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# EVALUATION OF 'PERAHU TAMBANG' ENGINE PERFORMANCE AND EXHAUST EMISSION

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# EVALUATION OF 'PERAHU TAMBANG' ENGINE

# PERFORMANCE AND EXHAUST EMISSION

**VOON CHUN YUNG**

**Thesis Submitted to the Faculty of Engineering,**

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**Specially Dedicated To My Beloved Parents,**
**Brother, Sisters And Loved Ones**

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# ABSRACT

This paper describes an evaluation of the engine's performance and exhaust emissions analysis of the four-stroke small utility engine (Robin Engine Model EY20-3D), which is commonly used to power the 'Perahu Tambang' alongside the Kuching Waterfront Park. The Robin engine model is chosen for this study due to its similarity to the other models of engine that used by the operators to power their boat. The engines are similar in term of its type, operation, size and the capacity. The objectives of this evaluation are to test the engine's performance and the exhaust emissions. The engine's performance was tested on the fuel consumption rate and the exhaust temperature. Meanwhile, the exhaust emissions for the CO and HC emissions level were analyzed. The experiments were done based on three types of emissions control devices, which are the original exhaust, direct flow and custom built catalytic converter at different engine speed rate (RPM). Experimental results indicate that the engine's performance was not much affected on the fuel consumption rate when tested with all three types of emissions control devices. The exhaust temperature analysis results has proven that the custom built catalytic converter had slightly reduced the CO and HC emissions level even though the emissions level analysis results showed only minor changes in percentage between the emissions control devices.

# ABSTRAK

Kertas kerja ini menerangkan evaluasi prestasi enjin dan analisis penghasilan gas eksos ke atas enjin serbaguna empat strok (Robin Engine Model EY20-3D) yang menjadi pilihan operator Perahu Tambang di sepanjang tebing Taman 'Waterfront' Kuching. Jenis enjin Robin dipilih untuk analisis kerana ia mempunyai kesamaan dari segi jenis, operasi, saiz dan kapasiti. Objektif kertas kerja ini menguji tahap prestasi enjin, suhu eksos dan juga analisis terhadap penghasilan gas CO dan HC. Eksperimen ini dijalankan menggunakan tiga jenis eksos berlainan iaitu eksos asal, aliran terus (tanpa penapis) dan 'custom built catalytic converter' pada kelajuan enjin berlainan. Keputusan eksperimen menunjukkan bahawa pretasi enjin tidak menunjukkan kesan perubahan ketara terhadap penggunaan minyak dengan ketiga-tiga ekzos yang berlainan jenis. Maka, analisis suhu eksos membuktikan bahawa 'custom built catalytic converter' telah mengurangkan aras penghasilan CO dan HC walaupun keputusan analisis penghasilan gas CO dan HC hanya menunjukkan sedikit perubahan antara ketiga-tiga jenis eksos yang diuji.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background and Overview

In Sarawak, river transportation system is one of the significant modes of transportation that has a great significance to a large section of population living in the rural area and also along the coast. Yet, the system is vital to both the passengers and goods due to the geographical factors that constrained other modes of transportation in reaching the destination in the state.

There are about 55 navigable rivers in the state with the combined length of 3,300 km. However, Sungai Rejang is the longest river in Malaysia with the total length of 567 km, which is the most important of all the rivers in the State and between 300-500 boats and vessels plies the river daily.

Out of 50% of the transportation system in the state is mainly engaged in passengers' transportation, and the rest are for transporting goods and logs. Express boat services in the state are economical yet efficient that utilizes the many waterways inland to get more rural areas inaccessible by road [1].

The boats and vessels are powered either by a small four-stroke utility engines or diesel engines. Typically the small four-stroke utility engines are commonly used to power the 'Perahu Tambang' in Sarawak River. A survey was conducted verbally among twenty-six 'Perahu Tambang' operators on the type and brand of the engine they used to power their 'Perahu Tambang' along side the Kuching Waterfront Park. The data collected on the types and brand used on the 'Perahu Tambang' is shown in **Table 1.** From the data, it shows that the most preferred type of engine is the four-stroke Honda Model GX160 5.5 HP, Electronic Ignition.

**Table 1: The data on the types and brands used on the 'Perahu Tambang'**

| Type | Brand | Model | Number of engine used |
|---|---|---|---|
| Four-stroke | Honda | GX160, 5.5 HP, Electronic ignition | 19 |
| Four-stroke | Robin | EY20-3D, 5.0 HP, Electronic ignition | 5 |
| Four-stroke | Honda | GX120, 4.0 HP, Electronic ignition | 2 |

From the data collected, Honda model GX160 5.5 HP is the most commonly used due to its high durability and less maintenance required as it has slightly more horsepower compared to the other models of engine. Robin engine model EY20-3D, 5.0 HP and Honda engine model GX120 4.0 HP are uncommonly used on the 'Perahu Tambang'. The higher maintenance costs and less horsepower have switched the 'Perahu Tambang' operators to use the Honda model GX160 5.5 HP.

## 1.2 Problem Statement

All automotive vehicles contribute to air pollutants, included the small two-stroke and four-stroke utility engines. The emissions contain some metallic contaminants that are harmful to the environment. The exhaust gases emitted contain generally of Carbon Monoxide (CO), Nitrogen Oxide (NOx), Carbon Dioxide ($CO_2$), a few Sulfur Dioxide ($SO_2$) and great number of Hydrocarbons (HC) or some organic carbon derivates, and some heavy metals particles.

These compounds are harmful and directly toxic to the living organisms especially when they occurred in closed environment such as rooms, tunnels and subterranean car parks. Besides, the gases emitted will interact with oxidants to form new labile compounds which this compound has a high phytotoxic activity at low concentrations (photochemical smog).

Thereby, reducing the lead addition in the fuels in clean motors is able to prevent and reduce the risk for environment alterations. This will give a drastic reduction of gaseous pollutants.

Two-stroke engines are widely used and have great popularity especially in Asian countries, which they are mostly used on two-wheel vehicles. Global experts shared their knowledge about these vehicles at an international conference held on 30th March 2004 - 1st April 2004 at the Center for Science and Environment (CSE) in New Delhi, India. From the conference, it had found that the two-wheelers form a staggering 75 % - 80 % of the traffic in most Asian cities. Meanwhile, there are about 66 % of two-wheel vehicles out of the total of 16 million vehicles in Taiwan, and 61 % out of the 66 % are the two-stroke engines two-wheels vehicles [2].

However, the small four-stroke utility engines are used to power the generators, sand-compactor, the 'Perahu Tambang' and more. The uses of four-stroke engines have great impacts on the environment and human health due to the high emissions level. Based on the 1996 Preliminary Estimates of Vehicles Emissions in New Delhi (in Thousand Ton/annum) Data from the Department of Transport, New Delhi, India, two-wheel vehicles emitted 4.6 of particulate matter less than 10μm ($PM_{10}$), 47.2 of Hydrocarbon (HC), 75.7 of Carbon Monoxide (CO) and 0.9 of Nitrogen Oxide (NOx) respectively. From the data collected, the emissions level of HC and CO are the highest numbers out of the total of 100.0 HC and 279.4 of CO. Two-stroke engines burn an oil-gasoline mixture, which emit more smoke than that of four-stroke engines that contains high Carbon Monoxide, Hydrocarbons and some $PM_{10}$. Therefore, internal

combustion engines especially the two-stroke engines are major contributors to the air pollution and resulting respiratory illness in people [3].

## 1.3 Objectives

The objectives of this study are to test the engine's performance on the fuel consumption and the exhaust temperature (inlet and outlet) and also to perform an exhaust emissions analysis of CO and HC emissions level on the small four-stroke utility engine (Robin Engine Model EY20-3D 5.0 HP). The Robin engine model is chosen for this analysis because the engine's model is closely matches to the other models of engine used to power the 'Perahu Tambang', but it is different model with some specifications differences. The Robin engine model is similar to the other models in term of its type, operation, size and capacity. The project's objectives can be divided into three categories:

1. To evaluate the engine's performance, based on the fuel consumption rate.

2. To measure the exhaust inlet temperature (from the engine) and the exhaust outlet temperature.

3. To analyze the CO and HC emissions level during engine's operation.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 The History and Development of Internal Combustion Engines

An internal combustion engine is any engine that uses the explosive combustion of fuel to push a piston within a cylinder - the piston's movement turns a crankshaft that then turns the car wheels via a chain or a drive shaft. The different types of fuel commonly used for car combustion engines are gasoline (or petrol), diesel, and kerosene.

As early 1680, Dutch physicist, Christian Huygens first designed an internal combustion engine. The first combustion engine was fueled with gunpowder. However, the engine was never built. The development continued as Francois Isaac de Rivaz of Switzerland invented an internal combustion engine that used a mixture of hydrogen and

oxygen for fuel in 1807. Rivaz designed a car for his engine - the first internal combustion powered automobile. However, his was a very unsuccessful design.

In 1862, a French civil engineer, Alphonse Beau de Rochas, had patented a four-stroke engine. However, the design was never built and it was further developed and invented by Nikolaus August Otto.

In 1867, Nikolaus August Otto, a German engineer, had invented and futher developed the four-stroke "Otto" cycle, which is widely used in transportation automotives till these days. Otto had developed the four-stroke internal combustion engine when he was 34 years old. Together with Eugen Langen, they founded and established the first engine company - "N.A.Otto & Cie". Then they improved the atmospheric gas engine and in 1867 they won a gold medal at the Paris Exposition. It corresponds to the today's engines [4].

The characteristics of an internal combustion engine had become the most utilized engine in all applications since it has invented.

## 2.2 Researches and Studies on Internal Combustion Engines

Several studies on the internal combustions engine have been made such as to increase the fuel efficiency, power and the durability of the engine were tested and most significantly the reduction of the engine's emissions.

An analysis has been done on the influence of air–fuel ratio on engine performance and pollutant emission of an SI engine using ethanol–gasoline-blended fuels (Chan et-al 2003) [5]. From the study, the engine performance and pollutant emissions were measured on the utilization of the ethanol–gasoline-blended fuel under different air–fuel equivalence ratios. The results showed that the air–fuel equivalence ratio and ethanol content play an important role in combustion process.

They have concluded that CO and HC emissions were reduced with the increase of ethanol content in the blended fuel, which resulted from oxygen enrichment. At an air–fuel equivalence ratio slightly larger than one, the smallest amounts of CO and HC and the largest amounts of $CO_2$ resulted. It was noted that under the lean combustion condition, $CO_2$ emissions was controlled by air–fuel equivalence ratio, while under the rich combustion condition, $CO_2$ emissions is offset by CO emissions. It was also found that $CO_2$ emissions per unit horsepower output for blended fuel was similar or less than that for gasoline fuel.

A study had been done on air pollutant emissions factors from new and in-use motorcycles (Jiun et-al 2000) [6]. The reading of emissions of CO, NOx and HC were collected using Emission Analyzer from 7 new and 12 in-use motorcycles with or with out catalyst were evaluated by testing these vehicles on a dynometer.

The results were collected and the emissions of CO, HC and some Volatile Organic Compounds (VOCs) from in-use motorcycles are higher than those from the new ones as tested on the dynometer. The emissions of HC from two-stroke

motorcycles, with or without installation of catalysts are higher than that of four-stroke motorcycles without catalyst. The emission of CO for in-use motorcycles are much higher than the new ones whether with or without installation of catalyst. It also shows a clear degradation of CO emissions for in-use motorcycles.

However, installation of catalyst on two-stroke motorcycles could significantly reduce the emissions of CO and HC but not the NOx emission. The effect of accumulated running mileage and engine age on the emissions of CO and HC show a slight correlation but great variation. The results indicate that a number of factors, such as maintenance may play an important role in engine emissions from motorcycles.

## 2.3 The Basic Four-Stroke Engine Principles

A four-stroke internal combustion engine consists of four phases, which are the intake stroke, compression stroke, combustion stroke and exhaust stroke.

### 2.3.1 Intake Stroke

On the intake stroke, the intake valve has opened. The piston is moving down, and a mixture of air and vaporized fuel is being pushed by atmospheric pressure into the cylinder through the intake valve port.