CHARACTERIZATION OF MOTOR LUBRICATING OILS

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ABSTRACT

Very important component for safe and undisturbed functioning of any internal combustion engine is a sound lubrication of vital parts with engine (motor) oil. Simultaneously with engines development, new requirements were also set for engine oils in order to get more power from the engines to withstand higher working temperatures, wear and load and to last longer. At first mineral engine oils were used, but synthetic engine oils that could fulfil the highest requirements are more and more implemented. Nowadays, technically and commercially, engine oils have gained more than 60% of market share on the global market of lubricants. For proper functioning of the engine, engine oil must fulfil requirements: minimizing wear, assisting in cooling, keeping the compression ratio, reducing corrosion and friction and controlling the deposits. Lubricant characteristics and performances are managed by standard or industrial organization as API, ACEA, and SAE through specific norms. Each norm defines technical requirements as physical properties, engine tests results and other various criteria. This paper describes the importance of grade of engine oil as per SAE and compare various properties of engine oil as per their grade and brand of engine oil. It gives idea about the selection of engine oil depends on the climate condition, load, speed, driving condition and local availability etc.

Key words: lubrication, lubricants, engine oil, properties, additives

1. Preliminary observation

1.1 Introduction

The principle of supporting a sliding load on a friction reducing film is known as lubrication. The substance of which the film is composed is a lubricant, and to apply it is to lubricate. A lubricant (sometimes referred to as "lube") is a substance (often a liquid) introduced between two moving surfaces to reduce the friction between them, improving efficiency and reducing wear [1]. Lubricants are comprised of a base fluid, usually of petroleum origin, combined with added chemicals that enhance performance. Base fluids are collected from two main sources. Refined crude oil (the crude oil is refined into gasoline, diesel, kerosene, LPG, naphtha and base stocks (Lube) or a mixture of chemical compounds that perform the same task. Typically lubricants contain 90% base oil (most often petroleum fractions, called mineral oils) and less than 10% additives [2]. Lubricants play a vital role in every industry including: Electronic, Automotive, Aerospace, Forestry, Naval and numerous others. Lubrication failure may result in thousands of dollars of production losses including downtime and equipment failure. In this research paper only four wheeler gasoline engine oil is included for review purpose. It includes comparison between kinematic viscosity at 40˚C and 100˚C for different brands of engine oil, characterization of properties for different grade engine oil and takes a case study about maruti gasoline passenger car.

1.2 Properties of Lubricating Oil and its Additives [3]

The quality of a lubricating oil is tested for the following various properties like viscosity, Flash point, Pour point, Total Base Number (TBN) and Viscosity Index (VI) etc to evaluate its suitability and merits for certain service conditions.

Additives [4] are chemical compounds added to lubricating oils to impart specific properties to the finished oils. Some additives impart new and useful properties to the lubricant; some enhance properties already present, while some act to reduce the rate at which undesirable changes take place in the product during its service life. Table 1 shows the different additives, its purpose and typical compounds contained by it.

Table 1: Classification of additives

Additives	Purpose	Typical Compounds
Viscosity Index Improvers(VI)	Reduce the rate at which oil viscosity decreases with increasing temperature	Polyisobutylene, methacrylate polymers, olefin copolymers
Pour Point Depressants	Modify wax crystal formation to reduce interlocking	Alkylated naphthalene and phenolic polymers, polymethacrylates, maleate/fumerate copolymer esters
Emulsifiers	Promote formation of stable mixture (emulsion) of water & oil by changing interfacial tension	Soaps of fatty acids, sulfonic & napthenic acids, certain animal & vegetable oils
Friction Modifiers	Reduce or modify friction	Long chained polar compounds (amides, phosphates, phosphites, acids, etc)
Dispersants	Keep oil degradation by products, and/or combustion related by products in small suspended state within the bulk oil by preventing agglomeration	Alkylsuccinimides, alkylsuccinic esters, and mannich reaction products
Detergents	Keep surfaces free of deposits	Metallo-organic compounds of sodium, calcium and magnesium phenolates and phosphonates
Corrosion and Rust Inhibitor	Prevent corrosion and rusting of metal parts in contact with the lubricant	Zinc dithiophosphates, metal phenolates, basic metal sulfonates, fatty acids and amines
Anti-Wear (AW) additives	Reduce friction and wear and prevent scoring and seizure	Zinc dithiophosphates, organic phosphates, acid phosphates, organic sulfur and chlorine compounds, sulfurized fats, sulfides and disulfides

2. Lubricants market in India[5]

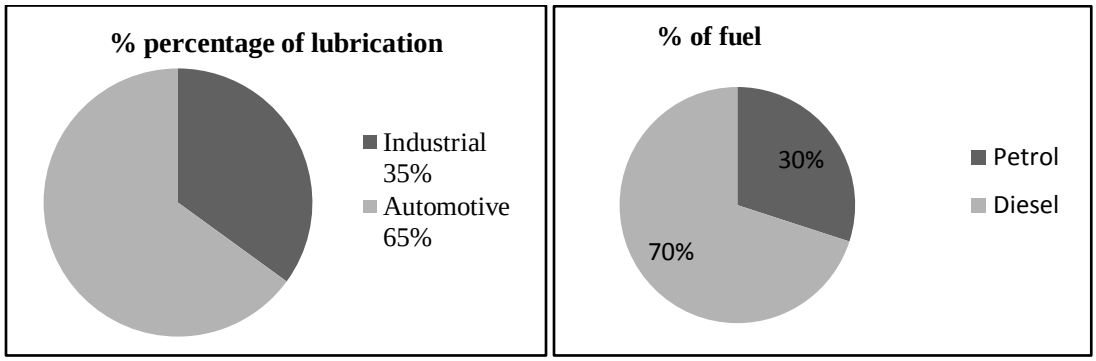

Figure 1: Indian Automotive lubricants market

India is the fifth largest lubricant market globally in volume terms behind the US, China, Russia and Japan. India is a net base oil deficit market and many additives used in lubricants are mostly imported. Volume consumption of lubricants in India has consistently declined over past few years as a result of improving lubricant and engine quality. Following figure 1 shows the market condition of the Indian Automotive Lubricants

2.1 Lubricant companies in India [6]

The India auto lubricant manufacturer produces classified into two types:

Table 2: Public sector units of engine oil

Company Name	Brand Name	Major Product
Indian Oil Corporation Ltd.	SERVO	Servo super mg, Maruti genuine oil, Servo superior xee
Bhara Petroleum Corporation Ltd.	MAK	MAK classic, MAK supreme, MAK ultima
Hidustan Petroleum Corporation Ltd.	HP	HP extra super motor oil, HP SGX, HP cruise classic

Table 3: Private sector units of engine oil

Company Name	Brand Name	Major Product
Castrol India Ltd.	Castrol	Castrol GTX , Castrol EDGE, Castrol Magnatec
Gulf Oil Corporation Ltd.	Gulf	Gulf Formula GX, Gulf MAX Supreme, Gulf Multi GTS
Shell oil corporation Ltd	Shell	Shell helix HX3, Shell helix HX5 , Shell helix HX7

The oil PSUs (IOC, HPCL and BPCL) along with Castrol control ~80% of the market, with 15 other players competing for the remaining pie. IOC is the market leader in the overall lubricants industry in PSU.

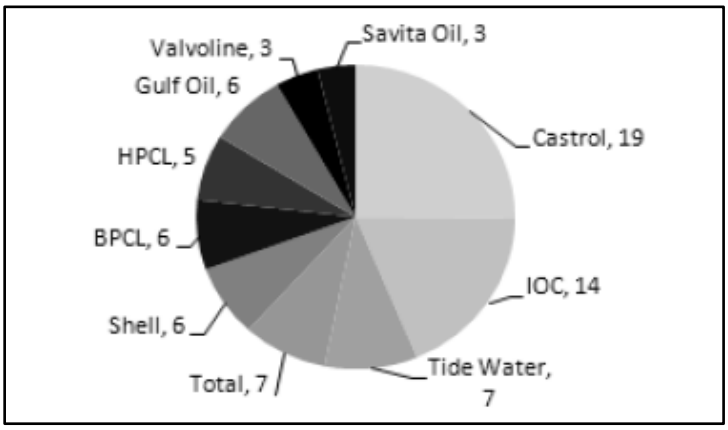

Figure 2: % of consumption in Indian market

2.2 Engine oil designation and standards [7]

Lubricant characteristics and performances are managed by standard or industrial organization as American Petroleum Institute (API), Association des Constructeurs Européensd' Automobiles (ACEA), Japanese Automotive Standards Organization (JASO) and International Lubricant Standardization and Approval Committee (ILSAC). Each standard defines technical requirements as physical properties, engine tests results and other various criteria. The Society of Automotive Engineers (SAE) established a viscosity grading system for engine oils. According to the SAE viscosity grading system all engine oils are divided into two classes: monograde and multigrade [8]:

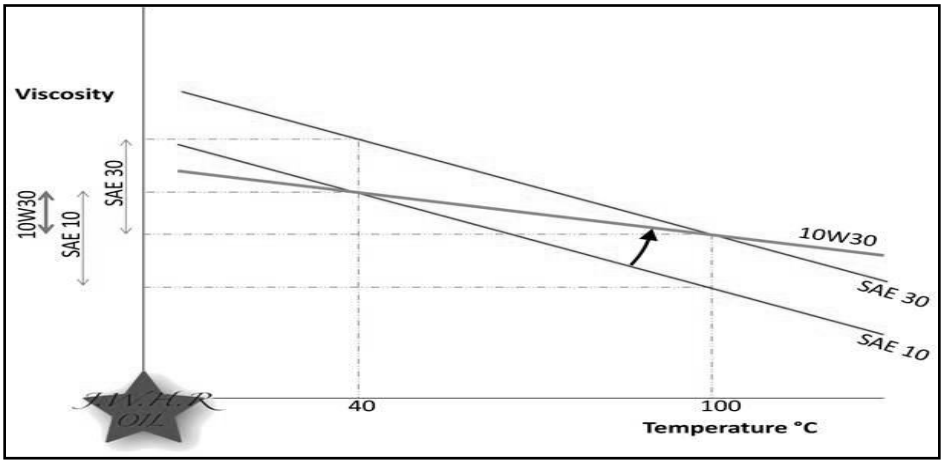

Figure 3: Monograde V/S multigrade oil

3. Characterisation of different engine oil

There are number of manufacturers with number of brands available in the market with specific properties. The selection of the lubricants for the particular engine is dependent on the number of factors [13] [15].

3.1 Compare kinematic viscosity at 40˚C and 100˚C for different brand

Figure 4 is showing the relationship between different viscosities. It is observed that at the low temperature test (at 40˚C), the viscosity variation is almost 60% but as the oil warms up, they get very close to each other. Notice that the lines do not cross even though there are only two data points, the viscosity of oil has a linear behaviour so the oil that you select is going to be important from that standpoint.

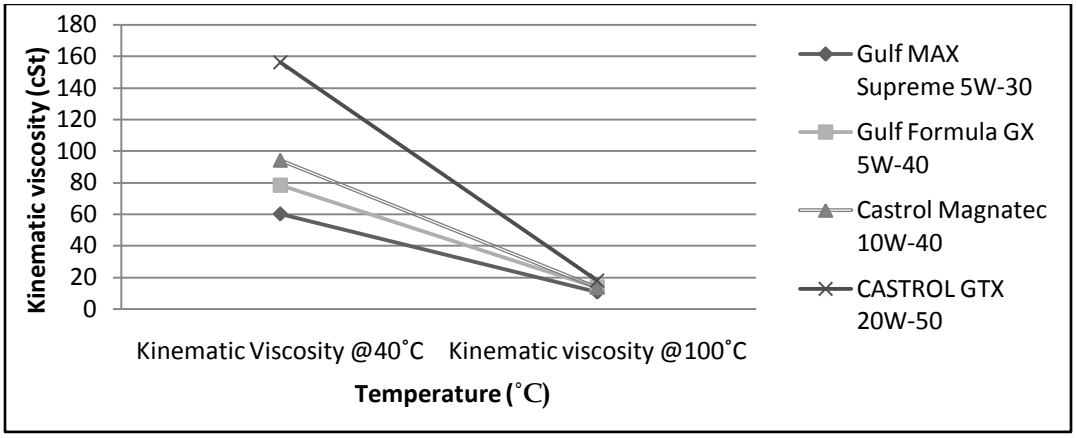

Figure 4: Oil viscosity v/s Temperature for different brand

3.2 Compare various properties of 20W-50 with 10W-30 engine oil

3.2.1 Kinematic Viscosity (D 445)

The kinematic viscosity determines the value at which the fluid can flow. With the higher grade of engine oils (20W-50), the value of kinematic viscosity is 62% to 77% higher because the engine oil is thick hence more internal deformation and shear is present. This graph shows that there is a little difference in kinematic viscosity for all types of products [9].

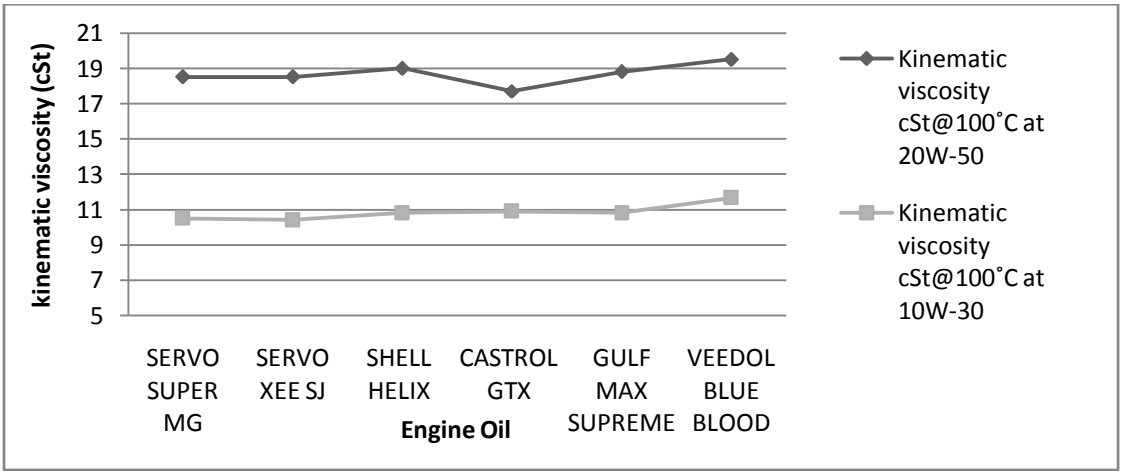

Figure 5: Kinematic Viscosity v/s Engine oil for different grade

3.2.2 Flash point (D 92)

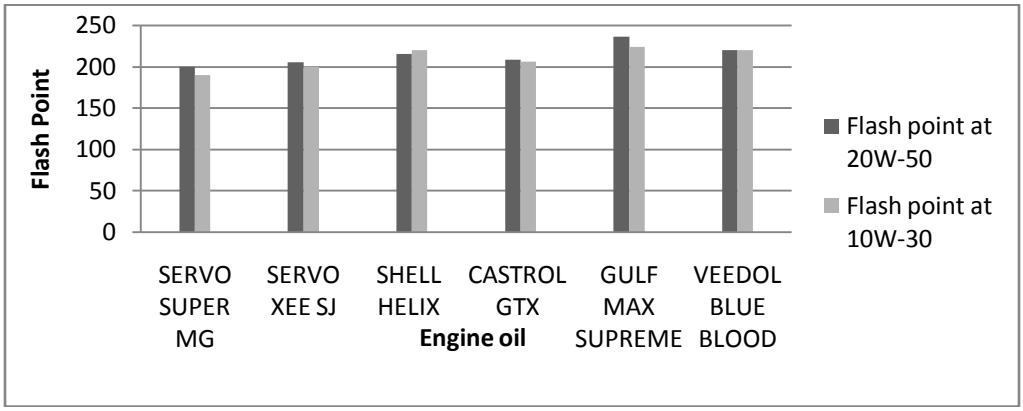

Figure 6: Flash Point v/s Engine oil for different grade

Figure 6 shows that there is only 0% to 5% change in value of flash point due to change the grade of engine oil. A higher FP is better for engine oil. Servo, Castrol and Shell have almost similar values while Gulf and Veedol have a higher flash point at the same grade of engine oil. Gulf has the highest flash point value because it is Saudi Arabian product, so the engine oil prefers more value of flash point for the particular grade.

3.2.3 Pour Point (ASTM D-97)

From the figure 7, it is observed that the value of the pour point for a higher grade of engine oil (20W50) is 12% to 55% lower as compare to the low grade of engine oil (10W30). The lower a lubricant's pour point better protection it provides in low temperature service.

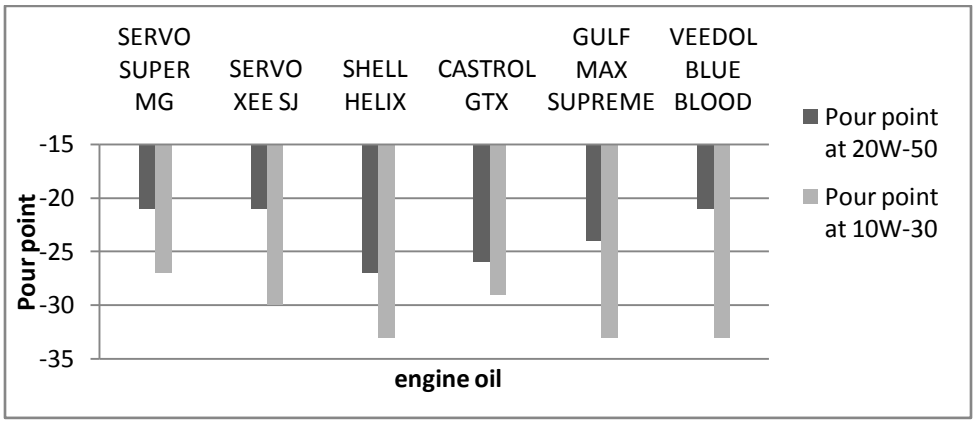

Figure 7: Pour point v/s Engine oil for different grade

3.2.4 Viscosity Index (VI) (D 2270)

It is observed from figure 8 that lower grade of engine oils have 2% to 12% higher value of viscosity index compare to higher grade of engine oils because lower grade of engine oil is suitable for cold countries where the temperature difference is quite more. A low VI means a relatively large viscosity change with temperature and a high VI denotes a smaller change of viscosity with temperature [10].

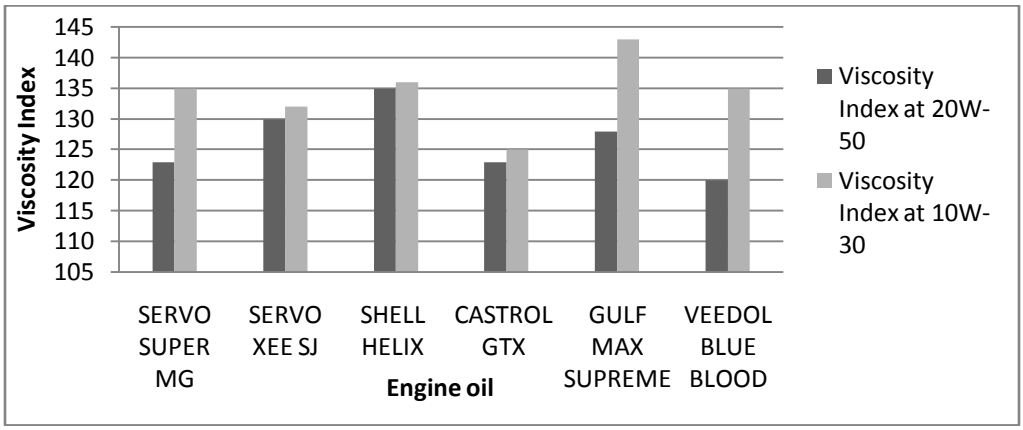

Figure 8: Viscosity Index v/s Engine oil for different grade

3.2.5 Total Base Number (ASTM D-2896)

Total Base Number (TBN) is the measurement of a lubricant's reserve alkalinity, which aids in the control of acids formed during the combustion process. Generally engine oils have a minimum TBN of about 6. Dangerously low would be 2. Oils rated for diesel have a higher TBN, around 10, because they contain more detergents.

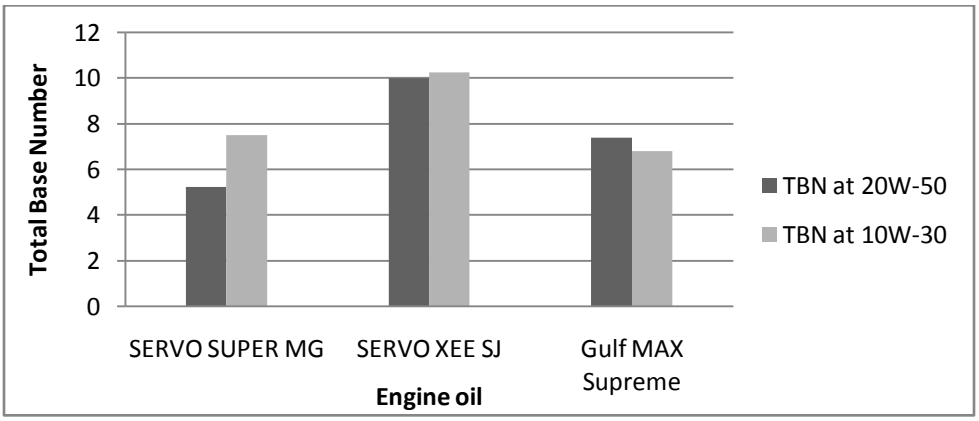

Figure 9: Total base numbers v/s Engine oil for different grade

The high TBN of Motor Oil allows it to effectively combat wear-causing contaminants and acids, providing superior protection and performance over extended drain intervals.

3.3 CASE STUDY

Engine oil 5W-30 (used in modern car) and 20W-40 (used in before 2008 model) used in maruti gasoline passenger car.

As per maruti user's manual, newer vehicles will specify lower viscosity oils such as 5W-30 while older vehicles will specify higher viscosity oils such as 20W-50. This is because today's engines are built with tighter bearing clearances to take advantage of the fuel economy benefits of lower viscosity oils. It is not really a good idea to use thicker oil in one of these engines because it will disrupt the oil flow characteristics of the engine and may create excessively high oil pressure. In an older engine that was

designed with larger bearing clearances, it is appropriate and recommended to use a thicker oil to maintain proper oil pressure and provide adequate bearing film thickness.

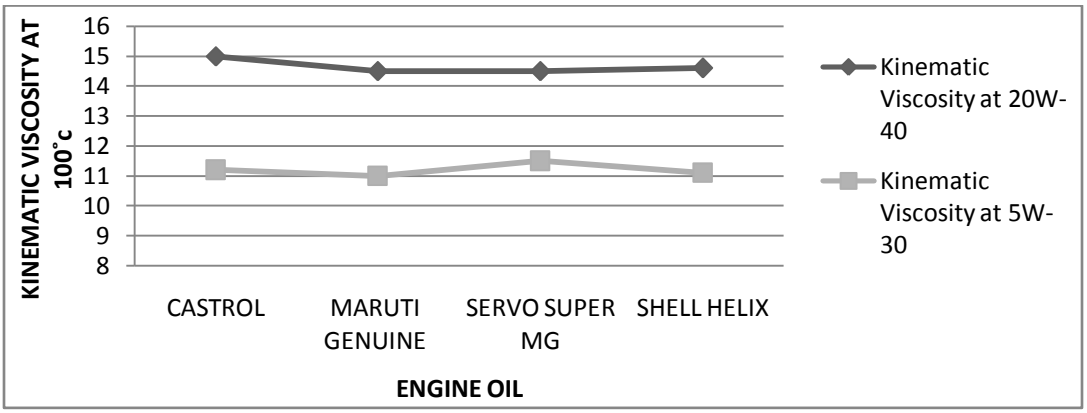

Figure 10: kinematic viscosity v/s Engine oil for 20W-40 and 5W-30

Figure 10 shows the comparison of kinematic viscosity at 20W-40 and 5W-30 grade engine oil. For both the grades of engine oil, it will follow the same trend and there is 3.5% to 4.5% variation in values which is found from the graph it indicates that we can use any brand of engine oil.

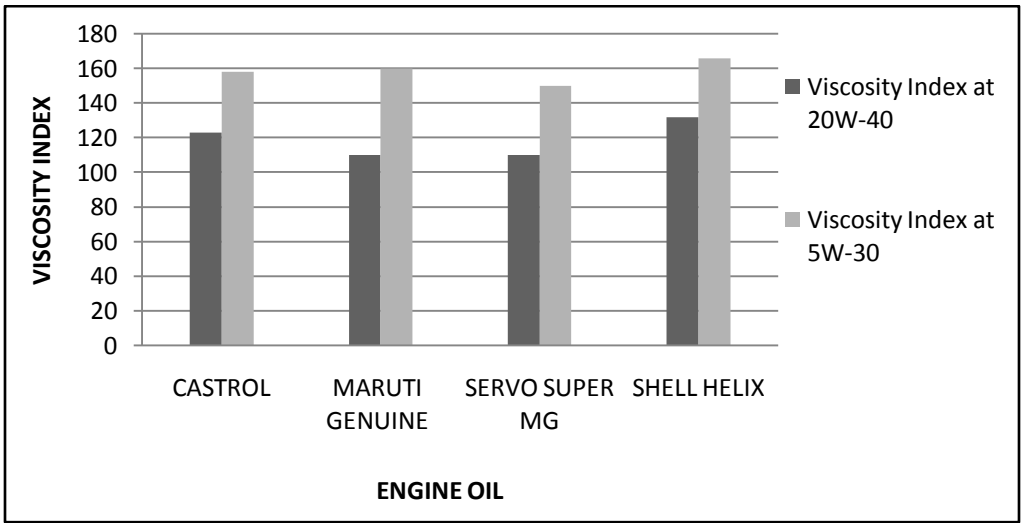

Figure 11: Viscosity Index v/s Engine oil for 20W-40 and 5W-30

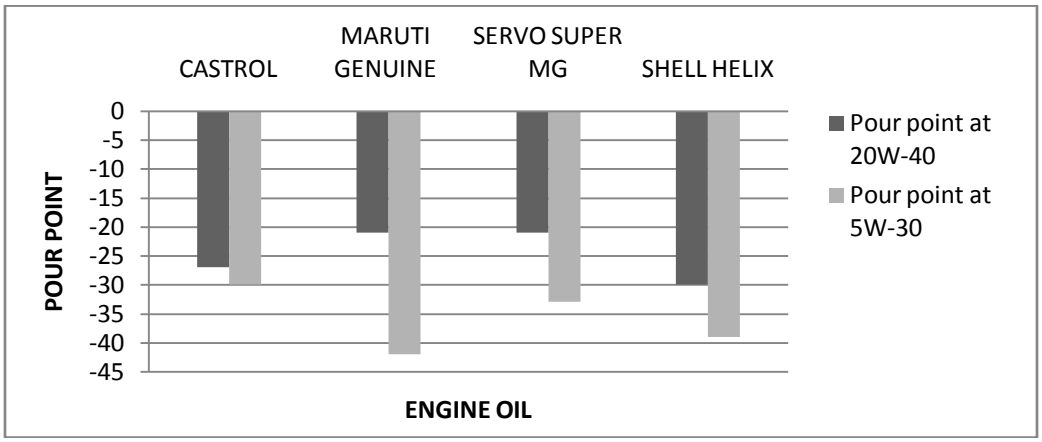

Figure 12: Pour Point v/s Engine oil for 20W-40 and 5W-30

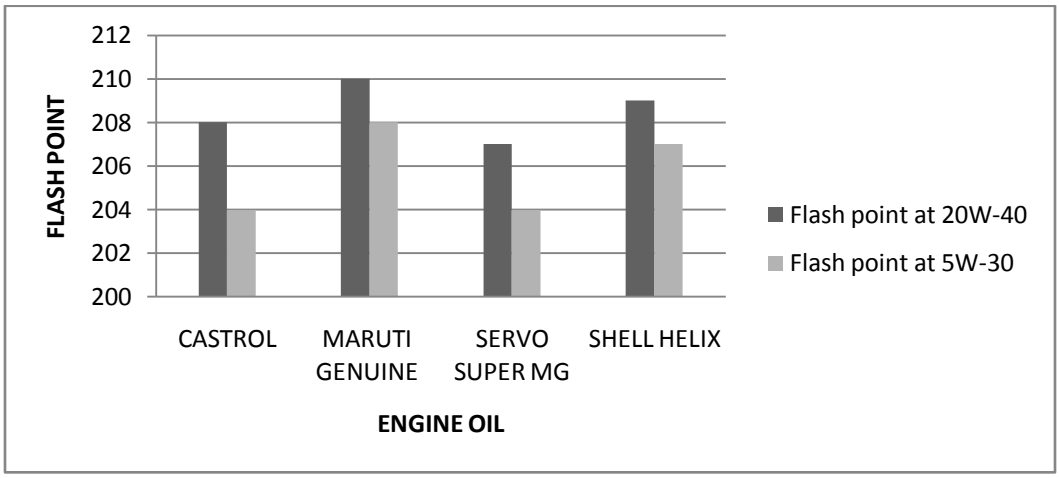

Figure 13: Flash Point v/s engine oil for 20W-40 and 5W-30

Synthetics engine oil like 5W-30 grade can be used in wide temperature extreme, not just cold weather but heat as well. So due to wide temperature range

- High viscosity index (like 25% to 45%) improver is required to take a small change in kinematic viscosity of engine oil.
- Lower value of pour point is required to take the benefits of cold condition in winter hence the variation is 5% to 20%. Maruti genuine engine oil with servo brand has the lowest value of pour point.
- The figure 13 shows that there is only 1.5% to 2% variation in flash point and it is due to change in grade only.

What type of motor oil to use, it is actually recommended by the owner's manual of the vehicle and it depends on the climate condition and clearance between the components of the engine. Maruti engine generally prefers IOC Company with servo brand. Servo has provided special name Maruti Genuine Engine Oil with 20W-40 and 5W-30 to avoid confusion with different brands and grades of engine oil. They also prefer Castrol and Shell lubrications as per the availability of engine oil with same grade.

CONCLUSION

Using the correct oil keeps your engine running smoothly and gives better performance. The selection of appropriate engine oil depends upon load, speed and driving condition of a car. However, their applicability strongly depends on the local availability and atmospheric condition.
Some of the concluding remarks based on the comparisons are given below:

- Thinner oils have a water-like consistency and pour more easily at low temperature hence it can be used for lower starting and/or operating temperature, lighter the load and faster the operating speed of an engine.
- Thick engine oil is better for maintaining film strength and oil pressure at high temperatures and loads hence it can be used where higher the starting or operating temperature, higher load and slower the operating speed of an engine.
- With the higher grade of engine oils like 20W-50, the value of kinematic viscosity 62% to 77% higher as compare to 10W-30 because the engine oil is thick hence more internal deformation and shear is present.
- It is observed that lower grade of engine oils like 10W-30 have 2% to 12% higher value of viscosity index as compare to 20W-50 because they are suitable for cold countries where wide temperature difference is there[9].
- A higher FP is better for engine oil. About 400ºF (204˚C) is the lowest acceptable FP for new oil. With the change of grade, the variation in flash point is only 0 % to 5% because it is the temperature which effect at the operating condition of an engine.
- The lower a lubricant's pour point, the better protection it provides in low temperature service. With the change of grade, the variation is quite more (depends on the grade) because it depends on the lowest temperature of an engine which depends on the climate condition of the particular region.
- The higher a motor oil's TBN, the more effective it is in suspending wear-causing contaminants and reducing the corrosive effects of acids over an extended period of time. Generally engine oils have a minimum TBN of about 6. Dangerously low would be 2.

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