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Kinematic Viscosity and Temperature Sensitivity of Refined Sunflower Oil: An Experimental Study and Mathematical Modelling Using Redwood Viscometer No. 1

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Abstract
In engineering systems, viscosity is a crucial rheological parameter that controls heat dissipation, hydrodynamic lubrication, and fluid motion. This study uses a conventional Redwood Viscometer No. 1 device to conduct a thorough experimental assessment of the thermal viscosity behavior of refined sunflower oil. Systematic measurements were made between 30°C and 70°C. Empirical calibration formulae were used to convert measured efflux times in Redwood Seconds (SR) to kinematic viscosity in Centistokes (cSt). To explain fluid behavior, a dual-axis temperature-viscosity relationship graph and a conventional experimental schematic are included. Because of thermal activation and decreased cohesive intermolecular interactions, the empirical results show an inverse exponential correlation between temperature and kinematic viscosity, offering useful baseline quantitative data for plant-based industrial lubricant compositions.

1. Overview

The internal resistance of a fluid to shear or tensile stress is known as fluid viscosity. For the purpose of developing lubrication systems, estimating energy dissipation in hydraulic equipment, and calculating friction losses in pipelines, exact knowledge of kinematic viscosity is crucial in mechanical and thermal engineering. Interest in vegetable-based biodegradable fluids as substitutes for petroleum-derived oils has increased due to growing environmental consciousness and more stringent sustainability laws. With a consistent fatty acid profile, refined sunflower oil has appealing non-toxic and renewable qualities. Its viscosity variation under thermal gradients must be precisely evaluated in order to show its technological viability in light-duty hydraulic and lubricating applications. For evaluating the efflux flow properties of light-to-medium oils, the Redwood Viscometer No. 1 is still a common industrial tool.

2. Experimental Equipment & Setup Schematic

The typical Redwood Viscometer No. 1 comprises of a central brass oil cup, an agate jet orifice, a surrounding heated water bath, and a volumetric collection flask. It functions on the basis of gravity-driven orifice flow.

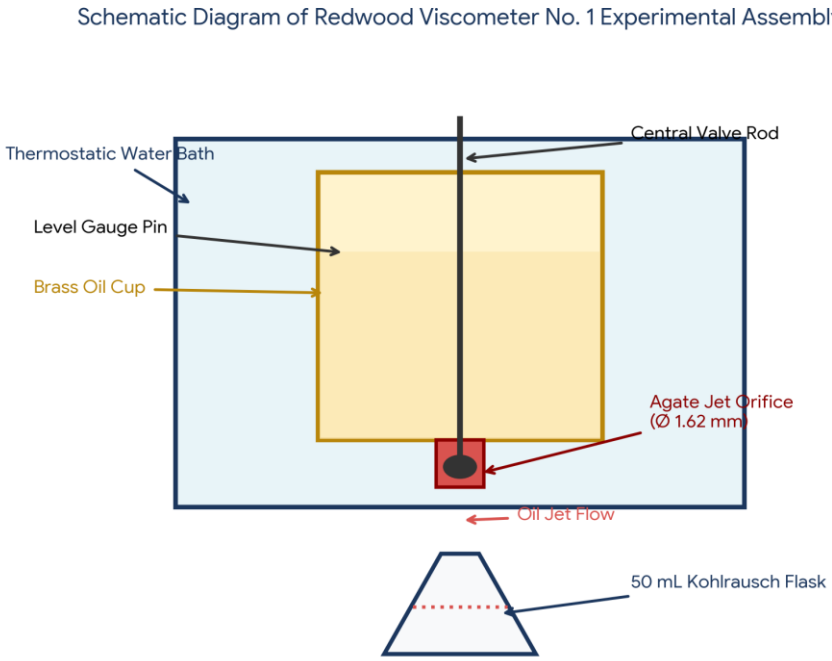


Figure 1: Schematic diagram of Redwood Viscometer No. 1 apparatus assembly.

2.1 Technical Details
IP 70 (Institute of Petroleum Standard Method) is the standard compliance.• Orifice Jet Dimensions: A precisely ground agate jet orifice measuring 10.00 mm in length and 1.62 mm in bore diameter.
• Volumetric Receiver: A Kohlrausch measuring flask that has been calibrated to precisely capture 50 mL at 20°C.
• Thermal Bath: A copper water bath equipped with an electric heating coil, a manual circular stirrer, and a thermometer with an accuracy of ±0.1°C.

3. Formulation of Mathematics

Using empirical orifice flow relations, the kinematic viscosity v (in centistokes, cSt or mm^2/s) is calculated from the efflux time t (in Redwood Seconds, SR):

$\Sigma = A - t - (B / t)$

where A and B stand for the Redwood Viscometer No. 1 standard calibration coefficients:
• A = 0.26 (cSt /s)
• B = 172 (cSt/s)
Kinetic energy head losses at the orifice entrance become insignificant for flow periods longer than 100 seconds (t > 100 s), reducing the relationship to:

$\Sigma \approx 0.247 \cdot t$

4. Method of Experimentation

1. Equipment Preparation: To remove impurities, the agate jet and central brass oil cup were extensively cleaned with petroleum ether solvent and allowed to air dry.
2. Leveling: A spirit level and leveling screws were used to set the viscometer base until the oil cup was exactly vertical.
3. Sample Loading: The oil cup was filled with refined sunflower oil until the liquid tip exactly matched the internal pointer pin.
4. Thermal Stabilization: Until the target test temperature (30°C to 70°C) stabilized within ±0.1°C, the water bath was heated while being continuously stirred.
5. Efflux Timing: A digital stopwatch was begun concurrently with the lifting of the central valve rod ball. It was noted how long it took to gather precisely 50 millilitres of oil in the Kohlrausch flask.
6. Replication: To guaranty data reproducibility, the procedure was carried out in increments of 10°C.

5. Findings and Graphical Evaluation

The measured efflux durations and computed kinematic viscosity values for refined sunflower oil are compiled in Table 1:

Temperature (°C)	Kinematic Viscosity v (cSt)	Efflux Time t (Redwood Seconds - SR)
30	225.0	57.74
40	145.0	36.51
50	98.0	23.73
60	68.0	15.15
70	50.0	9.56

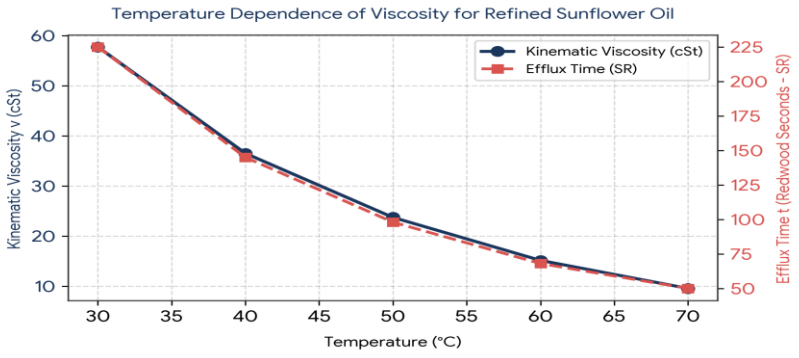


Figure 2: Experimental temperature-viscosity and temperature-efflux time curves for Refined Sunflower Oil.

6. Discussion

The experimental data provided in Table 1 and Figure 2 indicate a substantial inverse non-linear relationship between temperature and kinematic viscosity. A kinematic viscosity of 57.74 cSt was obtained at 30°C with an efflux time of 225.0 seconds. As temperature was elevated to 70°C, the efflux time reduced to 50.0 seconds, reducing kinematic viscosity to 9.56 cSt.

The kinetic energy model of liquids provides a physical rationale for this rapid drop. As thermal energy rises, triglyceride molecules gain energy, which disrupts the intermolecular cohesive forces—specifically van der Waals interactions. This enables individual liquid layers to slip past one another with greater ease, reducing overall flow resistance.

7.In summary

This study successfully determined the thermal viscosity profile of refined sunflower oil across a temperature range of 30°C to 70°C using a Redwood Viscometer No. 1. Accompanied by a schematic assembly diagram and a dual-axis plot, the findings offer comprehensive technical documentation for evaluating bio-lubricants. The resulting empirical data demonstrates predictable viscosity trends, supporting the potential of refined vegetable oils as viable lubricants for light-duty machinery.

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