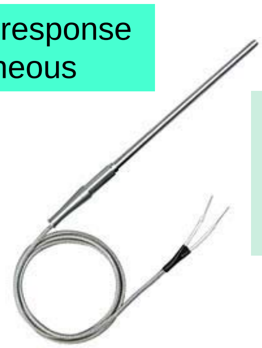
CM3215 Assignment 7: Resistance Temperature Detectors (RTDs)

Definition: devices that measure temperature based on the positive temperature coefficient of electrical resistance of metals. The hotter they become, the larger or higher the value of their electrical resistance.

www.temperatures.com/rtds.html

But: Temperature response is not instantaneous



"They are among the most precise temperature sensors available with resolution and measurement uncertainties or ±0.1 °C or better possible in special [situations]."

www.indiamart.com/thermechinstruments/products.html

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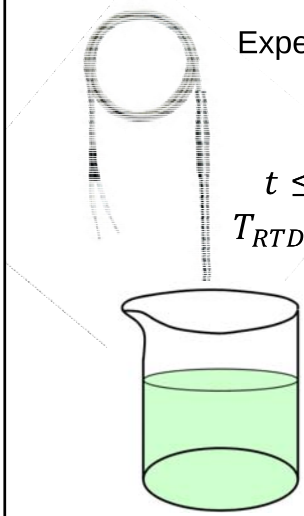
Experiment: Measure T(time)



$t \leq t_0$

$T_{RTD} = T_1$

Bath controlled to

$T = T_1$

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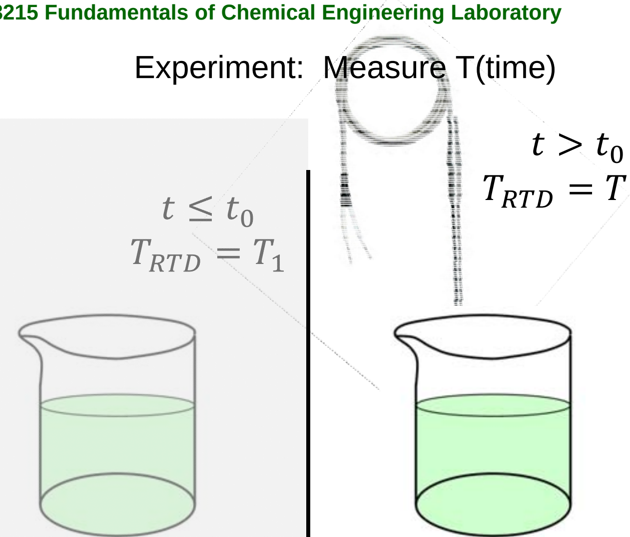
Experiment: Measure T(time)



$t \leq t_0$

$T_{RTD} = T_1$

Bath controlled to

$T = T_1$

$t > t_0$

$T_{RTD} = T(t)$

Bath controlled to

$T = T_2$

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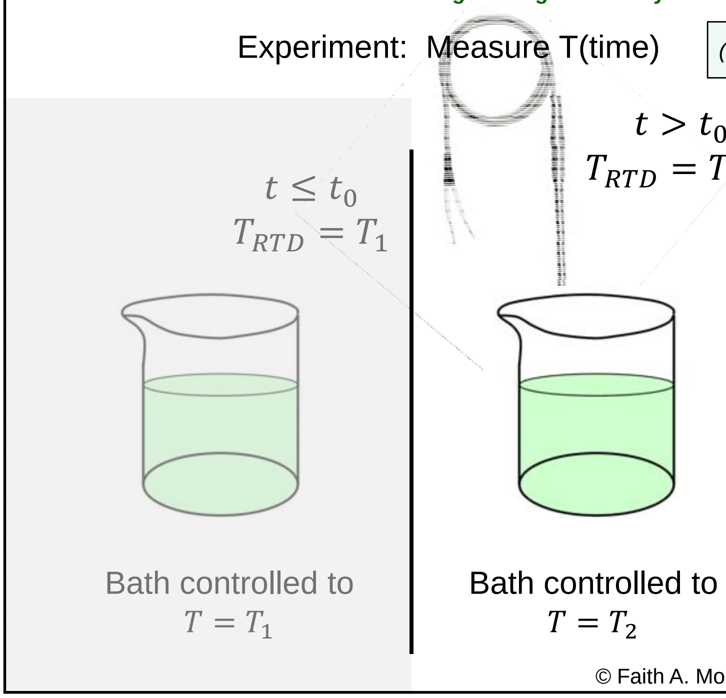
Experiment: Measure T(time)

(already done for you)



Excel:

t(s)	T(°C)
9.50E-02	7.46E+00
2.11E-01	7.44E+00
3.09E-01	7.44E+00
4.09E-01	7.57E+00
5.24E-01	7.46E+00
6.23E-01	7.49E+00
7.39E-01	7.53E+00
8.37E-01	7.46E+00
9.54E-01	7.59E+00
1.05E+00	7.53E+00
1.15E+00	7.58E+00
1.27E+00	7.48E+00
1.37E+00	7.57E+00
…	…

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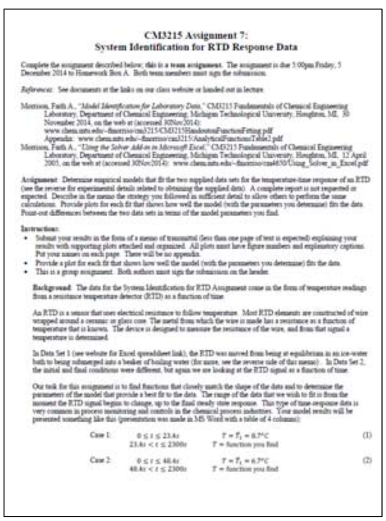
Assignment 7: RTD Dynamics – Choosing Empirical Models for Representing Lab Data



CM3215 Assignment 7:
System Identification for RTD Response Data

Measure RTD Time Dependence

Pre-laboratory Assignment

Introduction

Data Collection Procedure

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Assignment 7: RTD Dynamics – Choosing Empirical Models for Representing Lab Data

- Team assignment—both must sign the submission.
- Obtain data from Dr. Morrison
- Fit an appropriate model to the $T(t)$ data; for models, see:

www.chem.mtu.edu/~fmorriso/cm3215/CM3215HandoutonFunctionFitting.pdf

www.chem.mtu.edu/~fmorriso/cm3215/AnalyticalFunctionsTable2.pdf

- Report the parameters of the fit
- Show plots of "goodness of fit"
- As always, consider uncertainty and express uncertainty along with answers
- Write cover memo to transmit your plots and fit; address all objectives
- **Due 2:05pm Wednesday 6April2016, Homework Box A**