Research Experiences for Teachers

The Importance of Viscosity as it Relates to 2K (two part) Product Formulation.

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Overview

Liquid viscosities are needed by process engineers for quality control, while design engineers required the property to fix optimum conditions for the chemical process and operations as well as for the calculation of the power requirements for the unit operations such as mixing, pipeline design, etc.

Motivation

Gathering viscosity data on a material gives manufacturers the ability to predict how the material will behave in the real world. In an industrial set up, viscosities of fluid mixtures (meaning homogenous mixtures resulting out of mixing two or more fluids) are often needed for the design of the different unit operations and processes. Constraints on the availability of time, facilities and expertise, often force the designer to use an estimated value. The objective of this summer's RET is to take two product samples from the manufacturer, dilute with a small percentage of solvent or additive, and develop a method to measure each sample's viscosity to determine at what point the viscosity of both samples become equal. The viscosity was measured using a digital Brookfield DV-II + Pro Viscometer alongside a PC computer.

The Brookfield viscometer works by rotating a cylindrical spindle of known surface area in a fluid and finding the torque of the spindle. Torque is computed as the force acting on the outer surface of the spindle times the radius.

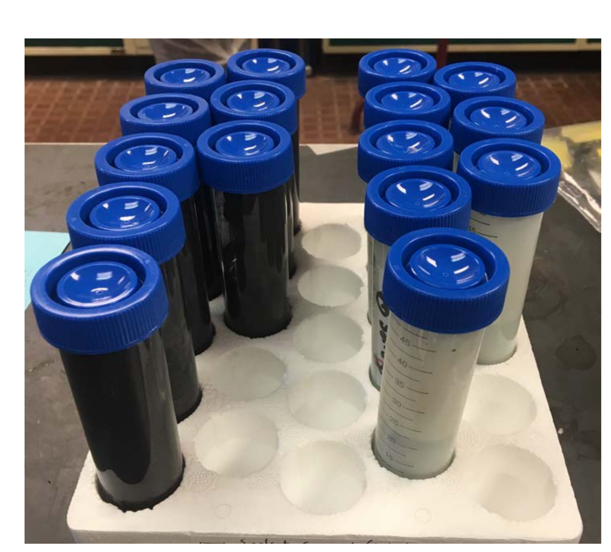
Figure 1: An image of the Brookfield DV-II+ Pro Viscometer .

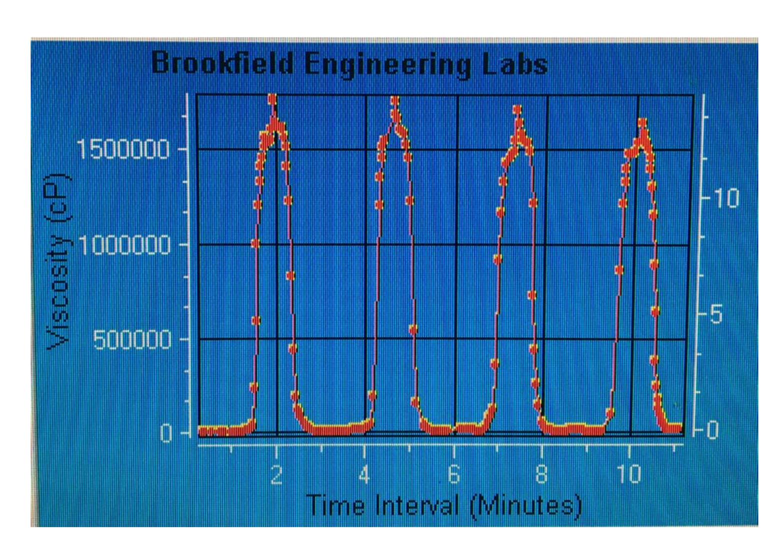
Methodology

Mixed up two separate samples (A and B) following the manufacturer's specifications. In sample A, a gradual increase of a designated solvent was added (by 1%, then 2%, then 3%, and finally by 4%). In sample B, a gradual increase of a designated additive was added (by 1%, then 2%, and finally by 2.9%). Using the viscometer and the appropriate spindle, data was collected to ascertain the viscosity of each sample.

Initially, The issue was to find the right spindle to measure the viscosity of both samples without digging a hole that did not collapse on itself (which rendered the data useless). The research process evaluated three different spindles. Spindle T-bar F96 gave the best results and was selected for the study. Data points from the graphs of each sample were then taken using the Rheocalc V3.3 software program.

Figure 2: An image of the three spindles used: RV7, LV64, and T-bar F96.





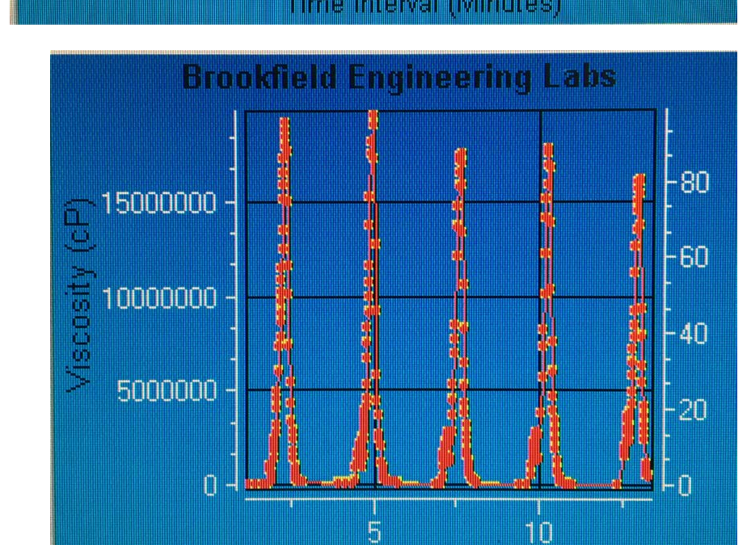


Figure 3, 4, 5 clockwise:: An image of the centrifuged samples, an image of the graph for sample A, and an image of the graph for sample B (x-axis: time interval in minutes, 2 y-axes: centipoise (cP) and torque (which had to be between 10 and 90 for a valid reading).

Results

The study found that sample B's density was significantly different than sample A's density due to the high metal content in sample B. This finding prevented the two graphs from ever intersecting. We extrapolated the intersection point using Excel spreadsheet software. The results showed a negative cP intersection which **in this dimension** is entirely impossible.

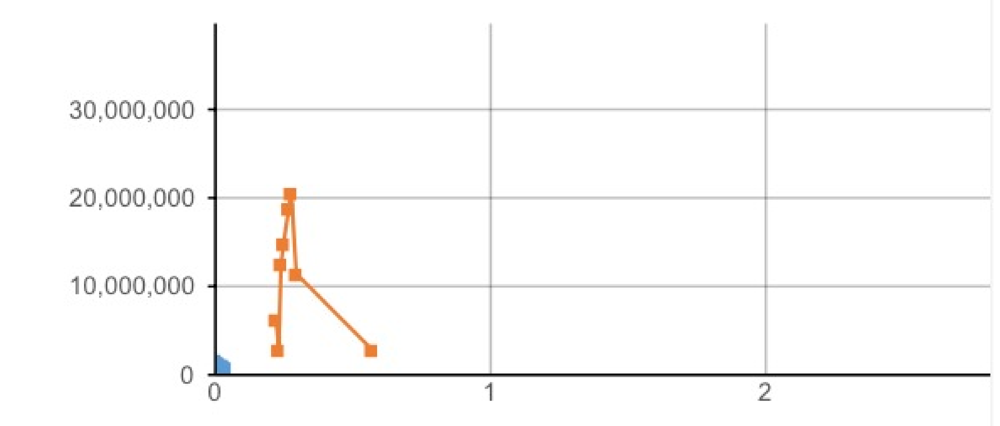


Figure 6: An image of the viscosity graph of sample A (cP vs solvent %).

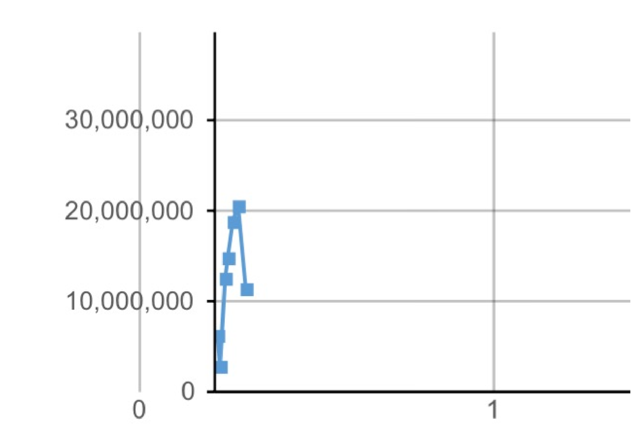


Figure 7: An image of the viscosity graph of sample A (cP vs additive %).

Conclusion

In conclusion, it was not practical to continue diluting sample B because 1)increasing the percentage of additives to dilute sample B would exceed the parameters set by the manufacturer and 2) because of the significant difference between the density of the sample A and sample B, the two graphs would never intersect.

The Boeing RET Sabbaticals for Urban Math and Science Teachers is funded by the Boeing Corporation.