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Mechanical Engineering Bachelor Degree (Thermal - Fluid)’

Signature : .....

Supervisor : MR. SAFARUDIN GAZALI HERAWAN

Date : .....

PREPARATION OF CATALYTIC CONVERTER FOR TWO STROKE GENERATOR ENGINE

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This report is proposed as cater to part of award condition
Mechanical Engineering Bachelor Degree (Thermal - Fluid)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

MAY 2009

"I admit this report is my own work except each summary and quotation I had explain their source"

Signature : .....

Author : MOHD NOOR ASRIL BIN SAADUN

Date : .....

This report is dedicated to

my lovely mother HJH. ZALEHA BINTI HJ. SATER,

my lovely father HJ SAADUN BIN HJ. BERHAN,

thank you for your 'doa', support and encouragement

that you have given in my life and all my family.

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ABSTRACT

Most small utility two stroke engine especially portable generator can emit several hundred times more poisonous carbon monoxide than a modern car's exhaust. This study is to understand and apply the method of catalytic converter component in determining to reduce the emission for small utility two stroke engine such portable generator which almost using at pasar malam. The objective of this study is to investigate the idea of application of catalytic converter at pasar malam portable generator exhaust systems and the possibility of decrease the engine emission without decreasing the engine performances. This work presents a gas analyzer to predict and to evaluate the composition of the emission in two stroke engine for this generator. In this work also the experimental is done without and with installed the commercial catalytic converter, impact of using liquid petroleum gas (LPG) as fuel and also different load imposed to portable generator to make a comparison for their emission effect. This is a quantitative study which involves the use of experimental and analysis to get the information about the data for their effect of composition of emission from the generator exhaust. Data obtained were analyzed and the result of experiment will be compared with original engine where without installed catalytic converter.

ABSTRAK

Kebanyakan enjin dua lejang yang berkapasiti kecil terutamanya untuk penjana mudah alih boleh mengeluarkan asap karbon monoksida dan asap – asap yang lebih beracun berbanding asap dari ekzos kereta moden. Tujuan kajian ini adalah untuk memahami dan mengaplikasikan kaedah pemangkinan komponen penukar dalaman supaya dapat mengurangkan pencemaran untuk enjin dua lejang yang berkapasiti kecil iaitu penjana mudah alih yang biasa digunakan di pasar malam. Objektif kajian ini adalah untuk menyiasat idea untuk mengaplikasikan pemangkinan penukar dalaman pada ekzos penjana mudah alih pasar malam dan kemungkinan pengurangan pencemaran asap dari enjin tanpa menjejaskan prestasi enjin tersebut. Dalam kajian ini, penganalisis gas digunakan untuk meramalkan dan untuk menilai komposisi pencemaran hasil pembakaran dalam enjin dua lejang untuk enjin penjana ini. Dalam kajian ini juga, eksperimen akan dilakukan dengan memasang bersama pemangkinan penukar sedia ada yang dijual dipasaran dan juga tanpa pemangkin penukar dalaman, kesan penggunaan gas petroleum cecair (LPG) sebagai bahan api dan seterusnya juga beban yang berbeza dikenakan terhadap penjana mudah alih tersebut untuk membuat perbandingan kesan pencemaran asap yang dihasilkan. Kajian ini merupakan satu kajian kuantitatif yang melibatkan eksperimen dan analisis untuk mendapatkan data dan maklumat untuk mengetahui kesan komposisi pencemaran daripada ekzos penjana mudah alih tersebut. Data yang diperolehi akan dianalisis dan hasil eksperimen akan dibanding dengan enjin asli di mana tanpa dipasang pemangkinan penukar dalaman.

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LIST OF SYMBOLS

CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
NO_X	-	Nitrogen Oxides
NO_2	-	Nitrogen Dioxides
SOx	-	Sulfur Oxides
O_2	-	Oxygen
PM	-	Particulate Matter
HC	-	Hydrocarbons
UHC	-	Unburned Hydrocarbons
Ppmv	-	Part Per Million Volume
H_2	-	Hydrogen
EPA	-	Environmental Protection Agency
HP	-	Horse Power
% Vol	-	Percent Volume

CHAPTER I

INTRODUCTION

1.1 Overview

Catalysis has provided one of the most realistic methods of decreasing the levels of exhaust gas species. However its efficiency of oxidation depends on amount of CO, HC and air and also temperature of exhaust gas. Catalytic converters especially with the fuel enriched exhaust gas of small capacity two-stroke engine undergo rapid damage of perforation and clog by unburned oil. They can cause also threat of misfire. With its subsequent fuel enriching of exhaust gas causes a thermal shock to the substrate. In general the efficiency of the catalyst is dependent upon two parameters, namely the physical formulation and the nature of the flowing gas containing different chemical substance. Recently widely applied fuel injection reduces to a large extent this phenomenon.

Engine performance changes as a result of negative effect of gas wave motion in exhaust system with monolith of converter, which should be fixed in exhaust pipe, where higher temperature takes place to initiate chemical reactions especially during engine start. Value of decreasing of engine torque and increasing of fuel consumption are the main parameters determining possibility of applying of catalytic converter in exhaust system. Most often catalytic converters in exhaust systems of two-stroke engines are placed before silencer.

Big size of the converter and lower temperature of gas flowing out from silencer takes effect on longer time of heating and oxidation of exhaust compounds. Placing catalytic converter near exhaust port assures higher temperature of wash-coat in catalyst containing precious metal as a result of short distance from exhaust port, but can also influence stronger on pressure variation before exhaust port.

1.2 Objectives Of The Study

This study scientifically reviews the current state of knowledge about air pollution caused by two stroke generator engine combustion. The main objective of this investigation is to question the perception about the idea of application of catalytic converter at portable generator exhaust systems and the possibility of decreasing the engine emission without decreasing the engine performances.

Another objective in this study is to make a comparison about the emission from two stroke engine especially for portable generator powered with gasoline. To make this comparison, the portable generator set must be installed with suitable catalytic converter and measure the effect of different emission using a gas analyzer. The suitable catalytic converter is from two stroke engine since the small generator used two stroke engines.

This study also evaluates how to make the experimental process of the catalyst and assessment of designed at exhaust system. The experimental procedure of this catalytic converter system is necessary to characterize the catalyst and to optimize the emission of two stroke engine for portable generator. Then the objective of this study also is to obtain an emission value and comparison of the emission effect using of LPG and apply with different load at two stroke generator engine.

1.3 Scope

The scope of this study is to make ability or application of the catalytic converter for small utility two stroke engine especially for portable generator. The exhaust from a two-stroke generator engine will be characterized using one type of gasoline, conventional lead-free gasoline. In addition, exhaust emissions of carbon monoxide (CO), carbon dioxide (CO_2), oxygen (O_2) and hydrocarbons (HC) will be measured. The two-stroke engine tested with use of catalysts at the exhaust to improve the emission after installation catalyst and assessment of designed exhaust system. This study discusses about the performance, combustion and emission characteristics of a two-stroke spark ignition engine in which the catalytic converter will be installed at exhaust system. Catalysts such as copper, chromium and nickel in the form of coating and a catalytic prechamber with platinum tipped multi-electrode spark plug were tried out to ensure rapid and efficient combustion. Considerable reduction of CO and HC emissions were obtained with some of the catalysts. Generally, the conventional gasoline gives higher effects a difference between lubricants was also seen, especially in combination with gasoline.

1.4 Limitation Of The Study

This study will be done at University Technical Malaysia Melaka (UTeM) laboratory. This study only concentrate at the exhaust system to reduce the emission of the portable generator where it almost using at pasar malam. The catalytic converter using in this study are from automobile market and not specifically designed for small utility two stroke engine such of a portable generator.

1.5 Statement Of Problems

In studying a catalytic converter of a two stroke engine for pasar malam portable generator, there are several things need to understand to solve the problem. The generator is working in two stroke engine and powered by gasoline fuel. The emission from this type of generator can emit several hundred times more poisonous carbon monoxide than a modern car's exhaust. To help quantify the dangers of improperly used portable generators and evaluate possible technical solutions to the problem, catalytic converter can be used to reduce the emission and then make the pasar malam generator safe to use without causes hazard poisoning for the user. The important aspect of the work is to determine the efficiency of the catalytic converter for the generator without decreasing the engine performances. To make a comparison between with and without effect of catalytic converter, gas analyzer is used to predict and to evaluate the gas composition from emission in two stroke engine for this portable generator.

CHAPTER II

LITERATURE REVIEW

2.1 Overview

Chapter 2 discusses about studies on the problem of emissions from two-stroke engine type. The major gasoline engines pollutants are carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx), particulate matter (PM), various hydrocarbons (HC) and also produces carbon dioxide, a greenhouse gas. The two-stroke engines produce significant amounts of unburned hydrocarbons, atomized lubricating oil, and CO due to their design, but little NOx. Carbon monoxide is generally a product of incomplete combustion and is frequently found in rich mixtures.

There are many effects to human health and environment if exposed with this toxic gas. Carbon monoxide binds with hemoglobin in the blood, reducing the blood's capacity to carry oxygen. This can result in heart strain and pulmonary problems. NOx combines with moisture to produce acid rain, and increases the risk of respiratory disease and causes pulmonary and respiratory problems. NOx and volatile organic compounds are also precursors for photochemically-produced ozone (smog), which is an irritant that affects the eyes, upper respiratory tract and causes asthma and headaches. Hydrocarbons in the atmosphere react photochemically to produce smog and this is a major problem. Also, certain hydrocarbons are directly toxic to the human body.

2.2 Emissions And Regulations

The development of the spark-ignited combustion engine permitted the controlled combustion of gasoline that provides the power to operate the automobile. Gasoline, which contains a mixture of paraffin and aromatic hydrocarbons, is combusted with controlled amounts of air producing complete combustion products of CO_2 and H_20 and also some incomplete combustion products of CO and unburned hydrocarbons (UHCs).

Hydrocarbons in gasoline: $O_2 \xrightarrow{\text{combustion}} CO_2 + H_20 + \text{heat}$

During the combustion process very high temperatures are reached due to diffusion burning of the gasoline droplets, resulting in thermal fixation of the nitrogen in the air to form NO_x. The quantity of pollutants varies with many of the operating conditions of the engine but is influenced predominantly by the air: fuel ratio in the combustion cylinder. Figure below shows the engine emissions from a spark-ignited gasoline engine as a function of the air: fuel ratio.

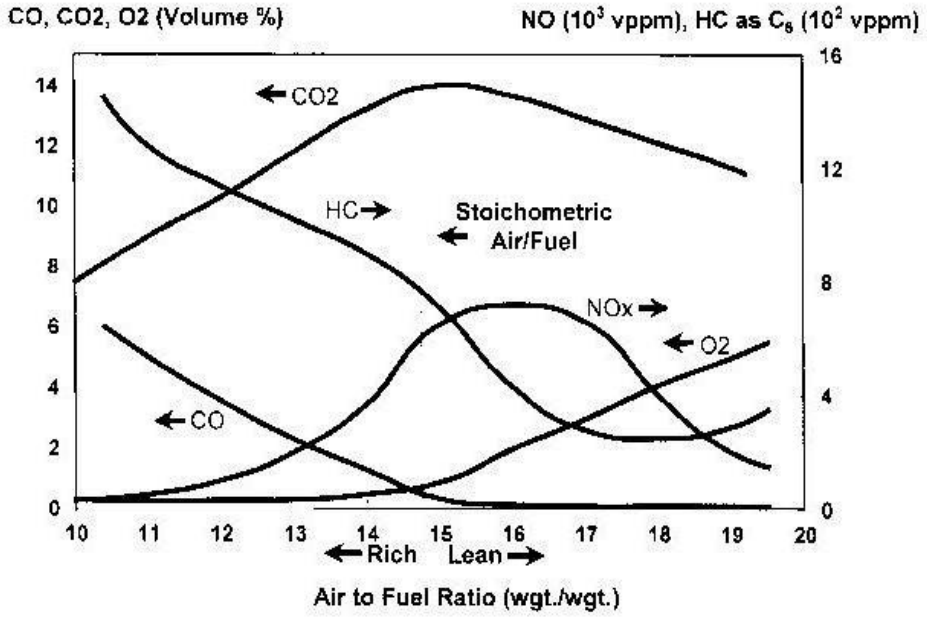

Figure 2.1: Spark-ignited gasoline engine emissions as a function of air: fuel ratio (Source: Kummer, (1980))

When the engine is operated rich of stoichiometric, the CO and HC emissions are highest while the NO_x, emissions are depressed. This is because complete burning of the gasoline is prevented by the deficiency in O_2. The level of NO_x is reduced because the adiabalic flame temperature is reduced. On the lean side of stoichiometric, the CO and HC are reduced since nearly complete combustion dominates. Again, the NO, is reduced since the operating temperature is decreased. Just lean of stoichiometric operation, the NO_x is a maximum, since the adiabatic flame temperature is the highest. At stoichiometric, the adiabalic flame temperature is lowered because of the heat of vaporization of the liquid fuel gasoline. The actual operating region of combustion for the spark-ignited engine is defined by the lean and rich flame stability, beyond which the combustion is too unstable. Within the region of the spark-ignited engine operation, a significant amount of CO, HC, and NO_X is emitted to the atmosphere. The consequences of these emissions have been well documented but briefly. CO is a direct poison to humans, while HC and NO, undergo photochemical reactions in the sunlight leading to the generation of smog and ozone.

2.3 Types Of Emissions

Gasoline engines contribute to air pollution by emitting high levels of particulate matter, lead if leaded gasoline is used, carbon monoxide, nitrogen oxides, and volatile organic compounds. Emissions are higher in two-stroke engines because of the design of the engine because the gas is exchanged through ports located in the cylinder, usually opposite each other. A fresh fuel and air mixture compressed in the crankcase enters through the intake opening, while exhaust gases exit through the exhaust port. While both the intake and exhaust ports are open some of the fresh fuel and air mixture escapes through the exhaust port.

As a result of these scavenging losses, which can amount to 15–40 percent of the unburned fresh charge, the exhaust contains a high level of unburned fuel and lubricant. Nitrogen oxide emissions tend to be lower because a significant portion of the combustion products remains in the cylinder.

In two-stroke engines the crankcase is not used as an oil reservoir, as it is in four-stroke engines. Instead a small amount of lubricating oil is added to the fuel or introduced continuously mechanically. Because lubrication is on a total loss (once-through) basis, incompletely combusted lubricant and other heavy hydrocarbons are emitted as small oil droplets. These oil droplets increase visible smoke and particulate emissions, with serious impact on public health because of their well-documented link to morbidity and premature mortality.

2.3.1 Carbon Monoxide Emissions

The process of generating carbon monoxide in two-stroke engines is identical to that of other engines. Therefore, the phenomenon can be described generally and qualitatively according to Figure 2.2. This figure also shows trends for two other primary pollutants, namely, HC and $N0_X$.

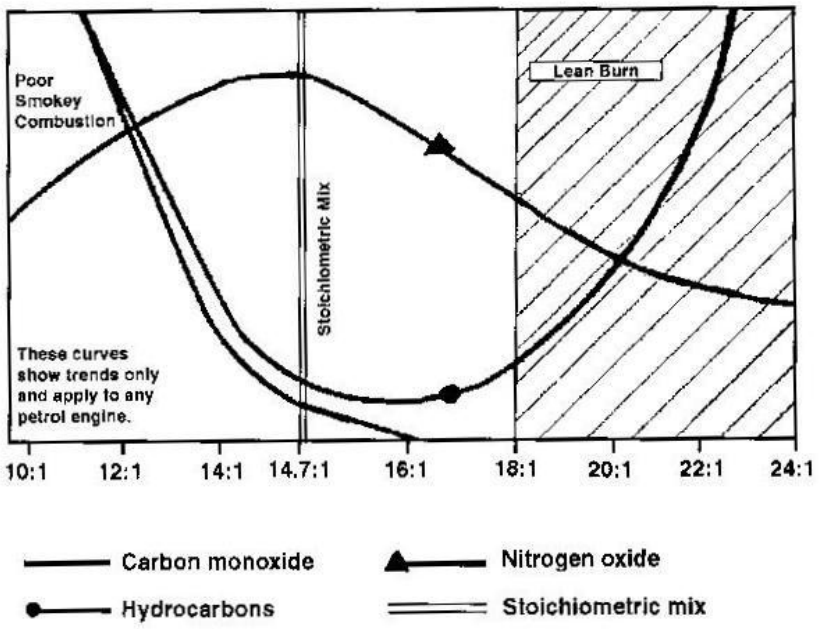

Figure 2.2: Trend Of Pollutants Versus The Air Fuel Ratio

(Source: Kummer (1980))