SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Material)"

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Date : 21 JUN 2013

DECLARATION

'I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged.'

Signature:

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Date: 21 / 6 / 2013

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ABSTRAK

Di dalam enjin diesel jelaga terbentuk akibat berlakunya proses pembakaran yang tidak lengkap di kebuk pembakaran. Sesetengah jelaga ini akan bergerak ke piston engine dan seterusnya akan masuk ke dalam minyak pelinciran. Jelaga menyebabkan minyak pelincir menjadi pekat. Pada satu masa kadar penyerapan minyak pelincir akan mencapai tahap maksimum. Kesannya jelaga akan melekat pada ruang pembakaran dalam enjin dan kesan lanjutannya piston dalam enjin akan menjadi haus. Kajian simulasi jelaga bertujuan untuk membuat analisis tentang saiz jelaga untuk keseluruhan ruang pembakaran dalam enjin diesel. Melalui kajian ini, kita boleh lihat corak tumpuan saiz jelaga dalam enjin. Kajian mengenai jelaga ini sangat penting kerana jelaga ini sangat merbahaya kepada engin dan alam sekitar.

ABSTRACT

In a diesel engine the soot produce because of incomplete fuel combustion happen in combustion chamber. Some of this soot will move to piston and slowly move downward were the lubricant oil is located. This soot make the lubricant oil become dirty and increase it viscosity. Until one moment, the oil lubricant has reach its limit in absorbing soot. As a result soot will be stick on the combustion chamber and lastly it will cause engine wear. Soot simulation research is done to create analysis of soot-size inside the combustion chamber of diesel engine. From this research, we can see the pattern concentration of soot-size inside the engine. This soot research is important because soot is very dangerous to engine and environment.

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NOx = Nitrogen Oxide

CO2 = Carbon dioxide

PAH = Poly-aromatic hydrocarbons

C_2H_2 = Acetylene

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CHAPTER 1

INTRODUCTION

1.0 PROJECT BACKGROUND

In this globalization era, soot emission is one of the problems that contribute most of the air pollution and it also will affect health. Soot particle is poisonous to our body because it will leads health problem such as irritation of the eyes, nose, and throat vomiting, light-headedness, headache, heartburn, numbness, bronchitis, chronic respiratory, cardiovascular, cardiopulmonary and allergic diseases such as shortness of breath and painful breathing, cancer, and premature death [R.` Prasad, 2010]. As we know, the property of soot which is dark in color. If they accumulate on a clean surface it will darken the surface. Compared with dust, it will show non-significant color. So the property of soot will make our properties such as vehicle easy to be dirty. Based on previous research, most of emission of soot come from vehicle especially form un-service vehicle. Internal combustion engines produce soot as a result of incomplete fuel combustion. Ideally, complete combustion in a cylinder would only produce carbon dioxide and water, but no engine is completely efficient [M. Dave, 2000].

Because of the way that fuel is injected and ignited, soot formation occurs more commonly in diesel than in gasoline engines. Unlike gasoline engines where the fuel/air mixture is ignited with a spark, fuel and air entering the diesel cylinder ignite spontaneously from the high pressure in the combustion chamber. The fuel and air mixture in diesel engines typically does not mix as thoroughly as it does in gasoline engines. This creates fuel-dense pockets that produce soot when ignited. While the majority of soot easily escapes through the exhaust, some gets past the piston rings and ends up in the oil [M. Dave, 2000].

1.1 PROBLEM STATEMENT

In engine combustion system, soot is developed when the process of the combustion in diesel engine is not in complete combustion. High development of soot will cause the motor oil exceed their ability to absorb soot and this cause the soot to accumulate on the inner wall of the engine. High contaminant of soot will increase the acidic level of the engine. This will leads to corrosion and engine weariness [DA Green, 2008]. If there is a way to cope this problem, soot emission will not be an issue on the environmental problem.

So, this research is done to study the soot size inside the engine and its behavior. By doing this research, the knowledge of soot particle size and its number distribution is important in both areas, environmental and diesel engine maintenance. The key reason for going from mass to number limit is the health hazard posed by the smallest particles which contribute little to mass emitted. However, with current measurement technology, smaller particles could pass through measuring equipment undetected thus giving rise to the concern of meaningless soot emission legislations [Mahmood, 2011].

Soot particle size and number distribution also influence the behavior of particles in the environment and within the engine itself. Particle size influences the environmental impacts of engine exhaust particles in several ways: it influences the atmospheric residence time of the particles, the optical properties of the particles, the particle surface area and ability to participate in atmospheric chemistry, and the health effects of the particles. In the engine environment, soot particle size and its distribution influence how the soot particles grow from nucleation, how they coagulate, agglomerate and oxidize, and finally how the soot particles are transferred to the liner before they are scraped into the engine oil. The size and distribution of in-cylinder soot particles, during the engine cycles, influence the size of soot particles at the exhaust tailpipe. It also affects the interactions between the in-cylinder soot particles and the cylinder wall which may in turn influences the amount of soot entry into the engine oil [Mahmood, 2011]. Due to these, the investigation of in-cylinder soot particle size and distribution is valuable.

1.2 OBJECTIVE

- Develop a model that shows the soot movement inside diesel engine using MATLAB software.

1.2 SCOPE

- Study the soot movement that develop under combustion process of a diesel engine.

CHAPTER 2

LITREATURE REVIEW

2.1 SOOT DEFINITION

Soot is impure carbon particles resulting from the incomplete combustion of hydrocarbons. It is more properly restricted to the product of the gas-phase combustion process but is commonly extended to include the residual pyrolyzed fuel particles such as coal, cenospheres, charred wood, petroleum coke, and so on, that may become airborne during pyrolysis and that are more properly identified as cokes or chars [J. Eilperin, 2013].

Soot, as an airborne contaminant in the environment has many different sources but they are all the result of some form of pyrolysis. They include soot from coal burning, internal combustion engines, power plant boilers, hog-fuel boilers, ship boilers, central steam heat boilers, waste incineration, local field burning, house fires, forest fires, fireplaces, furnaces, etc. These exterior sources also contribute to the indoor environment sources such as smoking of plant matter, cooking, oil lamps, candles, quartz/halogen bulbs with settled dust, fireplaces, defective furnaces, etc.

Soot in very low concentrations is capable of darkening surfaces or making particle agglomerates, such as those from ventilation systems, appear black. Soot is the primary cause of "ghosting", the discoloration of walls and ceilings or walls and flooring where they meet. It is generally responsible for the discoloration of the walls above baseboard electric heating units and can be known as a gas [Scienfield, 2012]. Figure 2 shows an example of emission of soot by a diesel truck.

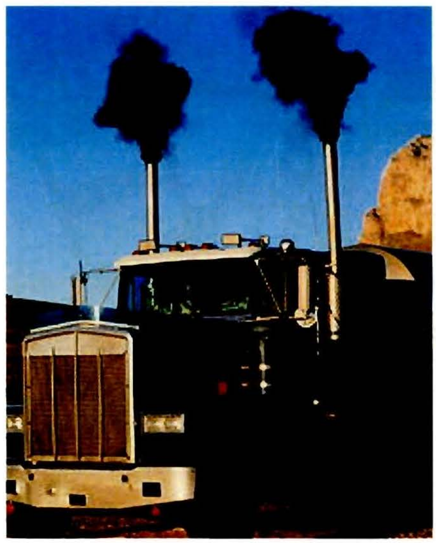

Figure 2: Emission of soot from a large diesel truck, without particle filters (Source: planetsave.com)

2.2 DIESEL ENGINE COMPONENT

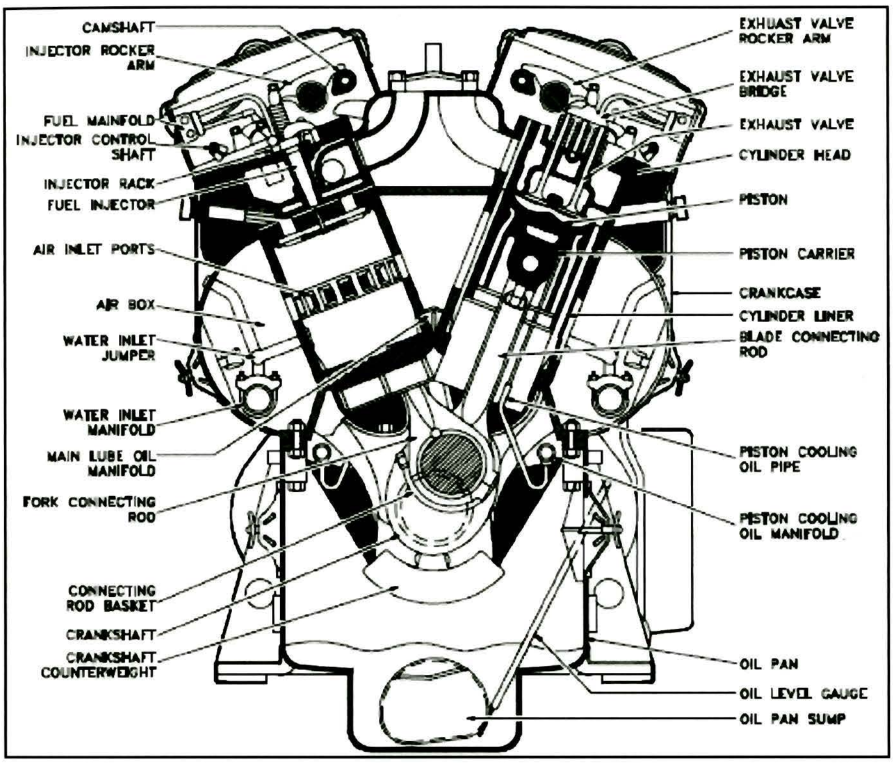

Figure 2.1: Cross section of V-type diesel engine

(source : Barbara Meinkiel, 2012)

The main components of a diesel engine are [Menkiel, 2012],

- Cylinder block: usually made of grey cast iron (low cost and high resistance to wear). It houses both the cylinders and pistons.
- Cylinder head: is made from iron and aluminium, is connected to the top of cylinder block and forms top of combustion chamber. In diesel engines the cylinder head contains the fuel injectors and valves. The In-line engine has one cylinder head for all the cylinders.

- Valves and valve trains: are usually made from forged alloy steel. Sometimes steel is mixed with chromium or silicon to make them more resistant to corrosion. Exhaust valves are frequently made from nickel based alloy. Valves are located in the cylinder head.
- Camshaft and drives: made of hardened iron alloy or steel, the camshaft is usually cast or machined. Its main function is driving the valves and is supported by the main bearings. The number of bearings depends on number of cylinders and typically is one more than number of cylinders.
- Crankshaft: is made of alloy steel of great mechanical strength. Is attached to the connecting rod in areas called throws - where the downward power pulses change into rotating motion.
- Crankcase: is often integrated with the cylinder block and is sealed at the bottom with a pressed steel or cast aluminium oil pan.
- Piston: is made of aluminium and its design depends on the engine type. Pistons transfer the gas energy into the crank through connecting rods. The piston is fitted with rings used to seal the cylinder and prevent both heat and pressure from escaping. Upper rings are called compression rings and lower oil rings. Oil rings scrape the oil from the cylinder wall and returns it to crankcase.

2.3 DIESEL ENGINE OPERATING CYCLE

Most engines operate on a four-stroke cycle. To complete the sequence of events, the piston has to complete four strokes that correspond to two crankshaft revolutions. Four strokes are schematically presented in figure shown and are composed of [Menkiel, 2012]:

1. An intake stroke starting at TDC and ending at with piston at BDC. In this stroke air mixture enters the combustion chamber. The intake valves open just before the stroke starts and close after it ends.

2. A compression stroke when all valves are closed and the mixture inside the cylinder is compressed to a small volume while piston moves towards TDC. Towards the end of compression stroke, the combustion is initiated and the cylinder pressure rapidly rises.

3. A power stroke (expansion stroke) starting at TDC and ends at BDC. High-temperature and high-pressure gases push down the piston and force the crank to rotate. While the piston approaches BDC the exhaust valves open and the in-cylinder pressure drops.

4. An exhaust stroke in which gases remaining after combustion exit the cylinder. The piston in this time moves towards TDC and just after the exhaust valves close, the intake valves open and the cycle begins again.

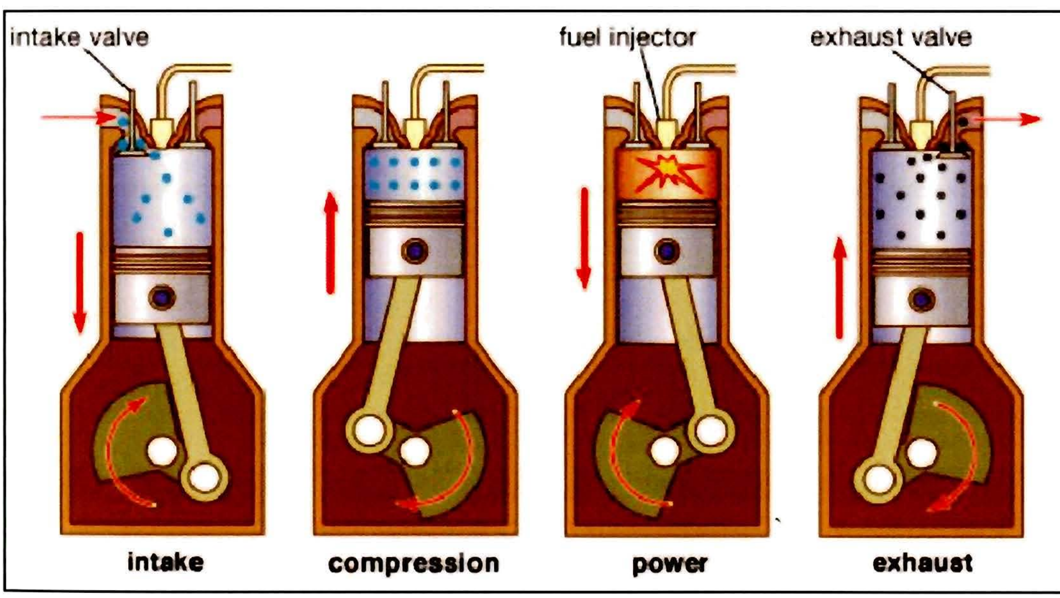

Figure 2.2: 4 stroke stages of diesel engine

(Source: Encyclopedia Brintannica)

2.4 DIESEL ENGINE COMBUSTION PROCESS

The combustion process in a diesel engine is a combination of complex chemical and physical mechanisms. The process starts from the injection of fuel under high pressure near the end of the compression stroke. A high speed fuel jet enters the combustion chamber through the injector nozzles and its liquid core quickly brakes up into small droplets. A turbulent environment together with the swirl of the intake air improves the mixing process of air and fuel. The time available for mixing in a diesel engine is limited and it is therefore imperative to achieve the best possible atomization. While the piston moves towards TDC, the in-cylinder pressure and temperature increases and the injected fuel quickly evaporates. Combustion is initiated while the temperature reaches the level sufficient for spontaneous auto-ignition and this temperature is one of the most important parameters in combustion process. Auto-ignition depends on in-cylinder temperature (pressure), concentration of air, fuel and its chemical composition. Fuel auto-ignition is characterized by cetane number and may occur simultaneously in different locations of combustion chamber. The production of soot and compounds like nitrogen oxides, carbon monoxides, carbon dioxides and unburned hydrocarbons are correlated with combustion process and are known as pollutants [Menkiel, 2012].

2.5 ADVANTAGES AND DISADVANTAGES OF DIESEL ENGINE

An increase in the popularity of diesel engines over recent years is a result of their numerous advantages over gasoline combustion engines. The advantages and disadvantages of diesel combustion engines are as shown in table 2 [Alastaik, 2003];

Table 2: Advantage and disadvantage of diesel engine

Advantages	Disadvantages
Diesel engined vehicles tend you have a higher resale value then the petrol equivalent.	Diesel engine vehicles are more expensive than the equivelent petrol model.
Diesel engines can save you money on fuel if you make regular long journeys.	Occasionally servicing can be more costly than petrol engines.
Diesel engines have more torque than the petrol equivalent meaning fewer gear changes and lots of overtaking flexibility.	Parts tend to be more expensive for diesel engines.
Longer lifetime in comparison to petrol engines	The cost of diesel at the pump is higher then petrol (higher fuel tax on diesel).
Lower vehicle excise duty due to the greater fuel economy.	Diesel vehicles tend to emit more particulates than petrol.
Lower maintenance cost	Diesels are generally more noisy (in a bad way) so not what you want if you are buying a sports car.
Can run with bio-fuels	

2.6 DIFFERENCE BETWEEN GASOLINE ENGINE AND DIESEL ENGINE

Table 2.1: Difference between gasoline engine (petrol engine) and diesel engine

Diesel engine	Gasoline engine
➢ Air is compress first and then the fuel is injected because air heats up when it is compressed ➢ The fuel ignited	➢ Fuel is mixed with air compressed by pistons and ignited by sparks from spark plug
➢ Use only air compression to ignite its fuel	➢ Petrol engine use spark plugs to ignite its fuel
➢ Diesel engine use their fuel much more efficiency than equivalent-size petrol engine	➢ For long period of running time engine can be allowed to turn much faster than diesel engine

2.7 SOOT FORMATION MECHANISM

Soot is impure carbon particles resulting from the incomplete combustion of hydrocarbons. Soot formation is a very complicated process involving hundreds of elemental steps. Qualitatively, there are seven stages that lead to a primary soot particle [Mahmood, 2011]:

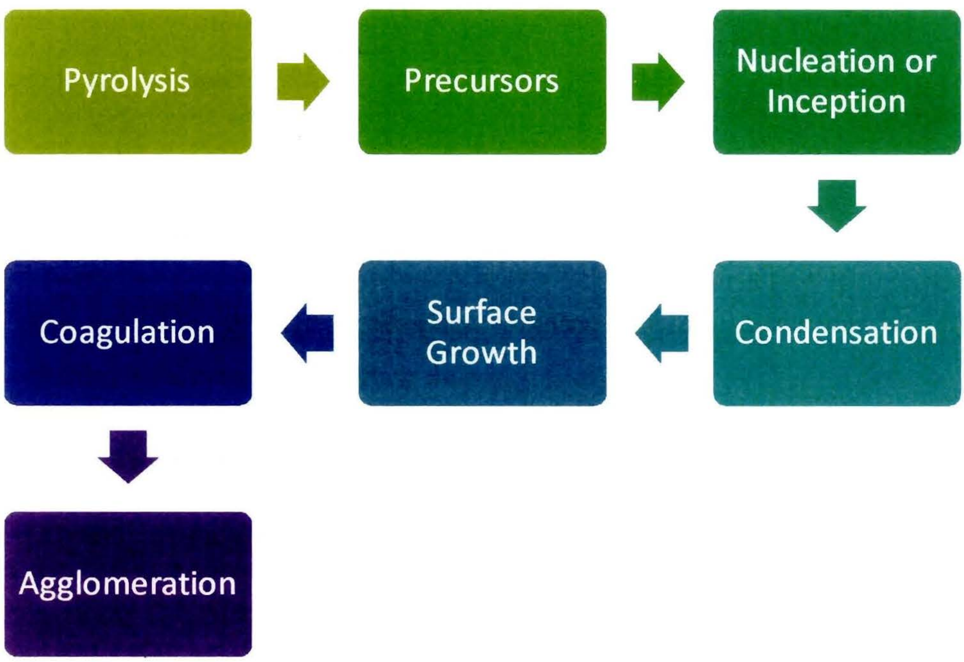

Figure 2.3: Flow chart of soot formation mechanism

Pyrolysis

- Pyrolysis is the process of fuel changing their molecular structure in the present of high temperature without significant oxidation even though oxygen species are present.
- Produce unstaturated hydrocarbon, polyacetylenes and other aromatic compound..