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Study of Important Performance Characteristics of Commercially Available Two and Four Stroke Engine Lubricants

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Abstract

Background/Objectives: In this paper, a complete study and experimentation of engine lubricants or engine oils with the help of viscosity grades through the mathematical formulas and experimental data having different viscosity grade of lubricants at different temperature. **Methods/Statistical Analysis:** For analyze the viscosity, density and thermal conductivity with the assistance of Redwood viscometer, Hydrometer and Transient hot-wire method, and reciprocal of thermal conductivity (k) is called thermal resistivity (r). Engine oils 10W40, 10W30, and 15W40 are selected for testing. **Findings:** in these different types of engine oil tests, four parameters (viscosity, thermal conductivity (k), density, thermal resistivity and 126 experiments were performed with four different temperature 30°C, 40°C, 50°C, and 60°C, which shows the comparisons of different engine lubricants at same viscosity grade. **Applications:** The oil lubrication pollution against the motor part wear, leading the loss of engine performance and life, the dynamic engine oil or lubricant oil films confine moving portion surfaces cause a the significant bit of the engine wear. In the engine lubrication system, viscosity plays important role, wearing of the automated parts. There are different lubricants are in market having different viscosity grades. A mechanical or automated engine is a completed machine; it comprises of several moving parts. The moving part of the automated or mechanical engine is driven under different temperature and pressure ranges to reduce the friction or erosion and control wear. Engine oil plays the important role, so the oil action and specifications reduce the friction or erosion and control the engine wear behavior, the viscosity is one of the most important parameter of the engine oil specifications, the viscosity comprises and shows the number of forces or power between the oil particles.

Keywords: Friction Loss, Lubricant Oils (10W40, 10W30, 15W40), Oil Density, Oil Viscosity, Optimization, Two and Four Stroke Engine

1. Introduction

The basic function of the lubrication is to overcome the friction between two mechanical partsby use of a suitable substance between the rubbing surfaces of the bodies having relative movement. Substances enforced to overcome or reduce friction are called lubricants. Lubrication in the technical sense refers to the action of lubricant in separating the rubbing of machine elements.In the tribological field the part of engine oil viscosity plays the important role. The part of oil is to smoothen out the development of one surface over another and to keep up the viscoelastic behavior[1].

Starting with the primary mechanical device, lubricant oil has been a significant outline parameter for any mobile parts associated with machinery, mechanical apparatuses, and transport implies. An assortment of materials, in the form of gas, liquid or solid, were intervened between two surfaces keeping in mind the end goal to enhance the smoothness of relative development and to avoid harms to the surfaces[2].

Principally oils are liquids, (for example, mineral oils, engineered oil, water, and so on). Choice of engine lubricants is essential for providing machine instruments a more extended life. To choose suitable oil lubricant, it is

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necessary toknow its properties, used in machinery, and cost of engine lubricants. In general, the success of a lubrication system in a machine relies on the performance of many mechanisms of lubricant. One of the ways to enhance the properties of lubricants is that a less number of additives are added in lubricants. This causes arrangement to improve viscosity layer close to the surfaces which thus support higher load limit. At the point when additive substances were added to the oil the lubricants qualities move toward becoming non-Newtonian contrasted with Newtonian. If these addictive substances are in the type of long-chain atoms they may deliver couple stresses which significantly affect the bearing qualities and its belongings are more articulated when the oil streams in the limited gap which are the situation in oil system. Stokes couple stress fluid model takes into account effects of such properties as couple stresses, body couples and polar effects due to asymmetric stress tensor. Consequently, in this thesis, the effects of included substances diverse bearing qualities have been contemplated by taking the oil as stokes couple pressure liquid[3].

Properties of lubricants are: viscosity, density, viscosity index, compressibility, cloud point, surface tension, pour point or low temperature property, high resistance to oxidation, flash point, friction coefficient, thermal stability, freezing point, boiling point, , corrosion prevention, and so on. The most critical property is its thickness (viscosity). Viscosity is depending on temperature (T) and pressure (P). The relationship between temperature (T) and viscosity (v) and the relationship between viscosities and pressure (P) are also important in lubricant rheology as well as for the life of machine elements. While temperature increase, reduces the viscosity of lubricating oil, also increase in pressure produces a rise in its viscosity. Barus expressed relation between viscosity and pressure introducing a constant α named pressure-viscosity coefficient[4].

In recent years, viscosity pressure relationship became an essential parameter of lubricating oil to know its performance, mainly in high-temperature applications, so viscosity measurement becomes an essential tool for doing so. Rheology is the investigation of the stream of fluids and semi-solids under conditions in which they stream instead of distorting flexibly. It would be difficult to imagine any type of machinery without lubrication. One of the major applications of lubrication, as engine oil, is ensuring the inner burning motors in engine vehicles and power equipment. Typically, lubricants comprises of 90% base oil and 8-10% additives. Vegetable oils or manufactured fluids, for example, hydrogenated polyolefin, silicones, esters, fluorocarbons, and numerous others are utilized as base oils. The main purpose of the additives is to enhance or improve the lubricant properties and decrease the friction and wear rate in engine parts, and enhance the viscosity (as per requirement), optimize viscosity index and protection from erosion and oxidation and so onward. Sometimes lubricant like 2 stroke engine lubricant is included to fuels such as gaseous engine which has very less lubricity[5].

Maintenance of high pressure viscosity index at various temperatures in multi-grade and additionally single-grade motor oil is the key for its sustained performance. It is also a resulting factor of wear of machine parts. Better rheological behavior with temperature will lead to better tribology[6].

2. Materials and Methods

Oil analysis and observing is an effective instrument in counteractive action breakdowns by flagging up potential issues previously a genuine breakdown happens. lubricating oils are utilized as a part IC engine for four principle purposes: to overcome friction and erosion between two or more rubbing surfaces; by sealing of piston rings it can provide good compression; it can use as cooling purpose and remove heat from the mechanical engine; and the purpose of the scavenging agent, carbon particles, chips of the metal, dust or any other materials, to be acceptable the utilization of lubricants must be free from acids or destructive material. It must be sufficiently liquid at low temperatures to allow simple beginning but then not as the liquid at high or working temperatures as to lose its lubricating quality[7], it must be sufficiently steady to stay in great condition for extended periods without decay and free from any materials which tend to form carbon deposits as shown in Table 1, 2.

2.1 Viscosity

The most important characteristics of the engine lubricant are viscosity[8]. It is the measure of resistant to flow of liquid, and also shows the ability of engine oil to support load shows in Figure 1.

The viscosity of the oil is estimated as the period of time in seconds required for a measured amount of the oil to move through a standard measured opening. The outcome is expressed either by say jolt seconds or by centistokes. The oil changes the viscosity when viscosity test

Table 1. Lubricants and specification

LUBRICANTS	VISCOSITY GRADE	SUITABLE FOR
Castrol MAGNATEC	10W40	PETROL
Shell Helix	10W40	PETROL
Gulf ULTRASYNTH X	10W40	PETROL
SERVO 4T ZOOM	10W30	PETROL (2 Wheelers)
CASTROL POWER'1	10W30	PETROL (2 Wheelers)
Castrol Active	10W30	PETROL (2 Wheelers)
Castrol MAGNATEC	15W40	DIESEL
Castrol CRB MULTI	15W40	DIESEL
Shell RIMULA	15W40	DIESEL

Table 2. Properties and method

Sr.no.	PARAMETER	METHOD USED FOR TESTING
1	VISCOSITY	Redwood Viscometer
2	DENSITY	Hydrometer
3	THERMAL CONDUCTIVITY	Transient hot-wire method
4	THERMAL RESISTIVITY	1/ Thermal Conductivity

is made at different temperature. Temperatures generally employed are 40 °C, 50 °C, and 100 °C. The result is constantly analyzed with the specific temperature. Greasing up oils covering an extensive variety of viscosity is required with a specific end goal to accommodate all lubrication necessities.

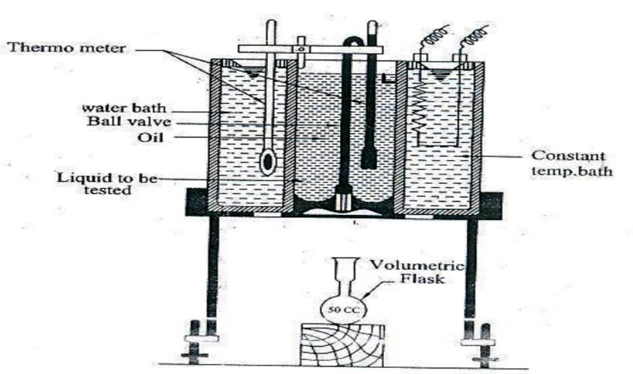


Figure 1. Redwood Viscometer[13].

As a guide to the purchaser in picking oil which will suit his specific need, a viscosity scale has been embraced. The scale was formulated by the Society of Automotive Engineers and comprises a progression of numbers - S.A.E. 10, S.A.E. 20, and so on. The S.A.E. number for oil is a reasonable sign of its viscosity. In other words, all oils with an S.A.E. 30 number, for example, are of about a similar viscosity regardless of what organization fabricates them. There is a permissible scope of viscosity for oils that might be given a specific number; however, this range is settled by most extreme and least cutoff points of viscosity. It is workable for an oil called S.A.E, 20 yet high reasonable range to have nearly an indistinguishable viscosity from an S.A.E, 30 oil, appropriately named yet low in its range, However, each organization keeps the viscosity of its oil of a given S.A.E., number very steady and when all is said in done the oils of various organizations yet of the same S.A.E., number are similar in viscosity. On heating, oil changes viscosity despite the fact that not every one of them to a similar degree. The oil must be adequately thick to continue moving parts isolated at the highest working temperatures but then not be so viscous at low temperatures as to cause starting difficulty. Keeping in mind the end goal to think about the viscosity-temperature attributes of a progression of oils the Viscosity Index is to be calculated. For this computation, it is important to know the viscosity at 50 °C, and 100 °C, and to compare these and the relating value for lubrication run of the typical viscosity. When we increase the value of viscosity index the less the oil will change in viscosity with change in temperature, a high viscosity list is thought considered to be a good quality in an engine lubricant.

2.2 Density

Density assumes a basic role in how oil lubrication functions as well as machines perform[9]. Principally the outline of the system is to inject the fuel of a specific density, so as the density start to change; the efficiency of pump starts to change also[10]. The ASTM D1298-12b Standard Test Method for Density[11], Relative Density, or API (American Petroleum Institute) Gravity of Crude Petroleum and Liquid Petroleum Products expresses that exact assurance of the API gravity, density or relative density (particular gravity) utilizes a standard temperature of 60 degrees F (15 degrees C).In Layman's terms, density is the mass of an object with respect to the volume it involves. Numerically, density, mass, and volume are connected by the accompanying by the following Equation (1) (Figures 2,3):

$$\rho = m/V \qquad (1)$$

Where ρ=density, m=mass and V=volume.

The density ranges of most lubrication oil are between 700 and 950 kilograms per cubic meter (kg/m^3), and as the density of 1000kg/m^3, shown in Equation (1) and other oils have low volume as a result they will float on water. But not all oils are lighter some oils of Group iv base can be of higher volume as the result they will not float on water they will make a layer on water surface.

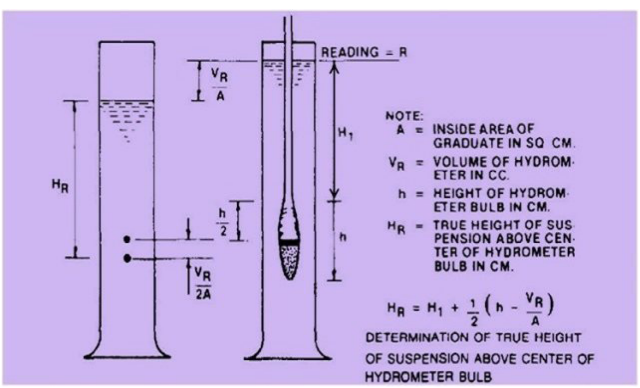


Figure 2. Hydrometer[14].

2.3Thermal Conductivity

During the time when engine oil lubricates reduce wear. It is necessary to serves as heat transfer fluid in engine. The important design parameter for engine cooling is oil thermal conductivity, specific heat and also depends on the temperature. Engine oil with more thermal conductivity value, heat transfer efficiency will be more. For a given measure of heat energy consumption oil with the more specific heat, there would be limited temperature ascend for a given measure of heat energy absorption. For Low Heat Rejection (LHR) the heat transfer properties of engine oil for a diesel engine are especially crucial. The outer oil cooler and radiator would not be available in proposed uncooled Lower Heat Rejection (LHR) engines. The heat transfer occurs with the sole of engine oil.

Figure 3. Pycnometer.

Current LHR motor oils are detailed with Group V base liquids, whose warmth exchange properties have not beforehand been resolved[12].

2.4 Cloud and Pour Point

Engine oils solidify if cooled to an adequately low temperature, either to the halfway partition of wax or, to a hardening of the oil itself. The temperature (T) at which was initially separates is known as the cloud point. The temperature (T) when the oil will simply stream under certain standard test conditions is known as the pour point. The cloud point is of esteem when the oil is to be utilized for the wick-feed application. The pour point gives a sign in the matter of what might be normal under low-temperature activity. It additionally speaks to the temperature underneath which it is risky to utilize them oil in gravity grease frameworks.

2.5 Thermal Resistivity

Thermal resistivity is the capacity of a material to oppose the flow of heat. Thermal resistivity (r) is reciprocal of thermal conductivity (k) Equation (2) and can be expressed as:

$$r = 1 / k \qquad (2)$$

Where r = thermal resistivity, k = thermal conductivity

Table 3. Experimental parameters and observations data for Castrol Magnatec

1. Castrol MAGNATEC (10W40)				
TEMPERATURE °C	VISCOSITY	DENSITY (kg/m3)	THERMAL CONDUCTIVITY	THERMAL RESISTIVITY
30	6470	872	0.146	6.849
40	6459	864	0.143	6.993
50	6449	854	0.138	7.246
60	6438	846	0.135	7.407

Table 4. Experimental parameters and observations data for Shell Helix

2.Shell Helix 10W40				
TEMPERATURE °C	VISCOSITY	DENSITY (kg/m3)	THERMAL CONDUCTIVITY	THERMAL RESISTIVITY
30	6371	860	0.151	6.622
40	6330	852	0.15	6.666
50	6308	839	0.148	6.756
60	6274	825	0.143	6.993

Table 5. Experimental parameters and observations data for Gulf Ultrasynth

3.Gulf ULTRASYNTH X(10W40)				
TEMPERATURE °C	VISCOSITY	DENSITY (kg/m3)	THERMAL CONDUCTIVITY	THERMAL RESISTIVITY
30	6273	850	0.149	6.711
40	6201	842	0.143	6.993
50	6168	834	0.138	7.246
60	6110	822	0.131	7.633

Table 6. Experimental parameters and observations data for Servo 4T Zoom

4.SERVO 4T ZOOM (10W-30)				
TEMPERATURE °C	VISCOSITY	DENSITY (kg/m3)	THERMAL CONDUCTIVITY	THERMAL RESISTIVITY
30	4597	780	0.142	7.042
40	4485	774	0.139	7.194
50	4398	765	0.136	7.352
60	4201	758	0.13	7.692

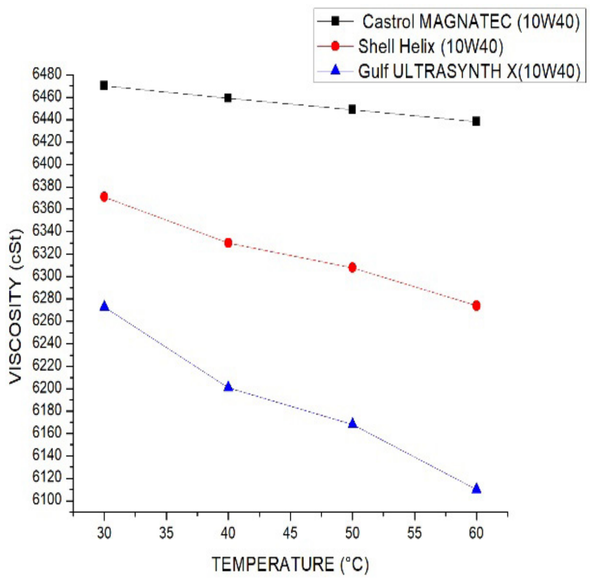
Table 7. Experimental parameters and observations data for Castrol Power'1

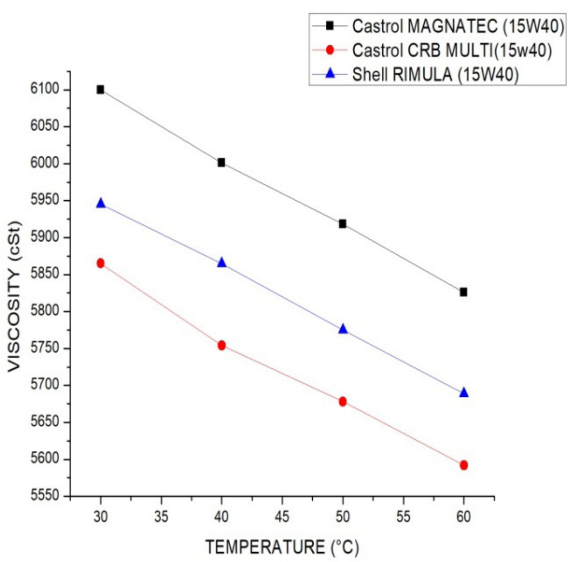
5.CASTROL POWER'1 (10w30)				
TEMPERATURE °C	VISCOSITY	DENSITY (kg/m3)	THERMAL CONDUCTIVITY	THERMAL RESISTIVITY
30	4200	870	0.15	6.666
40	4101	861	0.146	6.849
50	4035	849	0.141	7.092
60	3976	838	0.136	7.352

3. Results and Discussion

3.1 Experimental Plan

Study of engine lubricants based on different parameter such as viscosity, density, thermal conductivity, thermal resistivity, pour point, flash point, etc. Engine oils with diesel and petrol engine having different brand name 10W40, 10W30, and 15W40 are selected for testing as shown in Table 3-11.





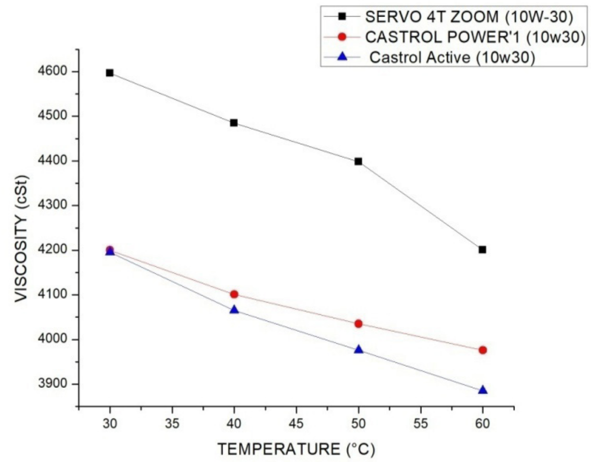
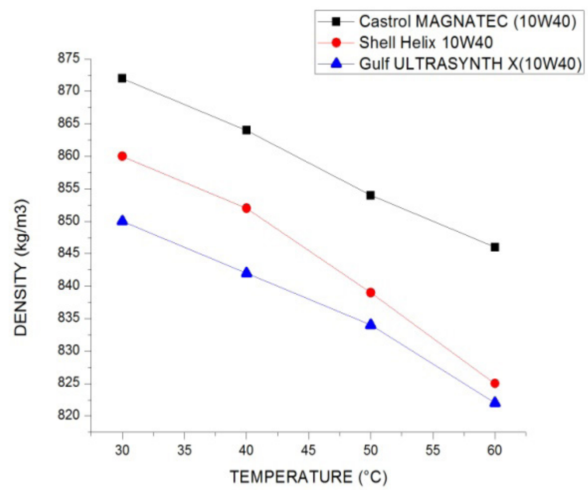
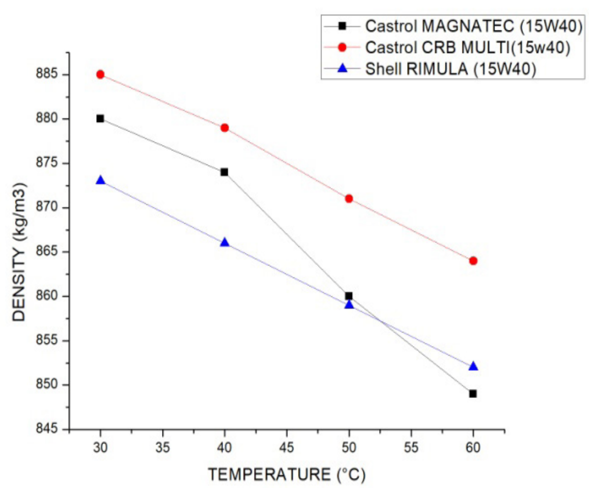


Figure 4. Temperature viscosity graph.





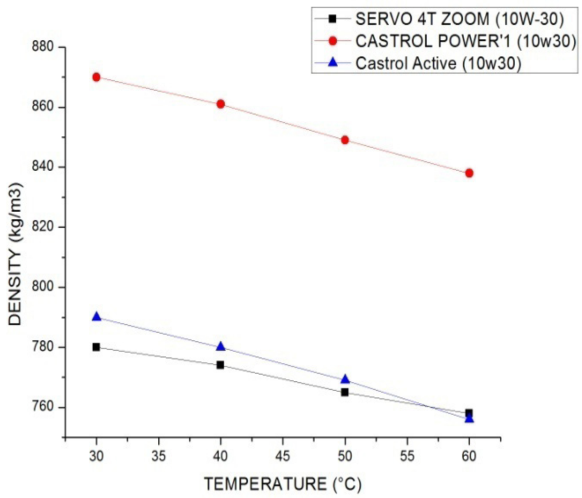
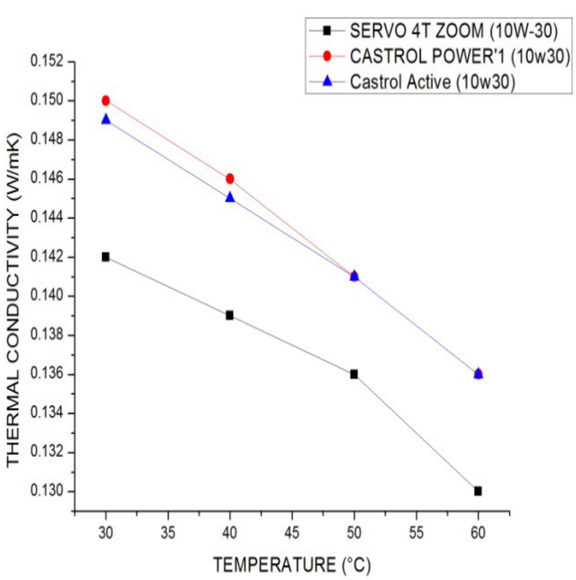
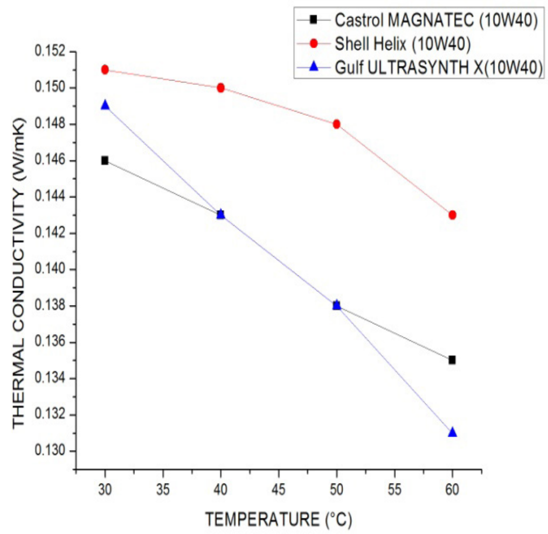


Figure 5. Temperature density graph.

3.1.1 Temperature-Viscosity

This report summarizes the result of 9 lubricants and showing the comparisons of different engine lubricants. With the assistance of Redwood viscometer after experimentation the values of viscosity at various temperatures (T) showing the variations of viscosity (v) of different engine lubricants at same viscosity grade as shown in Figure 4.





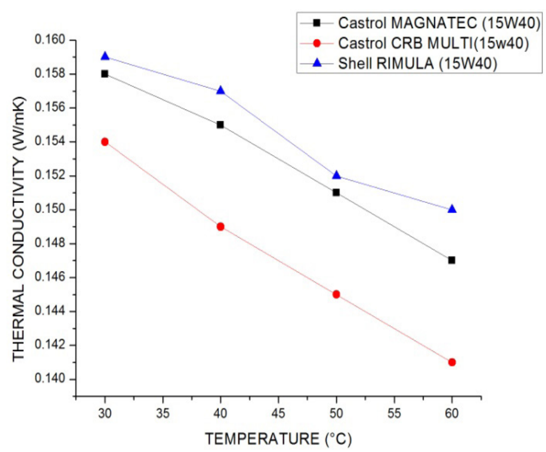


Figure 6. Temperature thermal conductivity graph.

3.1.2 Temperature-Density

By experimentation calculated that density is the function of temperature or density changes with change in temperature. Below figure shows that with increase in temperature density of lubricant oil will decreases. There is an inverse relationship between density and temperature as shown in Figure 5.

3.1.3 Temperature -Thermal Conductivity

Thermal conductivity of liquid is goes less at higher temperature of the engine lubricants. The experiment shows the relationship between temperature and thermal con-

Table 8. Experimental parameters and observations data for Castrol Active

6. Castrol Active (10w30)				
TEMPERATURE °C	**VISCOSITY**	**DENSITY (kg/m3)**	**THERMAL CONDUCTIVITY**	**THERMAL RESISTIVITY**
30	4195	790	0.149	6.711
40	4065	780	0.145	6.896
50	3976	769	0.141	7.092
60	3885	756	0.136	7.352

Table 9. Experimental Parameters and observations data for Castrol Magnatec

7.Castrol MAGNATEC (15W40)				
TEMPERATURE °C	**VISCOSITY**	**DENSITY (kg/m3)**	**THERMAL CONDUCTIVITY**	**THERMAL RESISTIVITY**
30	6100	880	0.158	6.329
40	6001	874	0.155	6.451
50	5918	860	0.151	6.622
60	5826	849	0.147	6.802

Table 10. Experimental Parameters and observations data for Castrol CRB Multi

8. Castrol CRB MULTI(15w40)				
TEMPERATURE °C	**VISCOSITY**	**DENSITY (kg/m3)**	**THERMAL CONDUCTIVITY**	**THERMAL RESISTIVITY**
30	5865	885	0.154	6.493
40	5754	879	0.149	6.711
50	5678	871	0.145	6.896
60	5592	864	0.141	7.092

Table 11. Experimental Parameters and observations data for Shell Rimula

9. Shell RIMULA (15W40)				
TEMPERATURE °C	VISCOSITY	DENSITY (kg/m3)	THERMAL CONDUCTIVITY	THERMAL RESISTIVITY
30	5945	873	0.159	6.289
40	5865	866	0.157	6.369
50	5775	859	0.152	6.578
60	5689	852	0.15	6.666

ductivity of lubricants at different temperature. The different comparison is shown in Figure 6.

3.1.4 Temperature- Thermal Resistivity

Thermal resistivity is the capacity of a material to oppose the flow of heat. Thermal resistivity (r) is reciprocal of thermal conductivity (k).

Relationship between Temperature and Thermal Conductivity and comparisons of different lubricant having same viscosity grade are shown in Figure 7.

4. Conclusions

In essence, a lubricant of any machinery is important as the design of the components of machinery. Equipment

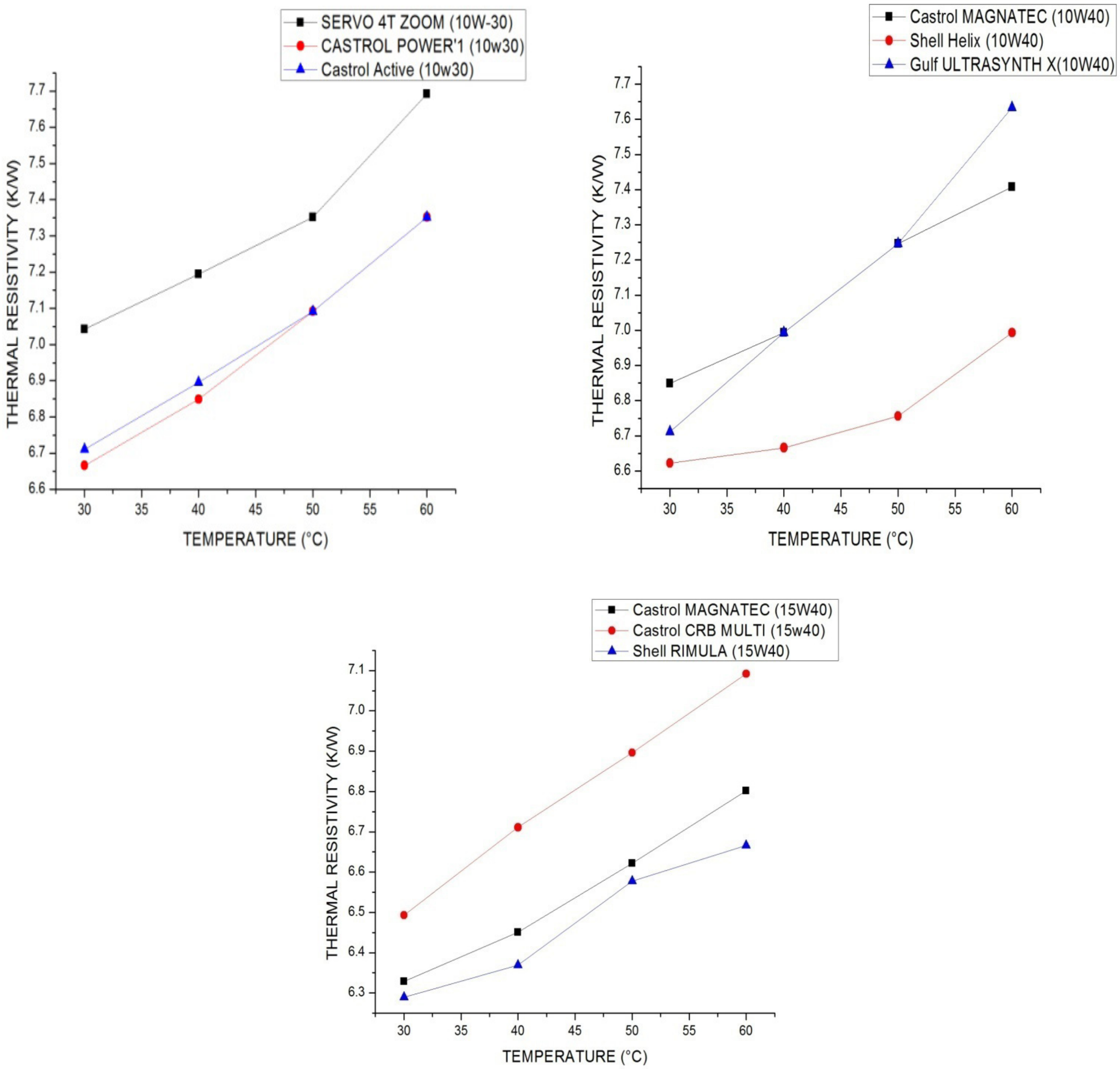


Figure 7. Temperature thermal resistivity graph.

manufacturers perform extensive research to development and to optimize each and every component of the machine to deliver the best possible performance.

The future of both the machine and the lubricant needs additional perspectives of development. For instance, all environmental aspects are of prime concern, as is superior performance. The two aspects sometimes do not go together, and consequently a judicious trade-off results. Today, some issues that are of significance include:

- Sustainability
- Enhanced durability.

Two of the main new directions that are interest of today are briefly mentioned here. It is to be understood that one or more of such developments could work in conjunction. Also, the economics and energy efficiency of these is still not fully defined at the present time and research is in progress to fully establish these.

The engine lubrication oil improved engine performance, longer engine life, reduced maintenance cost. This investigated under different engine conditions for analyzing the lubrication and wear on the engine. There would be aid-condition based monitoring strategies for wear rate and lubricant performance. The engine lubricants have a vital role in keeping an IC engine in operational and working condition and also give the proper cooling of an internal combustion engine.

5. Acknowledgement

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