CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY

Name(s)
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Project Number
J0120

Project Title
A Novel Approach in Determining the Temperature Dependence of Newtonian and Non-Newtonian Fluid Viscosities

Abstract

Objectives/Goals
Viscosity can be determined using the falling ball viscometer and Stokes' law. It is, however, limited to flows at Reynolds Numbers (Re) less than one. A method is needed to determine viscosity at any Re. This method can then be used to study the effect of temperature on the viscosity of a fluid. The objectives of this study are (1) to formulate a novel approach in determining the viscosity of a fluid, and (2) to determine the effect of temperature on the viscosity of representative Newtonian and non-Newtonian fluids. It is hypothesized that the viscosity of a fluid decreases as the temperature of the fluid increases.

Methods/Materials
Experiments were conducted to determine the viscosity of three Newtonian fluids (water, corn oil, and olive oil) and two non-Newtonian fluids (10W30 and 10W40 motor oils). The experiment with water was performed at room temperature to validate the procedure for determining viscosity. A ball made of Acetal Delrin was dropped into a graduated cylinder filled with the test fluid, and the transit time between two points on the cylinder was measured. Using a novel approach applicable to flow at any Re, I determined the viscosity of the test fluids from the test data. To determine the temperature dependence of viscosity, I curve fitted the data with an exponential function of temperature and obtained the correlation coefficients to assess the strength of the curve fits.

Results
The measured viscosity of water compares very well with the value published in the literature and provides a validation of my method. The results for corn oil, olive oil, 10W30 oil, and 10W40 oil show that the viscosity of a fluid decrases as the temperature of the fluid increases from 20 to 40 deg C. They also compare well with the published data, further validating my proposed approach. The correlation coefficients of the curve fits are very high, indicating a strong exponential relationship between viscosity and temperature.

Conclusions/Discussion
Using falling ball viscometry and a novel approach that applies the fundamental principles of fluid dynamics, I determined the viscosity of water at room temperature, and the viscosities of corn oil, olive oil, 10W30 oil, and 10W40 oil at various temperatures. The results show that the viscosity of a fluid decreases as its temperature increases, and therefore my hypothesis is correct. Besides proving my hypothesis, I formulated a novel approach whereby viscosity could be determined for all Re, thereby removing the limitations of Stokes' law.

Summary Statement
A new experimental and analytical method was developed to determine the viscosity of a fluid at any Reynolds number, and the method was used to assess the effect of temperature on viscosity.

Help Received
Mother helped format board; father explained fluid dynamic concepts.