CO_2 CAPTURE FROM EXHAUST GAS TO IMPROVE FUEL ECONOMY IN SINGLE CYLINDER DIESEL ENGINE

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This thesis is submitted in partial fulfillment of the requirements for the Bachelor of Mechanical Engineering (Automotive)

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JUNE 2015

DECLARATION

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

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DEDICATION

I dedicate this thesis especially to my beloved father and mother

ACKNOWLEDGEMENT

Alhamdulillah, I would like to thank Allah for giving me the strength and opportunity to finish this project. I owe great thanks to everyone who is always been with me and guided me through my studies in Universiti Teknikal Malaysia Melaka.

I would like to express my deepest appreciation to my supervisor, Prof. Madya. Dr. Noreffendy bin Tamaldin, who has willingly to offer his great effort and support for my final year project. He has constantly give guidance in helping me to complete this project. His experienced and knowledge in my field of study, has given a lot of contribution in my project.

I would also give my special thanks to my beloved family especially, my mother, Habsah binti Mohd Rodi, whose always encourage and give me support and never stop prayed for my success. They are the root of my strength and my success in this project and not forget my siblings too.

Last but not least, thanks to all my friends that helps me in good and bad situation and also to the lecturers, who directly or indirectly helping me through this project. The guidance and moral support from them give me confident to finish this project successfully.

ABSTRACT

Diesel engine is an internal combustion engine that uses the heat of compression to initiate ignition and burn the fuel that has been injected into the combustion chamber. Mixture of hydrogen and carbon dioxide will produce methane. Hydromethane is the blending of hydrogen and methane. This project will investigates the process to capturing CO_2 from exhaust emission and reuse it for producing hydromethane through conceptual design of CAD design for CO_2 trap in hydromethane exhaust system. Literature review on hydrocarbon conversion to CO_2 and emission measurement at various locations for optimization was completed. The aim of this project is to design a CO_2 trap that can be utilized in hydromethane exhaust system. The design will be presented in CAD drawing. Other than that, investigation regarding the hydrocarbon conversion to CO_2 will be conducted. An actual experiment will be perform to measure the emission of CO_2 released from the proposed system. Equipments utilized in this project are diesel engine, gas analyser and CO_2 trap. CO_2 trap will be designed by using CAD drawing software called CATIA. CO_2 trap system will contribute to the introduction of a new safe, clean, friendly and green technology solution. Result shows that there is linear relationship between the emission of carbon dioxide and fuel consumption. The longer engine is running, the more value of CO_2 had been captured and the lower the value of fuel consumption, which lead to more economical solution to run the engine.

ABSTRAK

Enjin diesel ialah enjin pembakaran dalaman yang menggunakan haba pemampatan untuk memulakan pencucuhan dan membakar bahan api yang telah disuntik ke dalam kebuk pembakaran. Campuran hidrogen dan karbon dioksida akan menghasilkan metana. Hydromethane adalah pengadunan hidrogen dan metana. Projek ini akan mengkaji proses untuk memerangkap CO_2 daripada pelepasan ekzos dan kemudian digunakan semula untuk menghasilkan hydromethane melalui konsep reka bentuk daripada CAD untuk perangkap CO_2 di dalam sistem ekzos hydromethane. Kajian ilmiah mengenai penukaran hidrokarbon kepada CO_2 dan pengukuran pelepasan di pelbagai lokasi untuk pengoptimuman telah dilaksanakan. Tujuan projek ini adalah untuk merekabentuk perangkap CO_2 yang boleh digunakan dalam sistem ekzos hydromethane. Reka bentuk tersebut yang akan dibentangkan dalam lukisan CAD. Selain daripada itu, siasatan berhubung penukaran hidrokarbon untuk CO_2 akan dijalankan. Eksperimen sebenar akan dilaksanakan untuk mengukur pelepasan CO_2 dilepaskan dari sistem yang dicadangkan. Peralatan yang digunakan dalam projek ini adalah enjin diesel, gas analyzer dan perangkap CO_2. Perangkap CO_2 akan disediakan dengan menggunakan perisian lukisan CAD iaitu CATIA. Sistem perangkap CO_2 akan menyumbang kepada pengenalan persekitaran baru yang selamat, bersih, mesra dan penyelesaian teknologi hijau. Keputusan menunjukkan bahawa terdapat hubung kait linear antara pelepasan karbon dioksida dan kepenggunaan bahan api. Semakin lama enjin beroperasi, semakin banyak nilai CO_2 yang diperangkap dan semakin rendah nilai kepenggunaan bahan api, akan menyumbang kepada penyelesaian yang ekonomikal dalam menjalankan enjin.

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LIST OF ABBREVIATIONS

CO_2	=	Carbon Dioxide
CAD	=	Computer Aided Drawing
DI	=	Direct Injection
IDI	=	Indirect Injection
UV	=	Ultra Violet
CATIA	=	Computer Aided Three-dimensional Interactive Application
CO	=	Carbon Monoxide
NO_x	=	Nitrogen Oxide
TDC	=	Top Dead Center
CCS	=	Carbon Capture and Storage
HC	=	Hydrocarbon
PSM	=	Projek Sarjana Muda
2D	=	Two Dimensional
3D	=	Three Dimensional
rpm	=	rotation per minute
ppm	=	parts per millions
Hp	=	Horsepower
Nm	=	Newton meter
ml	=	milliliter

s	=	second
l	=	liter
O_2	=	Oxygen
N_2	=	Nitrogen
H_2O	=	Water
BSFC	=	Brake Specific Fuel Consumption
r	=	Fuel consumption rate
P	=	Power
km	=	kilometer

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

Diesel engine is an internal combustion engine that uses the heat of compression to initiate ignition and burn the fuel that has been injected into the combustion chamber. It is also known as compression-ignition engine. This is different with spark-ignition engines such as petrol engine and gas engine which use a spark plug to ignite an air-fuel mixture. Diesel engine is manufacture in two-stroke and four-stroke. This type of engine usually used in submarines, locomotives, trucks, ships, automotives, agricultures and heavy duty industry.

Mixture of hydrogen and carbon dioxide, CO_2 will produce methane. Hydromethane is the blending of hydrogen and methane. The uses of this blending with small percentage of hydrogen mixed to compressed natural gas will increase the efficiency of internal combustion. It also reduces CO_2 emissions due to the lower carbon content and decrease fuel consumption. This blending is more clean. Other process that relates is methanation. Methanation is the reaction by which carbon oxides and hydrogen are converted to methane and water. Purposes of methanation are to remove traces of carbon oxides and to manufacture methane.

This project will investigates the process to capturing CO_2 from exhaust emission and reuse it for producing hydromethane through conceptual design of

CAD for CO_2 trap in hydromethane exhaust system. Literature review on hydrocarbon conversion to CO_2 and emission measurement at various locations for optimisation will be perform.

At the end of this project, CO_2 capture will produce effective system that can be use in the future. Hopefully, it can be implement especially in industries.

1.1 PROBLEM STATEMENT

Air pollution is one of the serious problems occur in world. Air pollution causes damage to animals, forests, water and especially human being. It can bring hazardous effects to human health. It also contributes to the depletion of the ozone layer that protects earth from sun's UV rays. Besides that, effects of air pollution are acid rain, haze, and global warming.

One of the causes of this pollution is carbon dioxide, CO_2 that been produced and released to the environment. It occurs due to some of human activities. Human activities had been highlighted as the major causes of air pollution. List of the human causes of air pollution includes vehicles, outdoor fires, and heavy duty industry.

This project focusing on creating a new environmental that safe, clean, friendly, and green technology.

1.2 OBJECTIVES

The aim of this project is to design a CO_2 trap that can be utilized in hydromethane exhaust system. The design will be presented in CAD drawing. Other than that, investigation regarding the hydrocarbon conversion to CO_2 will be conducted. An actual experiment will be perform to measure the emission of CO_2 released from the proposed system.

1.3 SCOPES

This project focussed on the development of CO_2 trap system. The design will be drawn by using CAD software (CATIA). The developed design will be tested an actual experiment to determine the chemical reaction that occurs inside the CO_2 trap system. The output of the system will be collected by using gas analyser. The data obtained will be analysed and interpret.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

In this chapter, articles, journal and paper of the previous researches that related with this project will be review and be discussed. This method is done through overview of those previous researches. After reviewing, the researches will be summaries. It is important component for every project that has to be complete. It is also a method to get more understanding and gain more knowledge about this project and to give opening ideas to the improvements regarding this project. CO_2 capture from exhaust gas is a project that continuously been researched and develops from time to time. It will help to improve fuel economy in single cylinder diesel engine. The development of this project will give benefits and hopefully useful in the future.

2.1 SINGLE CYLINDER DIESEL ENGINE

Engine is the heart of the automobile. It generates motive power for locomotion and converts chemical energy of the fuel to mechanical energy. In

addition, engine develops power and torque. Diesel engines is a special type of internal combustion engine, use heat of compression, rather than electric spark, to ignite hydrocarbon fuels injected into the combustion chamber (McClellan R.O et al. 2012). Diesel engines are widely used in industrial, domestic and automotive sector. They can be classified according to cycle, number of cylinders, arrangement of cylinder, fuel used, type of ignition, valve arrangement and cooling system. Development in diesel engine has been a research for many years to get their improvement and achieve a better efficiency even since it is invented. The diesel engine was invented by Rudolf Diesel. McClellan R.O et al. (2012), diesel engines have found increasingly wide application in industry and in the transportation of goods and people around the world from the time of invention of the technology by Rudolph Diesel in the 1890s to the present day. According to Lloyd A. C. et al. (2001), Rudolf Diesel used the developing science of thermodynamics and the ideas of Sadi Carnot to develop his heat motor which has subsequently evolved into fuel-efficient diesel engine. Today's diesel engines are refined and improved based on Rudolf Diesel's original concept. It is been developed and improved continuously to gain a better use through time. Lloyd A. C. et al. (2001) describe that much of the history of the internal combustion engine involved a search for the best way to get more power for less fuel cost. For example, James Watt (1736-1819) successfully halved the coal consumption of Thomas Newcomen's (1663-1729) steam engine by modifying the cycle through the addition of a separate condenser. Until recent years, diesel engine continues to be improved and develops in automotive industry.

Single cylinder diesel engine is simple and economical in its construction. Single cylinder means that the engine has one cylinder and piston connected to the crankshaft. Diesel engine is compression ignition engine and use diesel fuel. Compression ignition means that combustion process starts when the air-fuel mixture self-ignites due to high temperature in the combustion chamber caused by high compression. It can be classified into two types. There are Direct Injection (DI) and Indirect Injection (IDI). On DI, fuel is sprayed directly on top of the piston. It is highly fuel efficient, noisy and easy cold starting ability. Besides that, on IDI, fuel is sprayed on to a separated pre-chamber. It is less fuel efficient, less noisy and requires pre-heating for starting the engine. A compression ratio of diesel engine is from 20:1

up to 25:1. With high temperature ratios, temperature inside the combustion chamber may be as high as 700°C to 900°C.

Table 2.1 below shows the advantages and disadvantages of diesel engine.

Table 2.1: Advantages and disadvantages of diesel engine

Advantages	Disadvantages
More efficient, reliable and durable	More expensive
Release less amount of harmful fumes	Contribute to greenhouse effect (produce NO_x)
Produce minimal CO	Noisy

Diesel engine is manufacture in two-stroke cycle and four-stroke cycle. Two-stroke cycle have two pistons movements over one revolution for each cycle while four stroke have four pistons. **Figure 2.1** below shows the process of four-stroke cycle.

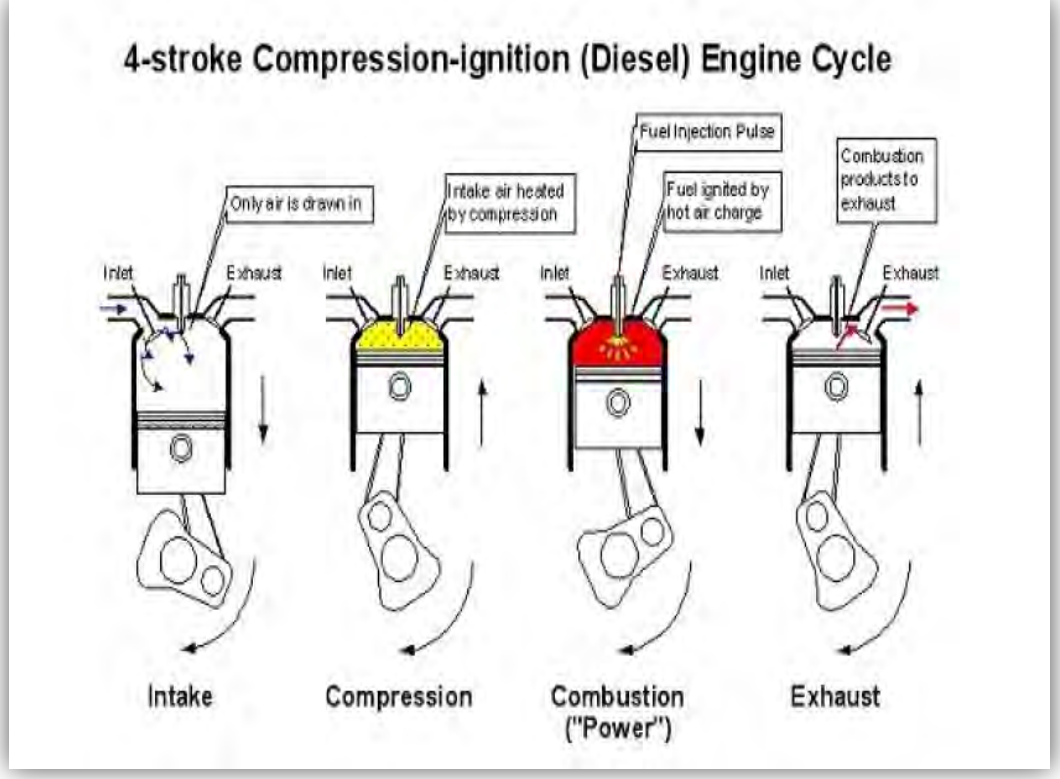

Figure 2.1: Diesel engine cycle (Prabuddha Fernando,2012)

Intake: The piston travel from TBC to BDC with the intake valve open and exhaust valve closed. This creates an increasing volume in the combustion chamber, which in turn creates a vacuum. The resulting pressure differential through the intake system from atmospheric pressure on the outside to the vacuum on the inside causes air to be pushed into the cylinder.

Compression: When the piston reaches BDC, the intake valves closes and the piston travels back to TDC with all the valves closed. This compresses the air, raising the high pressures and temperature in the cylinder. Late in the compression, stroke fuel is injected directly into the combustion chamber, where it mixes with the air. This causes the fuel to evaporate and self-ignite causing combustion to start.

Combustion: Combustion is fully developed by TDC and continues at about constant pressure until fuel injection is complete and the piston has started towards BDC

Power: the power stroke continues as combustion ends and the piston travels towards BDC.

Exhaust: by the time the piston reaches BDC, exhaust blowdown is complete, but the cylinder is still full of exhaust gases at approximately atmospheric pressure. With the exhaust valve remains open, the piston now travels from BDC to TDC in the exhaust stroke. This pushes most of the remaining exhaust gases out of the cylinder into the exhaust system at about atmospheric pressure, leaving only that trapped in the clearance volume when the piston reaches TDC. Near the end of the exhaust stroke at TDC, the intake valves starts to open, so that it is fully open by TDC when the new intake stroke starts the next cycle. Near TDC, the exhaust valve starts to close and finally is fully closed sometime at TDC. This period when both the intake valve and exhaust valve are open is called valve overlap.

2.2 EXHAUST GAS AND HYDROCARBONS

Combustion in an internal combustion engine will produce exhaust gas. It is discharged into the atmosphere after the combustion. The exhaust gas contains many compositions of gases and will give negative effects when the gases are released to the environment. Main effect occurs is air pollution. Air pollution will causes damage to animal, water, forest and especially human being. It is also contributes to the thinning of ozone layer. The thinning of ozone layer will leads to global warming which is the serious problem occurs in the world nowadays. One of the causes of this pollution is CO_2 that been released to the environment. In Shintaku H. et al. (2013), it is found that increase in the CO_2 content of the air is said to be the cause of global climate change today.

Based on McClellan R.O et al. (2012), diesel engine exhaust is a complex mixture of carbon dioxide, oxygen, nitrogen, nitrogen compounds, carbon monoxide, water vapour, sulfur compounds and numerous low and high molecular weight hydrocarbons, and particulate matter.