Viscosity Measuring Device

Department of Mechanical Engineering

ME492 Senior Project – Spring 2021

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OBJECTIVE

Viscosity is the measure of resistance to deformation at a specific rate for fluid. Viscosity is equal to product of pressure and time. The general unit of it is Pascal*seconds. (Pa.s) The objective is measuring the viscosity of Newtonian fluids.

LITERATURE SURVEY & THEORY

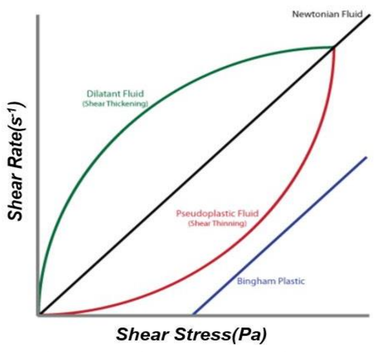


Figure.1 – Shear Stress vs Shear Rate

Viscosity remains constant at Newtonian fluids independently on shear stress applied on. Viscosity does not remain constant and is dependent on shear stress applied for the fluids which do not follow Newton's laws, are called as non-Newtonian fluids. Here, it will be dealt with Newtonian fluids such as water and glycerin.

Table.1 – Advantages & Disadvantages of Viscometer Types

Type	Advantages	Disadvantages
Capillary	Low cost, high accuracy, ability to work with high shear rates	High residence time and variation of shear across the flow
Falling Ball	Simplicity and cost-effectiveness	Not effective for high viscosities
Rotational	High accuracy at both Newtonian and non-Newtonian fluids	End Effects can be a problem
Rising Bubble	Affected minimally by the liquid while measuring	Container geometry (complex)
Orifice/Cup	Works well and gives accurate measurements for Newtonian fluids	Not appropriate for rheological measurements of non-Newtonian fluids
Parallel Disk	High accuracy	Shear rate is not uniform
Cone & Plate	Uniform shear rate can be obtained, good for non-Newtonian fluids	High cost and eccentricity issues

Table shows the advantages and disadvantages of different viscometer types. **Rotational viscometer** is chosen since it gives accurate results for both Newtonian and non-Newtonian fluids.

$$T_{NL} = \frac{P_m \times 60}{2\pi N_{NL}}$$

$$T_L = \frac{P_m \times 60}{2\pi N_L}$$

$$\rightarrow \mu = \frac{T \times 60}{4\pi^2 N_i h}\left(\frac{1}{R_i{}^2} - \frac{1}{R_i R_o}\right)$$

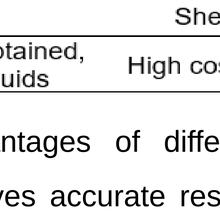
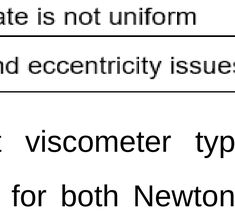
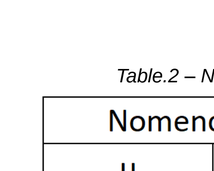
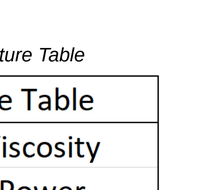
Table.2 – Nomenclature Table

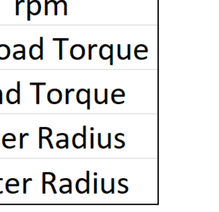
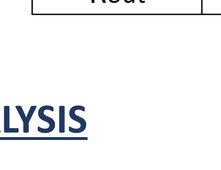
Nomenclature Table	
μ	Viscosity
P	Power
N	rpm
T_{NL}	No Load Torque
T_L	Load Torque
R_{in}	Inner Radius
R_{out}	Outer Radius

COST ANALYSIS

Table.3 – Table of Costs

Material Type	Material	Price
Sensor	Grove IR Sensor (V1.2)	52.76 TL
	Grove Current Sensor (ACS70331)	70.37 TL
	Voltage Sensor	5.78 TL
	Temperature Sensor (12V)	12.85 TL
Motor	DC Motor (12V 1800rpm)	15 TL
	Motor Holder (L 25D)	71.95 TL
	Motor Driver (L298N)	16.30 TL
	Motorobit Motor Cable	50.29 TL
Arduino	Arduino UNO R3	216.25 TL
	Arduino Cable	4.80 TL
	Grove Base Shield (V2.0)	100.73 TL
	DC Adaptor (12V 1A)	22.40 TL
Fluid - Beaker	Glycerine	28.99 TL
	Motor Oil	50 TL
	Water	2 TL
	Beaker (250 ml)	18.19 TL
Insulation	Polyethylene Pipe	6.99 TL
Other	Swanson Works Sprey (400 ml)	35 TL
	Globe Electric Tape	3.34 TL
Total Cost		**783.99 TL**

DESIGN & ANALYSIS

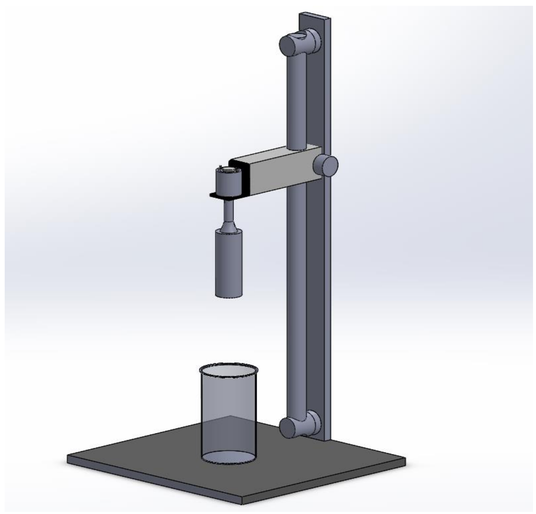


Figure.2 – Final Design

Name of the Product: Viscosity Measuring Device

Purpose: Measuring the viscosity of Newtonian fluids

Expectations: Making viscosity measurements accurately and precisely as much as possible for Newtonian fluids

Main Components of Product: Spindle (Inner Cylinder), Beaker (Outer Cylinder), Platform

Sub-Components of Product: DC Motor, Motor holder, Arduino Uno, Arduino Shield, Motor Driver, IR Sensor, Current Sensor, Voltage Sensor

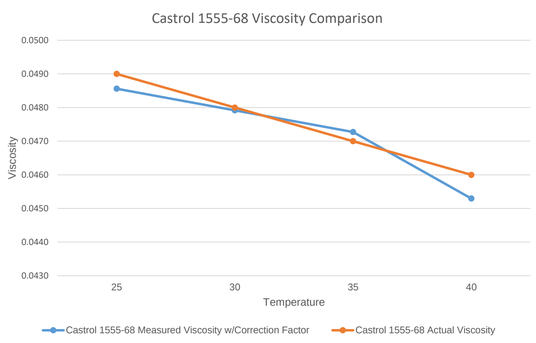


Figure.3 – Viscosity Comparison

Viscosity comparison between actual data and calculated data is shown on the graph. As it is observed, this dataset is precise and accurate for gear oils.

PRODUCTION SETUP

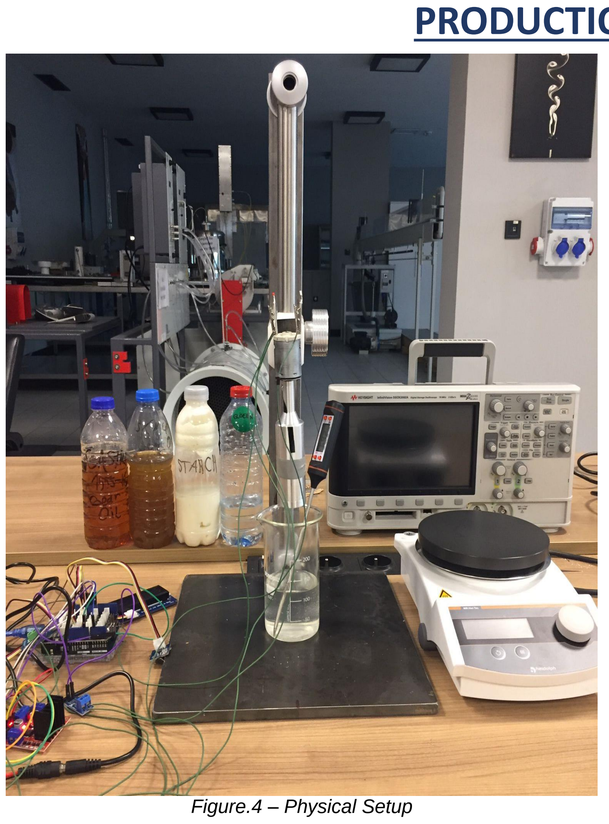


Figure.4 – Physical Setup

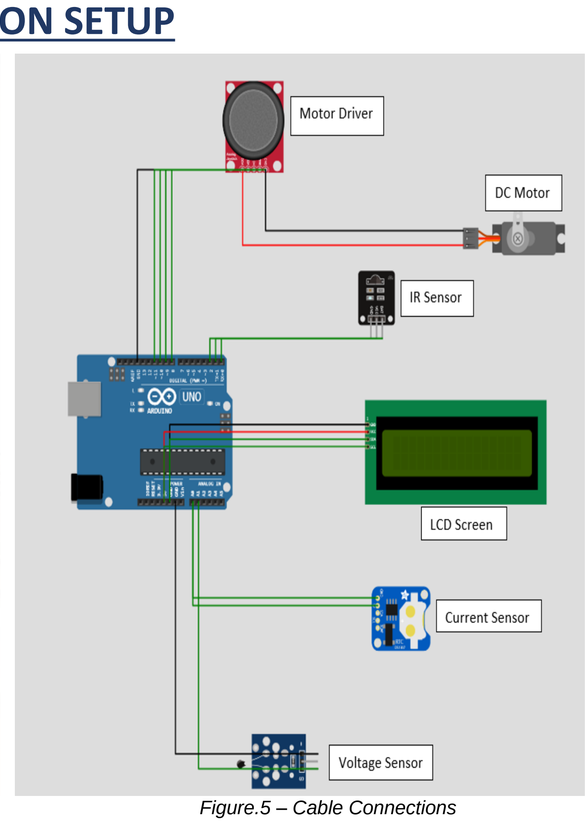


Figure.5 – Cable Connections

Physical setup is completed. After that, sensor connections and motor connections are done in order to take data from the physical setup. Arduino connection diagram is completed by wokwi.com web site.

CONCLUSION

To conclude, the definition of viscosity and measurement techniques of viscosity are mentioned. Manufacturing of a rotational viscometer has been made and viscosity data have been taken by the device. By using a current sensor and a voltage sensor, current and voltage data are taken. By taking these data, electrical power of the system is acquired by the multiplication of current, voltage and motor efficiency which is calculated by MATLAB code. By using an IR sensor, revolution per minute(rpm) of DC motor has been ready to use for viscosity calculation.

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- Islam, R., & Rahman, M. (2014). Design, Construction & Performance Test of a Rotational Digital viscometer. International Conference on Mechanical, Industrial and Energy Engineering.
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