Experimental Analysis of Thermal Conductivity for SAE20W40 blended with Al_2O_3

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Abstract - *Determining the physical properties of substances is an important subject in many advanced engineering applications. Thermal conductivity plays an important role in the design of a wide variety of engineering applications such as IC engines, transformers etc. This test describes a heat transfer experiment to determine the thermal conductivity of SAE20W40 engine oil and its composition with Al_2O_3 nano-particles at steady state heat transfer. Also the present study involves the comparison of thermal conductivity among three compositions at different heat input.*

Keywords: Thermal conductivity, Steady state heat transfer, SAE20W40 engine oil, Al_2O_3, nano-particles, Temperature gradient. etc.

1. INTRODUCTION

Nano fluids have novel properties that make them potentially useful in many applications in heat transfer, including microelectronics, fuel cells, pharmaceutical processes, and hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger, in grinding, machining and in boiler flue gas temperature reduction. They exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid. Knowledge of the rheological behavior of nano fluids is found to be critical in deciding their suitability for convective heat transfer applications. Nano fluids also have special acoustical properties and in ultrasonic fields display additional shear-wave reconversion of an incident compression wave; the effect becomes more pronounced as concentration increases.

In the present experiment the metal oxides i.e., aluminum oxide (Alumina) particles are mixed in two different composition with SAE20W40 oil and the thermal conductivity was measured. The thermal conductivity of SAE20W40 with 1 gram of Al_2O_3 nano particles is observed as higher value than the base fluid.

2. NOMENCLATURE

SAE: Society of Automotive Engineers
k: Thermal conductivity (W/m-K)
A: Area of the base plate (m^2)
ΔX: Thickness of the fluid film
Q: Heat Input (W)
T_1: Heater Temperature (^0C)
T_2: Liquid Chamber inlet Temperature (^0C)
T_3: Liquid Chamber outlet Temperature (^0C)
T_4: Coolant inlet Temperature (^0C)
T_5: Coolant outlet Temperature (^0C)
$\frac{dT}{dX}$: Temperature gradient ((^0C/m)
V: Applied Voltage (Volts)
I: Current (Amps)

3. MEASURING METHODS

There are number of possibilities to measure thermal conductivity, each of them suitable for limited range of materials, depending on the thermal properties and the medium temperature. In general, there are two basic techniques of measurement:

- The **steady state** technique performs a measurement when material that is analyzed is in complete equilibrium. This makes the process of signals analysis very easy (steady state implies constant signals). The disadvantage generally is that it takes a long time to reach the required equilibrium.
- The **unsteady state** techniques perform a measurement during the process of heating up. The advantage is that measurements can be made relatively quickly.

3.1 Steady State Techniques:

The **steady state technique** records a measurement when a tested material's thermal state reaches complete equilibrium. A steady state condition is attained when the temperature at each point of the specimen is constant and the temperature does not change with time. Steady state methods apply Fourier's law of heat conduction to measure thermal conductivity. The solution to the problems with the different steady heat flow methods is to convert the heat transfer problem to a one dimensional problem, thus simplifying the mathematics. The steady state techniques are (i) Guarded Hot plate (ii) Heat flow meters (iii) Direct heating methods (iv) Pipe Method.

3.2 Transient Techniques:

The method determines thermal conductivity properties by means of transient sensors. These measurements can be made relatively quickly, which garners an advantage over steady state techniques. For this reason, numerous solutions have been derived for the transient heat conduction equation by using one, two, three dimensional geometries. Transient methods generally employ needle probes or wires. The Transient techniques to measure the thermal conductivity are (i) Hot Wire Method (ii) Hot Disk Method (iii) Laser Flash method (iv) 3-ω Method (v) Fitch Method (vi) Photo Thermal Method.

4. EXPERIMENTAL SETUP

In the Present study, the thermal conductivity measuring device is similar to the guarded hot plate method. This experimental device contains: (i) Base frame (ii) A closed chamber (iii) Water circulation system (iv) Electric circuit board (v) Heater (vi) Pressure gauge. In measuring of thermal conductivity, the closed chamber consists of heater, mild steel plate, copper tube and water jacket.

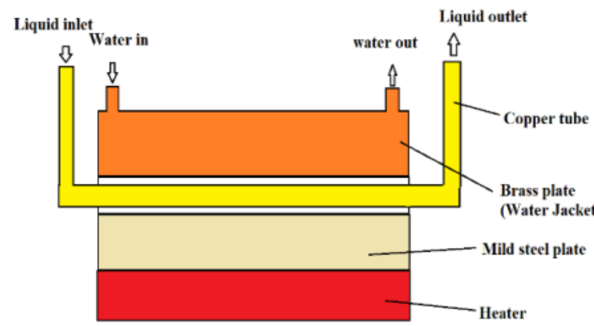

Fig-1: Experimental setup

4.1 Experimental procedure:

- Keep the unit near a 230V, 5 amps power source.
- Fill the water in the provided SS container which is kept above the table panel. Control the flow rate by operating the outlet valve to any desired flow rate (drop by drop) and measure with the help of a measuring jar and stop watch.
- Plug in the main power socket to the power source and then the digital instruments indicate zero on volt meter and ammeter and room temperatures on the temperature indicator.
- Rotate the electronic dimmer in clockwise direction to any desired heat input. (About 60-80 volts) and allow it to stabilize for 30-45 min.
- Note down the readings of Voltage, Current, temperatures from T_1 to T_5 and water flow rate.
- Calculate thermal conductivity of liquids by the given formulae.

4.2 Working Principle:

The basic working principle in this experiment is the Fourier's law of Heat conduction. In the present experiment the thermal conductivity of stagnant liquid (SAE20W40 with Al_2O_3 nano particles)which is in the form of a thin film is measuring on the principle of Fourier law of steady state heat conduction.. The heat transfer by conduction in liquid is given by

$$Q = \frac{-K.A.dT}{dX}$$

5. EXPERIMENTAL READINGS

In the present study the temperatures at different locations are measured with respective to the applied voltage and current to the base plate. The observations for SAE20W40 and its compositions are tabulated as follows:

Table-1: SAE20W40

S. No.	V (Volts)	I (Amps)	Temperature (^{0}C)				
			T_1	T_2	T_3	T_4	T_5
1	81	0.390	102	51	39	34	36
2	85	0.409	112	57	44	35	39
3	91	0.432	123	63	48	36	42

Sample Calculations:

$$\text{Thermal Conductivity}(k) = \frac{Q.\Delta X}{A.\Delta T}$$

Where

Q = V*I = 81*0.39 = 31.59 W, ΔX = 0.02 m

A = $(\pi d^2/4) = (\pi * 0.15^2/4) = 0.0176\ m^2$.

d = 0.15m, Δt = t_2-t_3 = 12^{0}C, ΔT =12+273 = 285 K

Therefore, k = **0.1254** W/m-K

Table-2*:* SAE20W40 + 0.8 gm of Al_2O_3 Nano Particles*:*

S. No.	V (Volts)	I (Amps)	Temperature (^{0}C)				
			T_1	T_2	T_3	T_4	T_5
1	81	0.395	100	54	44	35	39
2	86	0.413	114	61	48	36	43
3	92	0.441	132	70	55	37	40

Sample Calculations:

$$\text{Thermal Conductivity}(k) = \frac{Q.\Delta X}{A.\Delta T}$$

Where

Q = V*I = 81*0.395 = 31.995 W, ΔX = 0.02 m

A = $(\pi d^2/4) = (\pi * 0.15^2/4) = 0.0176\ m^2$.

d = 0.15m, Δt = t_2-t_3 = 10^{0}C, ΔT =12+273 = 283 K

Therefore, k = **0.1284** W/m-K

Table-3: SAE20W40 + 1 gm of Al_2O_3 Nano Particles*:*

S. No.	V (Volts)	I (Amps)	Temperature (^{0}C)				
			T_1	T_2	T_3	T_4	T_5
1	83	0.401	102	51	40	35	36
2	86	0.413	110	56	42	36	37
3	94	0.451	127	65	48	36	40

Sample Calculations:

$$\text{Thermal Conductivity}(k) = \frac{Q.\Delta X}{A.\Delta T}$$

Where

Q = V*I = 83*0.401 = 33.283 W, ΔX = 0.02 m

A = $(\pi d^2/4) = (\pi * 0.15^2/4) = 0.0176\ m^2$.

d = 0.15m, Δt = t_2-t_3 = 11^{0}C, ΔT =12+273 = 284 K

Therefore, k = **0.1291** W/m-K

6. RESULTS AND DISCUSSION

6.1 Results:

The aim of this experimental study is to enhance the thermal conductivity of SAE20W40 oil by blending with Al_2O_3 nano-particles. It is observed from the results that the thermal conductivity SAE20W40 oil is increases by blending the nano particles. The experimental results are summarized as follows:

Table-4: Thermal Conductivity Values:

Voltage (Volts)	Thermal Conductivity, k (W/m-K)		
	SAE 20W40	SAE 20W40 + 0.8gm Al_2O_3	SAE 20W40 + 1.0gm Al_2O_3
80	0.1254	0.1375	0.1544
85	0.1289	0.1405	0.1594
90	0.1335	0.1400	0.1650

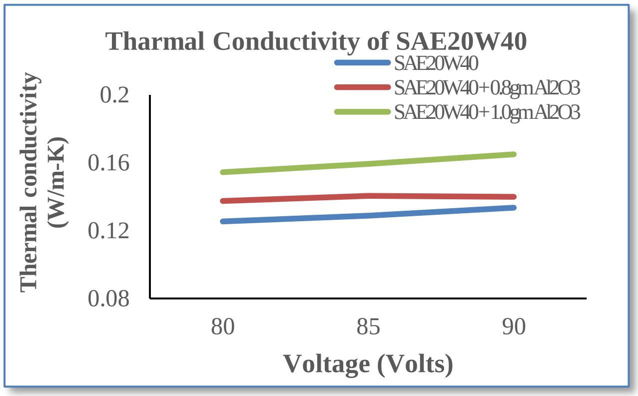

Chart-1: Voltage Vs Thermal Conductivity

Table-5: Average Thermal Conductivity Values:

S. No.	Working Fluid	Thermal Conductivity (W/m-K)
1	SAE20W40	0.1391
2	SAE20W40 + 0.8gms Al_2O_3	0.1434
3	SAE20W40 + 1.0 gm Al_2O_3	0.1436

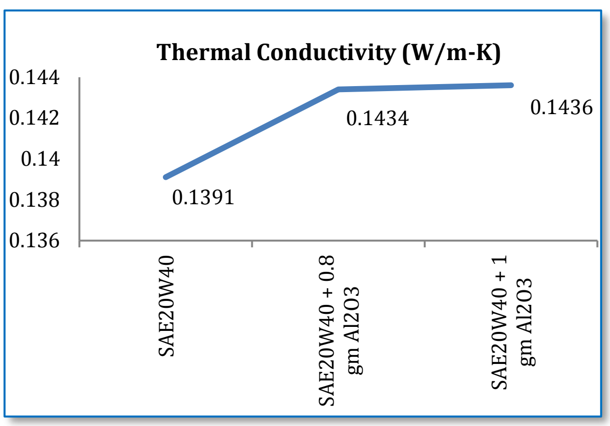

Chart-2: Thermal Conductivity of SAE20W40 and its compositions:

6.2 Discussion:

From the Chart-1 plotted above, it is clear that the thermal conductivity of SAE20W40 and its composition with Al_2O_3 nano-particles is increasing with applied voltage i.e., at higher heat supplied to the base plate the thermal conductivity is also higher.

From the Chart-2 plotted above it is analyzed that the thermal conductivity of SAE20W40 is increasing by blending with Al_2O_3 nano-particles and also it is observed that the thermal conductivity is more for higher concentration of nano-particles in SAE20W40 oil.

7. CONCLUSIONS

Based on the results obtained from the experimental analysis, the thermal conductivity of given oil is increases by blending with Alumina nano-particles. It is clear that, in heat transfer applications the higher thermal conductivity fluids are required to enhance the heat transfer rate. So instead the bare fluid it is better to use the blended fluid with Alumina nano-particles to increase the heat transfer rate.

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REFERENCES

[1] CHOI S., Enhancing Thermal Conductivity of Fluids with Nano-particles, ASME Fed 231, New York, 1995.

[2] MCLAUGHLIN E., Theory of the thermal conductivity of fluids, in Thermal Conductivity, Academic Press, London, 1969.

[3] ASSAEL M. J., NIETO DE CASTRO C. A., RODER H. M., WAKEHAM W. A., Measurement of the transport properties of fluids, in Experimental Thermodynamics, Blackwell Scientific Publications, Oxford, 1991.

[4] Van Den Brink J and Rongen M, 1994, Therm.Conduct. 22 70-79

[5] Liley P International Journal of Mechanical Engineering Education 32 (4) 45-50

[6] Bindeiiifinn. T h y ,r.eits, 11, bug (igiu); T lo m A n n . d. lAiys . 42, 1397 (1913)

[7] Moffat, R.J. (1988), "Describing the Uncertainties in Experimental Results," Experimental Thermal and Fluids Science, Vol. 1, No. 1, p. 3.

BIOGRAPHY

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