IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 8, Issue 1 Ver. III (Jan. - Feb. 2016), PP 33-35
www.iosrjournals

Determination of the Specific Heat Capacity of Different Sae 20w-50 Engine Oil Samples Using the Electrical Method

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***Abstract**: Specific heat capacities of various engine oil samples were measured. Electrical method was employed in the determination. The analysed engine oils present values in the specific heat capacity ranging from 2306.12J/Kg/K,-3062.59 J/Kg/K, Since the lower the specific heat capacity, the lower the retention capacity, that is the faster the cooling rate. Therefore samples P and T had lower specific heat while samples R having the highest value.*
***Key words**: Specific heat capacity, bomb Calorimeter*

I. Introduction

Engine oils are obtain from the fractional distillation of crude oil. It is the denser part of the crude oil because its density is greater than other products from the fractional distillation like petroleum, gas etc. Engine oil serves as coolant in our engines and machines. Its specific heat capacity should be smaller because substances with high specific heat capacity do not lose its internal energy completely or easily. (George et al, 2010).

When a substance is heated, its internal energy increases (potential and kinetic). The stronger the force between the particles in the substance, the more heat energy goes into potential energy (and less into kinetic), so the temperature rise is less than in substances with little force between particles. Obviously the more particles there are too, the more heat energy can be absorbed. (Wikipedia)

Heat capacity is the basic thermophysical and thermodynamic properties of materials. The property is directly linked with temperature derivatives of basic thermodynamic functions and therefore indispensable for the calculation of differences in these functions between different temperatures (Za´bransky et al, 2002).

The specific heat capacity is a characteristic material property of a substance. It describes the amount of heat required to increase the temperature (at constant pressure and is thus an important property for the calculation of thermal processes in the chemical industry. Specific heat capacity is defined as "the amount of heat required to raise the temperature of 1kg of material by 1°C.". This amount of energy depends on the substance; every substance has different heat capacities (Hamper, 2009).

Variations in heat capacities serve as a sensitive indicator of phase transitions and are an important tool for understanding changes in the structure of liquid solutions (Santos et al, 2005)

Oil thermal conductivity and specific heat are also important parameters for engine cooling system design, and are a function of temperature. Oils with a larger thermal conductivity value will transfer heat energy more efficiently. In any mechanical device using engine oil, the internal energy enables the engine to start faster because the heat lost by the engine is stored as an internal energy in the lubricating systems.(Corsico et al, 1999). Water has thermal conductivity and specific heat values approximately twice those of typical glycols. High-temperature heat transfer fluids and petroleum engine oils have lower values for thermal properties than glycols. Many types of oils are used as heat transfer fluids, which leads to a fairly wide band of typical thermal conductivity and specific heat values.(Wrenick et al, 2005**)**

II. Materials And Methods

Five (5) samples of SAE 20W-50 engine oil were collected from engine oil dealers in Umuahia City of Abia State and analyzed to determine their specific heat capacities. These samples were labelled as P, Q, R, S, and T. Copper calorimeter, digital thermometer ($\pm$ 0.5 ^{0}C), voltmeter ammeter, rheostat, stirrer, connecting wires, stop watch, lagging materials, measuring cylinder, measuring balance were used in the sets of experiment as materials for determining the specific heat capacity of the engine oil samples

Determination of the Specific Heat Capacity.

140cm³ of each of the samples were measured. The masses and their volumes were first noted and recorded. The initial temperature of the samples were also noted and recorded. The sample was put inside a bomb copper calorimeter with the electrode inside the sample oil and a stirrer to distribute the energy supplied.

The current and voltage in the experimental circuit was set at 1.3A and 3.2V respectively. The energy supplied through the calorimeter is given as

$$Q = IVt \quad (1)$$

where I, is the current supplied, V is the voltage across the load and t is the heating time.
In this experiment, the specific heat capacity of the sample engine oils is being calculated by using a heater. The temperature changes were observed every 30 seconds, till when the temperature gets to 60 ^{0}C.
The total heat gained is given by

$$H_T = m_c c_c \Delta\theta_c + m_s c_s \Delta\theta_s + m_l c_l \Delta\theta_l \quad (2)$$

Where m_c, c_c and θ_c represent mass, specific heat capacity and the initial temperature of calorimeter ; m_s, c_s, and θ_s indicates the mass, specific heat capacity and the initial temperature of the stirrer; m_l, c_l and θ_l indicates the mass, specific heat capacity and initial temperature of the liquid respectively. Or

$$H_T = \Delta\theta(m_c c_c + m_s c_s + m_l c_l) = \Delta\theta\lfloor(m_c + m_s)c + m_l c_l\rfloor \quad (3)$$

Where $\Delta\theta = \Delta\theta_c = \Delta\theta_s = \Delta\theta_l$ representing the change in temperature of the sample together with the calorimeter and $c_c = c_s = c$ represent the specific heat capacity of copper. If we assume that the total energy supplied is equal to the total heat absorbed, then

$$Q = H_T \quad (4)$$

we have

$$c_l = \frac{\frac{IVt}{\theta} - (m_c + m_s)}{m_l} \quad (5)$$

If $\frac{\Delta\theta}{IVt} = S$ is the slope of the graphs then

$$S = \frac{1}{\lfloor(m_c + m_s)c + m_l c_l\rfloor} \quad (6)$$

This implies that the slope of the specific heat capacities is dependent on their masses and the specific heat of the calorimeter, stirrer and the liquid. The specific heat capacity of the liquid is given as

$$c_l = \frac{1 - SC(m_c + m_s)}{m_l S} \quad (7)$$

Where
c_l = Specific heat capacity of the sample liquid; S= Slope of the graphs for each sample; C = the specific heat capacity of the copper calorimeter and the stirrer; $m_c + m_s$ = Sum of the mass of the calorimeter and stirrer; m_l = Mass of the liquid sample

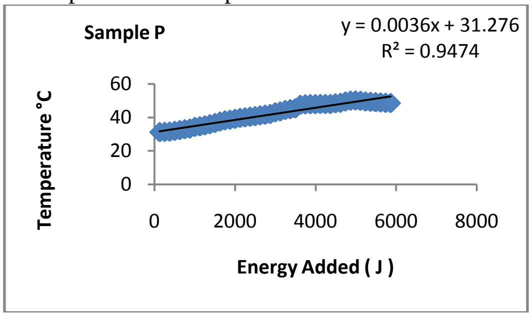
III. Result And Discussion

The table below shows the basics measurement of the sample oils

Table 1: Summary of the Physical dimensions of samples

Samples	Mass of samples	Volume of sample	Initial Temperature of samples in calorimeter
P	122.7g=0.1227kg	140.00cm^3	31.0 °C
Q	126.3g=0.1263kg	140.00cm^3	29.1 °C
R	128.4g=0.1284kg	140.00cm^3	25.2 °C
S	125.6g=0.125.6kg	140.00cm^3	29.8 °C
T	123.9g=0/123.9kg	140.00cm^3	30.5 °C

Figures 1 gives the plot of the temperature as a function of the energy added



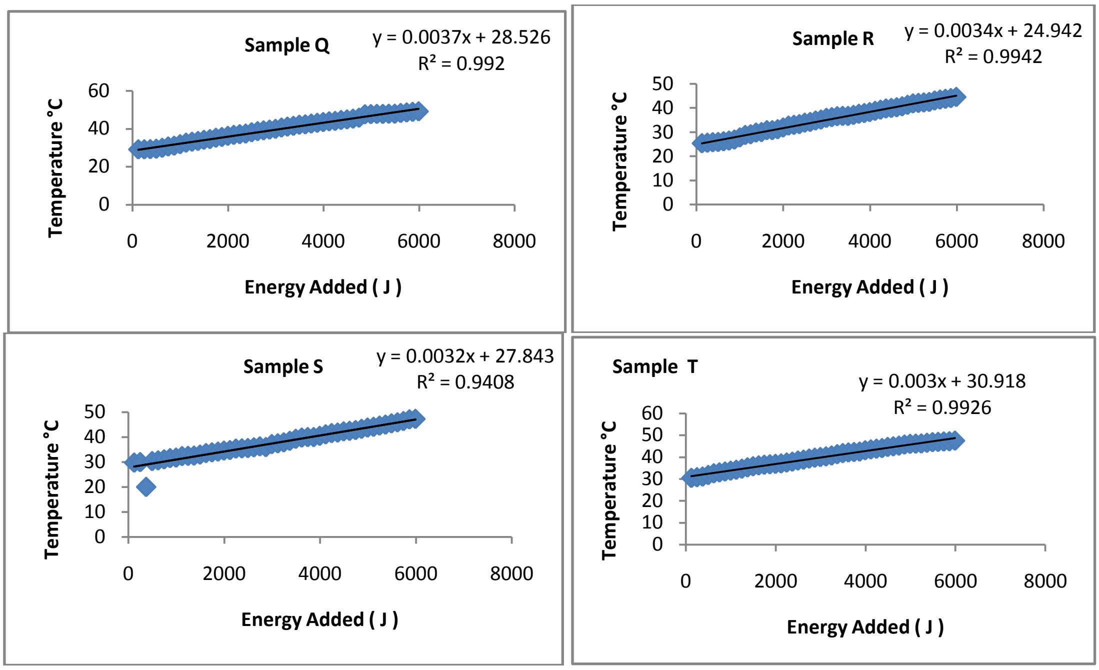


Figure 1:Temperature as a function of Energy supplied to Sample

From fig. 1, the slopes of the graphs are 0.0019238K/J, 0.0017963K/J, 0.0015871 K/J, 0.0017122 K/J and 0.0018459 K/J for Samples P, Q, R, S and T respectively. Given the mass of the calorimeter and the stirrer together as 612g equivalent to 0.612kg and having specific heat capacity of 387J/Kg/K, the specific heat capacities of the various samples were obtained as 2306.12J/Kg/K, 2532.51 J/Kg/K, 3062.59 J/Kg/K, 2764.33 J/Kg/K and 2460.83 J/Kg/K for P, Q, R, S and T oil sample respectively

IV. Conclusion

Considering the efficiency of any mechanical system that uses engine oil, its efficiency depends majorly on specific heat capacities. It also depends on the cooling rate and the viscous nature of the oil samples. Engine oils with low cooling rates and higher specific heat capacities readily become less viscous and lubricate better. The lubricating and cooling effects jointly prevent wear, tear and difficulty in starting the engine even when the environmental temperature is extremely low.

From the graph analysis, it is seen that increase in temperature is influenced by increase in the electrical energy supplied through the heater. The results of the specific heat capacities of the different SAE20W-50 oil samples show the behaviour of each of the samples coded as P, Q, R, S, and T at operating temperature of some lower engines. Based on the result obtained within the limit of experimental error, sample P has the fastest cooling rate with specific heat capacity of 2306.12J/Kg/K This shows that these two samples P and T respectively have good physical properties to maintain the longevity of engines.

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