LUBRICATION OIL SYSTEM DESIGN FOR A NEW 4-STROKES SINGLE-CYLINDER ENGINE CYLINDER HEAD

MUHAMMAD AFIQ BIN ZALI

Thesis submitted in fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Automotive Engineering

Faculty of Mechanical Engineering
UNIVERSITY MALAYSIA PAHANG

NOVEMBER 2009

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

Signature
Name of Supervisor: MR. MOHD FADZIL BIN ABDUL RAHIM
Position: LECTURER
Date: 4 DECEMBER 2009

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature
Name: MUHAMMAD AFIQ BIN ZALI
ID Number: MH06034
Date: 4 DECEMBER 2009

ACKNOWLEDGEMENT

First I would like to express my grateful to ALLAH s.w.t. as for the blessing given that I can finish my project.

In preparing this paper, I have engaged with many people in helping me completing this project. First, I wish to express my sincere appreciation to my main thesis supervisor Mr Mohd Fadzil, and my co-supervisor Mr Ismail Ali for encouragement, guidance, advices and motivation. Without their continued support and interest, this thesis would not have been the same as presented here.

Next, people who help me to grow further and influence my project are the colleagues who always help me in order to finish this project. I would like to express my gratitude to all my friends for their help and advices. I appreciate very much to those who help of giving the idea and information given.

Last but not least I acknowledge without endless love and relentless support from my family, I would not have been here. My father, mother, sisters and brother that always support and encourage me to success.

Thank you all.

ABSTRACT

Reliability and performance of modern engines are directly dependent on the effectiveness of lubricating systems. To be effective, an engine lubricating system must successfully perform the functions of minimizing friction between the bearing surfaces of moving parts, dissipating heat, and keeping the engine parts clean by removing carbon and other foreign matter. In almost all modern internal-combustion engines, the system that provides the lube for these functions is the forced-lubrication system. Although there are many variations in lubricating systems for internal-combustion engines, the components and method of operation are basically the same. Steady state thermal analysis is carried out for the thermal fluid flow in the engine. Solidwork software is used for modeling the design and steady state analysis. The upper piston with variation of groove has been design for this simulation. For each piston, four different radius of groove design at the upper piston are use to analyze the thermal effect to the cylinder head and engine oil temperature. For conclusion, the quality of engine lubrication depends upon how much oil is supplied and how the lubricant is fed under thermal load of the components. This state of lubrication is closely related to the safe operation of an engine and its lifetime. Therefore, a practically optimized analytical method has been required by engine designers.

ABSTRAK

Prestasi enjin moden secara langsung bergantung pada keberkesanan sistem pelinciran enjin. Untuk lebih efektif, sistem pelincir enjin seharusnya dapat memenuhi kriteria dan fungsi minyak enjin seperti mengurangkan geseran antara permukaan bersentuhan, bahagian yang bergerak,menyerap haba, dan menjaga bahagian-bahagian enjin supaya bersih dengan membuang karbon dan benda asing yang lain. Hampir semua enjin pembakaran dalaman pada masa kini menggunakan sistem jenis pelinciran paksaan. Walaupun terdapat banyak variasi dalam sistem pelincir untuk enjin pembakaran dalaman, komponen dan kaedah operasi pada dasarnya adalah sama untuk semua rekabentuk. Analisis terma dilakukan untuk menkaji aliran terma bendalir didalam enjin. Perisian Solidwork digunakan untuk merekabentuk model dan juga digunakan untuk menganalisis kesan terma ke atas enjin. Untuk simulasi ini,piston telah diubahsuai dengan menggunakan variasi pada diameter alur. Untuk setiap piston yang direkabentuk, empat diameter yang berbeza alur digunakan untuk menganalisis kesan terma pada silinder dan suhu minyak enjin. Sebagai kesimpulan, kualiti pelinciran enjin bergantung pada seberapa banyak minyak yang dibekalkan dan bagaimana pelincir bertindak di bawah kesan terma terhadap komponen yang berkaitan. Kegunaan pelinciran ini berkait rapat untuk memastikan enjin dapat operasi dengan selamat dan meningkatkan jangka hayatnya. Oleh kerana itu, kaedah analisis digunakan adalah praktikal yang disyorkan oleh pereka bentuk enjin.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF ABBREVIATIONS

3D	Three dimension
BDC	Bottom dead center
CAD	Computational aided design
CFD	Computational fluid dynamics
LL	Lower level
TDC	Top dead center
UL	Upper level

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The engine lubrication system is designed to deliver clean oil at the correct temperature and pressure to every part of the engine. To be effective, an engine lubricating system must successfully perform the functions of minimizing friction between the bearing surfaces of moving parts, dissipating heat, and keeping the engine parts clean by removing carbon and other foreign matter.

1.2 PROBLEM STATEMENT

From the previous study of the lubrication oil system in the four strokes engine, it is noticed that reliability and performance of the engines are directly dependent on the effectiveness of their lubricating systems. To be effective, an engine lubricating system must successfully perform the functions.

This study will improve the lubrication oil system in the four strokes engine using a new single cylinder head engine by removing the valve train on the cylinder head and develop piston that controlled intake port, maintaining the four strokes engine while adding another piston with two strokes that replacing the cylinder head.

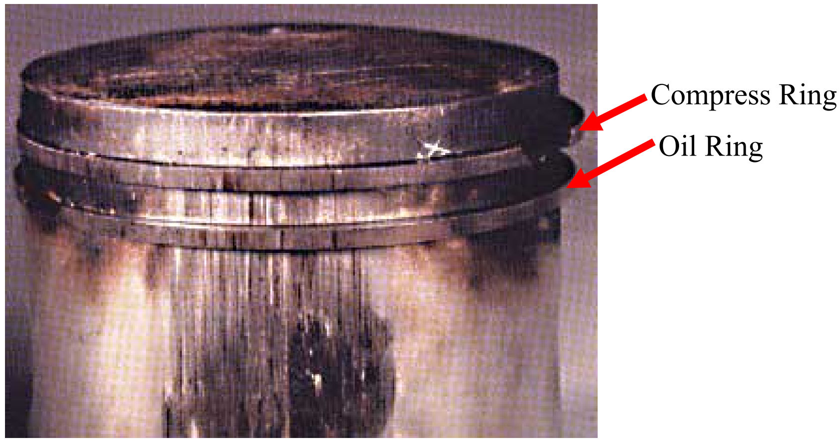


Figure 1.1: Piston with lubrication failure

Source: Laimbock 2002

Figure 1.1 shows scuffing marks on the exhaust side of the skirt without corresponding marks on the intake side. The lubrication film failed under thermal load.

1.3 OBJECTIVE

The objectives of this project are:

i) Analyze the effectiveness and design the flow diagram of lubrication system in a new cylinder head.
ii) Simulate and visualize the actual lube oil flow throughout the new cylinder head.

1.4 SCOPES

The following scopes are including in the study:

i) Design the conceptual model of lubrication system by using Computational Aided Design (CAD)
ii) Define the parameter involve.

iii) Simulation and design analysis by using Computational Fluid Dynamics (CFD)
iv) Design comparison.

1.5 PROJECT FLOW CHART

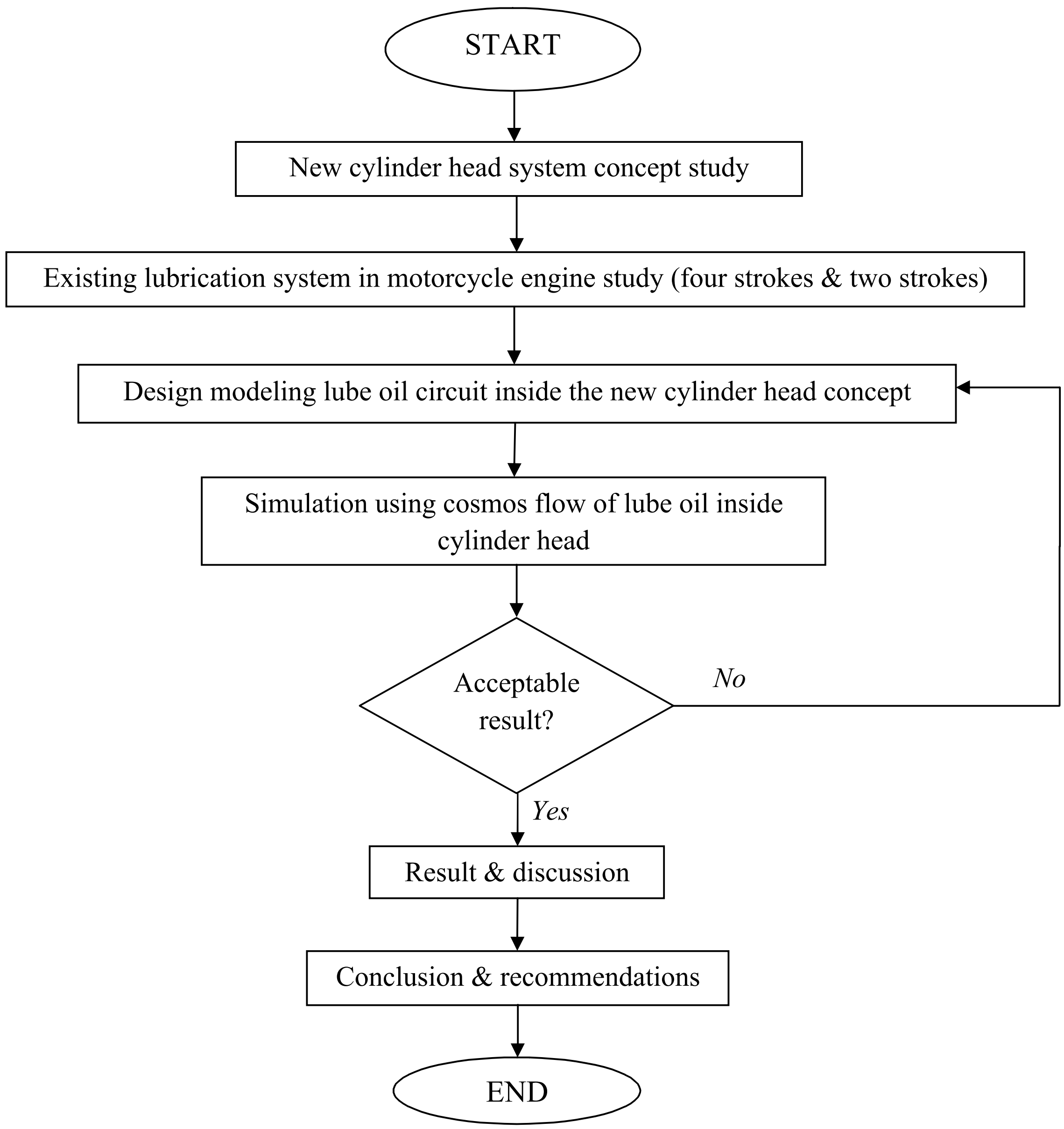


Figure 1.2: Project flow chart

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

The purpose of this chapter is to provide a review of the past research related to the lubrication system in engine, six strokes engine and flow diagram of lubrication, type of lubricant, governing equation of CFD, and thermal fluid analysis.

2.1 BASIC OPERATION OF SIX STROKES ENGINE

The six-stroke engine is a type of internal combustion engine based on the four-stroke engine, but with additional complexity to make it more efficient and reduce emissions. Two different types of six-stroke engine have been developed since the 1990s. Figure 2.1 shows the basic components of six strokes engine.

In the first approach, the engine captures the waste heat from the four-stroke Otto cycle or Diesel cycle and uses it to power an additional power and exhaust stroke of the piston in the same cylinder. Designs use either steam or air as the working fluid for the additional power stroke. As well as extracting power, the additional stroke cools the engine and removes the need for a cooling system. The pistons in this type of six-stroke engine go up and down six times for each injection of fuel.

The second approach to the six-stroke engine uses a second opposed piston in each cylinder that moves at half the cyclical rate of the main piston, thus giving six piston movements per cycle. Functionally, the second piston replaces the valve mechanism of a conventional engine but also increases the compression ratio (Beare 1998).

2.1.1 Six Strokes Engine Diagram

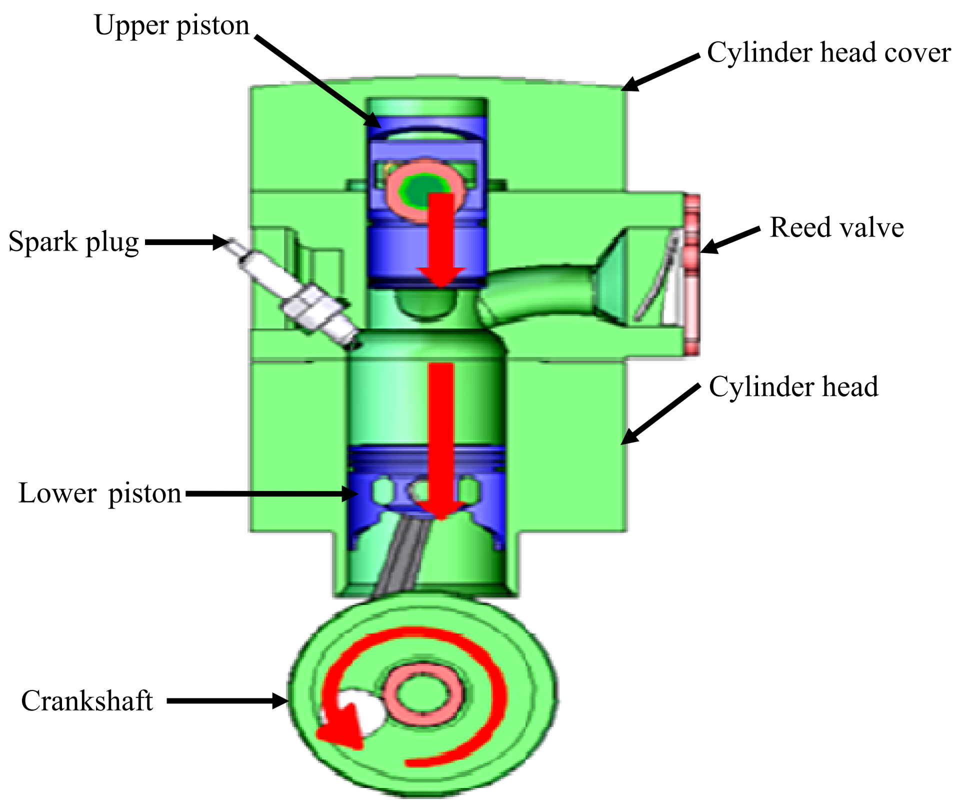


Figure 2.1: Cross sectional view of six strokes engine

Source: Amran 2008

2.1.2 Sequence of Operation for Six Stroke Engine

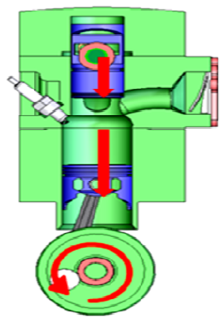
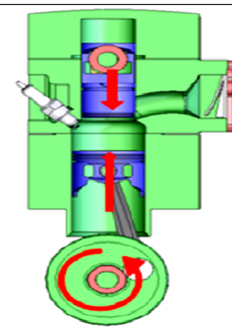
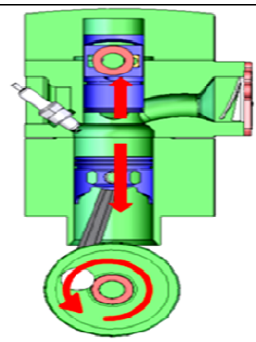
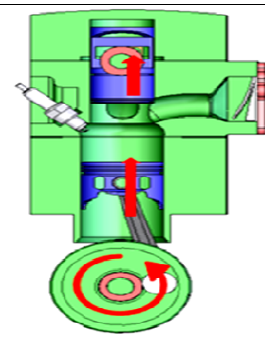
 **Figure 2.2 (a)** : Intake Strokes	 **Figure 2.2 (b)** : Compression Stroke
Piston starts moving downwards from top dead center (TDC) to bottom dead center (BDC). Upper piston starts moving down from upper level (UL) to lower level (LL). Vacuum created inside cylinder pulls air+fuel through reed valve. When piston reaches BDC, upper piston traveled ½ of its upper stroke.	Piston starts compressing the mixture by going towards TDC. Upper piston still going downwards to its LL. This further compresses the mixture.
 **Figure 2.2 (c)** : Power Stroke	 **Figure 2.2 (d) :** Exhaust Stroke
Just before piston reach TDC & upper piston is at LL position, ignition occurs. Expansion/power drives the piston downwards & the upper piston upwards. Thus upper piston contributes to power delivery, not consumes power as a valve-train will do. At the end of power stroke, upper piston will reach ½ of its upper stroke.	As piston moves upward from BDC to TDC, upper piston will also move upward another ½ of upper stroke. At the same time, the disc/rotary valve opens the exhaust port to atmosphere allowing exhaust gases to be expelled.

Table 2.1: Head operation sequence for six strokes engine

2.2 BASIC PRINCIPLE OF LUBRICATIONS

Engine oil is expected to provide a protective film, to prevent metal to metal contact (wear) and reduce friction. It must help remove heat from engine surfaces (i.e. piston), and flush away wear particles. It also aids in sealing the piston rings, serves as a hydraulic fluid (i.e. hydraulic lifters) and in some motorcycles, transfers power through a wet clutch assembly and lubricates the gearbox.

Viscosity is a measure of the resistance of a fluid which is being deformed by either shear stress or extensional stress. In everyday terms (and for fluids only), viscosity is "thickness". Thus, water is "thin", having a lower viscosity, while honey is "thick" having a higher viscosity. Viscosity describes a fluid's internal resistance to flow and may be thought of as a measure of fluid friction (Crouse 1993).

2.2.1 Keep Moving Parts

Lubricants are typically used to separate moving parts in a system. This has the benefit of reducing friction and surface fatigue together with reduced heat generation, operating noise and vibrations.

2.2.2 Reduce Friction

Typically the lubricant-to-surface friction is much less than surface-to-surface friction in a system without any lubrication. Thus use of a lubricant reduces the overall system friction. Reduced friction has the benefit of reducing heat generation and reduced formation of wear particles as well as improved efficiency. Lubricants may contain additives known as friction modifiers that chemically bind to metal surfaces to reduce surface friction even when there is insufficient bulk lubricant present for hydrodynamic lubrication.

2.2.3 Transfer Heat

Both gas and liquid lubricants can transfer heat. However, liquid lubricants are much more effective on account of their high specific heat capacity. Typically the liquid lubricant is constantly circulated to and from a cooler part of the system, although lubricants may be used to warm as well as to cool when a regulated temperature is required. This circulating flow also determines the amount of heat that is carried away in any given unit of time. High flow systems can carry away a lot of heat and have the additional benefit of reducing the thermal stress on the lubricant.

2.2.4 Carry Away Contaminants and Debris

Lubricant circulation systems have the benefit of carrying away internally generated debris and external contaminants that get introduced into the system to a filter where they can be removed. Lubricants for machines that regularly generate debris or contaminants such as automotive engines typically contain detergent and dispersant additives to assist in debris and contaminant transport to the filter and removal.

2.2.5 Protect Against Wear

Lubricants prevent wear by keeping the moving parts apart. Lubricants may also contain anti-wear or extreme pressure additives to boost their performance against wear and fatigue.

2.2.6 Prevent Corrosion

Good quality lubricants are typically formulated with additives that form chemical bonds with surfaces to prevent corrosion and rust.

2.2.7 Seal for Gasses

Lubricants will occupy the clearance between moving parts through the capillary force, thus sealing the clearance. This effect can be used to seal pistons and shafts.

2.3 TYPE OF LUBRICANT

Table 2.2: Type of grade oil

Fully Synthetic	**Characteristics**
0W-30	Fuel economy savings
0W-40	Enhances engine performance and power
	Ensures engine is protected from wear and deposit build-up
5W-40	Ensures good cold starting and quick circulation in freezing temperatures
Semi-synthetic	**Characteristics**
5W-30	Better protection
10W-40	Good protection within the first 10 minutes after starting out
	Roughly three times better at reducing engine wear
15W-40	Increased oil change intervals
Mineral	**Characteristics**
10W-40	Basic protection for a variety of engines
15W-40	Oil needs to be changed more often

Source: Lansdown 2004

An engine oil's job is primarily to stop all the metal surfaces in engine from grinding together and tearing themselves apart from friction whilst transferring heat away from the combustion cycle. Engine oil must also be able to hold all the nasty by-products of combustion, such as silica (silicon oxide) and acids in suspension. It cleans the engine of these chemicals and build-ups, and keeps the moving parts coated in oil. Finally, engine oil minimizes the exposure to oxygen and thus oxidation at higher temperatures. It does all of these things under tremendous heat and pressure. Table 2.3 shows the criteria of different type of grade oil.

The proper viscosity is the single most important criteria of a lubricating oil. The basic performance of machinery is based on the viscosity of the lubricant. Viscosity is, if you like, the resistance to the flow ability of the oil. The thicker an oil, the higher its viscosity. Figure 2.4 shows a rough guide to ambient temperatures vs oil viscosity performance in both multigrade (top half) and single grade (lower half) oils (Marchetti 2005).

Multigrade oils work by having a polymer added to a light base oil which prevents the oil from thinning too much as it warms up. At low temperatures, the polymers are coiled up and allow the oil to flow as it's low number (W number) indicates. As the oil heats up, the polymers unwind into long chains which prevent the oil from thinning as much as it normally would. The result is that at 100°C, the oil has thinned only as much as it's higher rating.

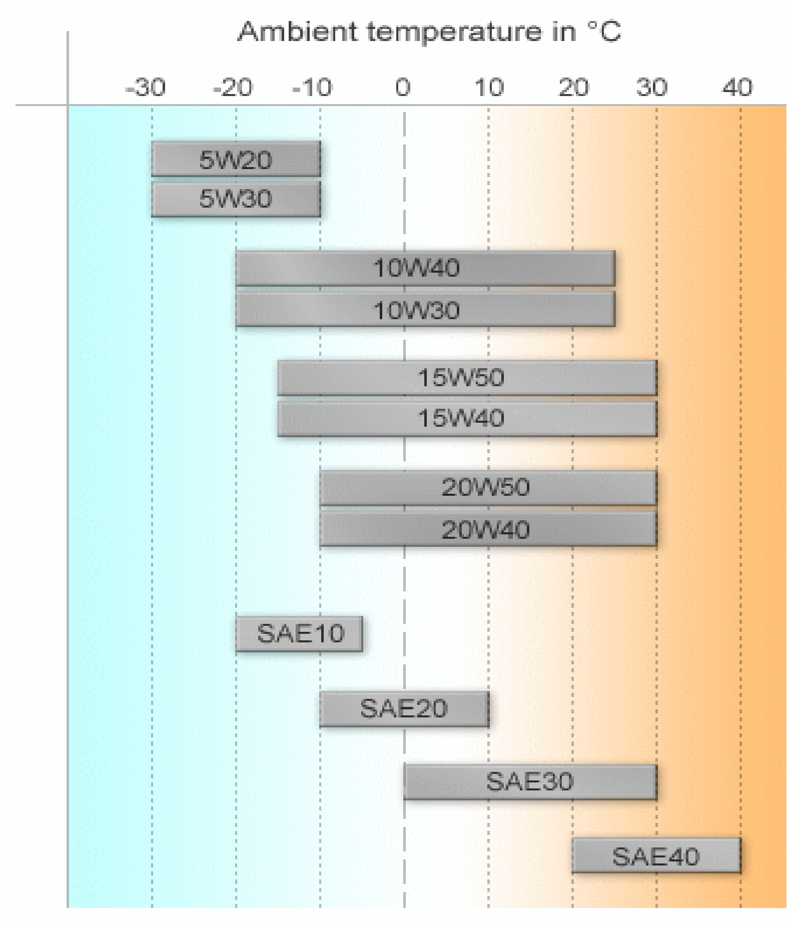


Figure 2.2: Ambient temperatures versus oil viscosity performance

Source: Lansdown 2004

2.3.1 Properties of Engine Oil

For satisfactory lubrication of the engine the oil should possess some functional properties of which viscosity of oil is one of the most important properties, as it brings out the oil's capacity to lubricate. Viscosity is the measure of oil's resistance to flow. Figure 2.5, 2.6, 2.7, 2.8 shows the viscosity, density, specific heat and thermal conductivity versus temperature of engine oil.