THE INVESTIGATION OF TURBO-GENERATOR ON EXHAUST MANIFOLD IN SPARK IGNITION ENGINE

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"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 (Thermal-Fluids)."

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DECLARATION

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

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This report is dedicated to my family. Thank you for your continuous support during my vibrant educational years. Without their patience, understanding and most of all love, the completion of this work would not have been possible.

To my parents,

Awang Bin Bakar and Ruminah Binti Makmum

My siblings

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ABSTRACT

In vehicle system, there many types of energy flow from the source of fossil fuel to the chemical reaction in combustion chamber throughout exhaust system. Without realize, lots of waste energy had occurred when the engine started. In fact, there is only 12-15% of the energy from the fuel gets the vehicle travel on the road and used in vehicle accessories. The rest of the energy is lost to engine, idling, driveline, aerodynamic drag, rolling resistance, overcoming inertia, braking and especially exhaust system, the temperature can reach around 900˚C with a pressure up to 2 Bar and this heat and pressure or thermal and kinetic energy are release to the environment as waste. Therefore, a system is required to reduce or recover the waste energy in vehicle. Thus, the investigation of Turbo-Generator system is conducted in which uses the energy losses and waste from the exhaust system by converting the waste energy to electrical energy. The methodology of this system, when energy flow to the exhaust system it will rotate the turbine and the turbine will rotates the generator. The generator produce electricity as an output by converting the mechanical energy from the turbine to electrical energy. The electricity produced can be stored to the battery or uses for other purpose such electrical equipment. During the fabrication, installation and testing of Turbo-Generator system, there were some setback. However, some of the data obtained still can be analyse to investigate the effect and output of Turbo-Generator system in a vehicle. The system produced an output of 24.47V at 11230.47 RPM of turbine speed with only 3461.91 RPM of engine speed. The vehicle performance also has similar behaviour with the Turbo-Generator system and without the system. Thus, Turbo-Generator system will benefit in every vehicle as a waste energy recovery.

ABSTRAK

Dalam sistem kenderaan, terdapat pelbagai jenis aliran tenaga dari sumber bahan api fosil untuk tindak balas kimia dalam kebuk pembakaran melalui sehingga sistem ekzos. Tanpa sedar, ia mempunyai banyak pembuangan tenaga telah berlaku apabila enjin mula berjalan. Malah, hanya 12-15% tenaga daripada bahan api dapat menjalankan kenderaan di jalan raya dan digunakan dalam aksesori kenderaan. Selebihnya daripada tenaga yang hilang untuk enjin, melahu, heretan aerodinamik, rintangan bergolek, mengatasi inersia, brek dan sistem terutama ekzos, suhu boleh mencecah kira-kira 900 ° C dengan tekanan sehingga 2 Bar dan haba ini dan tekanan atau tenaga haba dan kinetik dilepaskan ke persekitaran sebagai sisa. Sehubungan dengan itu, sistem pemulihan diperlukan untuk menyelesaikan masalah. Oleh itu, sistem Penjana Turbo perlu dikaji untuk pembuangan tenaga dan bahan buangan daripada sistem ekzos dengan menukarkannya kepada tenaga elektrik. Kaedah sistem ini, apabila aliran tenaga di sistem ekzos, ia akan memutarkan turbin dan turbin akan memutarkan penjana. Penjana tenaga elektrik sebagai output dengan menukar tenaga mekanikal daripada turbin kepada tenaga elektrik. Tenaga elektrik yang dihasilkan boleh disimpan dibateri atau menggunakan untuk tujuan lain seperti peralatan elektrik. Dalam ujikaji ini, semasa fabrikasi, pemasangan dan ujian Penjana Turbo, terdapat beberapa halangan dan juga penyelesaian yang telah dilakukan. Walau bagaimanapun, beberapa data yang diperolehi masih boleh menganalisis untuk mengkaji kesan dan output sistem Penjana Turbo di dalam kenderaan. Sistem ini menghasilkan output 24.47V di 11.230,47 RPM kelajuan turbin dengan hanya 3461,91 RPM kelajuan enjin. Prestasi kenderaan juga mempunyai tingkah laku yang sama dengan sistem Penjana Turbo dan tanpa sistem. Oleh itu, sistem Penjana Turbo dapat manfaat dalam setiap kenderaan dalam pemulihan sisa tenaga.

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RPM	=	Revolution per Minute
N	=	Engine Speed (rev/s)
V	=	Voltage (V)
^{o}C	=	Temperature, Celcius
^{o}	=	Degree
T	=	Torque (N.m)
W	=	Power (watt)
P	=	Pressure (Pascal)
Bar	=	Pressure (Bar)
I	=	Current (amp)

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CHAPTER I

INTRODUCTION

1.1 PROJECT BACKGROUND

Nowadays, most vehicles on the road are powered by internal combustion engine. The most common internal combustion engines uses by fossil fuel such as petrol or diesel. The losses can be divided into two general classifications which are thermodynamic which involve heat especially on exhaust system and mechanical losses which comprise the movement parts, load or component on the vehicle and the other. The combustion process produce heat and capable of transforming the heat into useful work. The energy losses in vehicle can be harvest in order to increase the usage of fuel and to increase the efficiency of the vehicle thus increasing the overall efficiency of the vehicle. Turbocharger is an energy recovery system that harvest waste energy from exhaust system and boost up the engine performance. Nevertheless, the turbocharger had also disadvantages that could reduce the lifespan of the engine. However, Turbocharger concept can be used in a new kind of concept that is Turbo-Generator system. The system produce electrical energy that may be used for other application for example car accessories such as, audio & navigation system, charging equipment and charging batteries for hybrid vehicle instead of boost up the engine performance that could reduce the lifespan of the engine. Therefore, new concept can be used as waste energy recovery system in vehicle thus increasing the usage of fossil fuel.

1.2 PROBLEM STATEMENT

Generally, vehicle energy supply by fossil fuel such as petroleum and diesel. Unfortunately, almost 90% energy supply from the fossil fuel were wasted throughout the process starting from combustion process in the engine through the exhaust system of the vehicle. This wasted energy should be recover such as to generate other kind of energy for example electrical energy. Turbocharger is an energy recovery system that had been develop, it uses waste energy from the exhaust gas that produce by the combustion process. The exhaust gas flown to the turbine shaft and rotate the compressor then increase the volume of air intake into the combustion chamber, thus producing more power to the engine performance. However, it also decreases the lifespan of engine for example over-boosting and engine knocking. Therefore, the turbocharger can also be uses for other application by converting mechanical energy to electrical energy.

1.3 OBJECTIVE

In this investigation, several objectives are focused such as:

1. To investigate the effect of Turbo-Generator system to the vehicle performance.
2. To determine how much the Turbo-Generator system can produce electrical energy on a vehicle.

1.4 SCOPE

By modifying the existing mechanism of turbocharger, by means of removing the compressor component and replace with electrical generator. The shaft will be connected directly to an electrical generator than can convert its energy to electrical energy. However, the investigation for this system must be fabricate and modify the original system and conduct a real road situation experiment with a supported data and analysis to evaluate the effects of Turbo-Generator system on actual vehicle.

1.5 PROJECT SIGNIFICANT

The significant of this project is developing a recovery waste energy system that has potential for its uses for other purpose. The Turbo-Generator system are used in many power generation for example power plant and ship that is a large application. However, this system is not currently developed in automotive industry where the challenge is mostly vehicle are open and reciprocating flow system compare to power generation in power plant that are close and continues flow system. Yet, there are many waste energy in vehicle, this system would maximize the energy usage supply by the fossil fuel. The energy will be converted to electrical energy. The electrical energy will be uses in many car application and operation such as navigation, audio, charging equipment, ECU, power steering, charging hybrid vehicle batteries and many in such way many application uses in modern vehicle today needs more electrical energy. In addition, it also can be apply to hybrid vehicle that currently being developing in these days, the system will supply electrical energy for charging thus adding an extra mileage. Thus, energy loses will be reduce if this mechanism apply in each vehicle in the future. It will bring great a benefit to the new era of automotive industry and to the entire world by reducing waste energy that will avoids the increasing price and depleting source of fossil fuel as well reducing the environmental effects.

CHAPTER II

LITERATURE REVIEW

2.1 ENERGY LOSES IN VEHICLE

When fuel supply to the tank and through internal combustion engine (ICE), it transform an enormous energy by chemical reaction occurs in ICE. The only energy use to travels the vehicle is only 12.6% from the fuel supply (Dario, V. 2009). The other energy some are use and also wasted as shown in Figure 2.1.

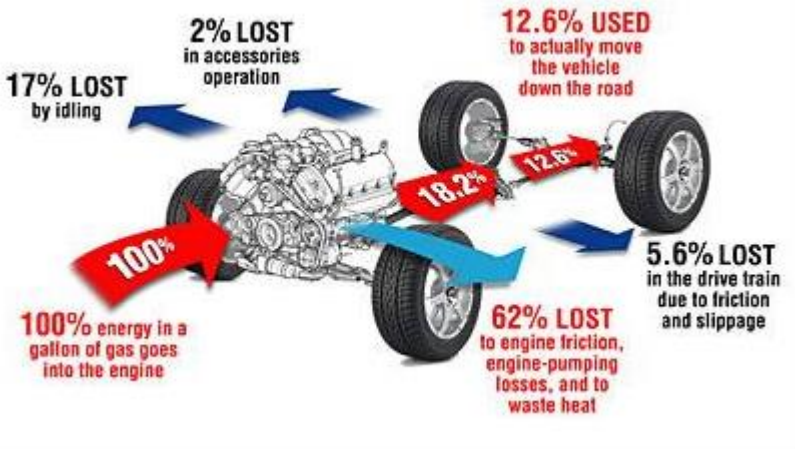

Figure 2.1: Energy loses occurs in vehicle.
(Source : www.consumerenergycenter.org)

The energy is divided by several type of energy Friction, Mechanical load, Heat and Noise whatever is use or not. Friction are the wind resistance, rolling resistance, hydraulic friction (force required to push or pump a liquid), and mechanical friction (two parts moving against each other) occurs in vehicle. Heat and noise where the energy loss in form of heat loss and vibrational noise. Mechanical load wherever the combination of losses occurred by the power steering, weight of the passage and vehicle, electrical and air conditioning that is losses by the engine to powering the

accessories and operation of the vehicle 3 of these type of loses (Friction, Mechanical load, Heat and noise) can be specific as about the fraction of the energy loses are describe in their process and operation (Dario, V. 2009).

2.1.1 Engine Losses – 62.4%.

In fossil fuel powered vehicles either using petroleum or diesel, over 62% of the fuel's energy is lost in the internal combustion engine (ICE). ICE engines are very ineffective at converting the fuel's chemical energy to mechanical energy, losing energy to engine friction, pumping air into and out of the engine, and wasted heat. More significantly, thermal energy are the most loses occurs such as in radiator and exhaust heat as high as 55% of total engine losses (Oliver, I. 2012). Progressive engine equipment such as variable valve timing and lift, cylinder deactivation, direct fuel injection, and turbo charging can be used to decrease these energy losses.

2.1.2 Idling Losses – 17.2%.

In metropolis driving, significant energy is lost to idling at stop lights or in traffic. Technologies such as integrated starter systems help reduce these losses by automatically turning the engine off when the vehicle comes to a halt and resuming it immediately when the accelerator is pressed (Oliver, I. 2012).

2.1.3 Accessories – 2.2%.

Air conditioning, power steering, windshield wipers, and other accessories use energy generated from the engine. These kinds of accessories are important to the driver aid to driving. Fuel economy improvements of up to 1% may be achievable with more efficient alternator systems and power steering pumps (Oliver, I. 2012).

2.1.4 Driveline Losses – 5.6%.

Energy is lost in the transmission and other parts of the driveline as gear rotation and other rotational equipment on the vehicle. Technologies, such as automated manual transmission and continuously variable transmission, are being developed to reduce these losses (Oliver, I. 2012).

2.1.5 Aerodynamic Drag – 2.6%.

A vehicle must consume energy to travel air out of the way as it drives down the road, less energy at lower speeds and progressively more as speed increases (Oliver, I. 2012). Drag is in a straight line related to the vehicle's shape. Smoother vehicle forms have already reduced drag significantly, but additional reductions of 20-30% are acceptable.

2.1.6 Rolling Resistance – 4.2%

Rolling resistance is an amount of the force needed to travel the tire frontward and is directly proportional to the weight of the load sustained by the tire. A variation of new technologies can be castoff to decrease rolling resistance, as well as improved tire tread and shoulder designs and materials used in the tire belt and traction surfaces. For passenger cars, a 5-7% decrease in rolling resistance intensifications fuel efficiency by 1% (Oliver, I. 2012). However, these developments must be balanced in contradiction of traction, durability, and noise.

2.1.7 Overcoming Inertia; Braking Losses – 5.8%

To travel onward, a vehicle's drivetrain essential deliver enough energy to overcome the vehicle's inertia, which is directly related to its weight. The lesser amount of a vehicle weighs the less energy it takes to travel it (Oliver, I. 2012). Weight can be reduced by using lightweight materials such as carbon fibre and lighter-weight

technologies (e.g., automated manual transmissions weigh less than conventional automatics). In addition, any time use brakes, energy initially used to overcome inertia is lost.

2.2 INTERNAL COMBUSTION ENGINE

An internal combustion engine (ICE) is an engine that runs by burning its fuel inside the engine. The most common internal combustion engine type is gasoline powered that is includes fueled by diesel, hydrogen, methane, propane, etc. Engines characteristically can singly run on one kind of fuel and involve adaptations to regulate the air/fuel ratio or mix (Ganesan, V.2002).

In a gasoline or petrol engine, a mixture of gasoline and air is sprayed into a cylinder by nozzle. Mixture is compressed by a piston and at optimal point in the high compression stroke. A spark plug in the valve creates an electrical spark that ignites the fuel. The combustion of the fuel consequences in the generation of heat, and the hot gases produced that are in the cylinder are then at a higher pressure than the fuel-air mixture and so drive the piston back down. These combustion gases are emitted and the fuel-air mixture reinstated to course a second stroke. The lined motion of the piston is generally connected by a crankshaft to create circular motion. Valves control the intake of air-fuel mixture and permit exhaust gasses to exit at the right times.

2.2.1 Four-stroke spark ignition engine

One of the greatest inventions in engine design comes from Nicolaus August Otto who in 1876 invented an effective gas motor engine. Otto constructed the first practical four-stroke internal combustion engine called the "Otto Cycle Engine," and as soon as he had accomplished his engine, he constructed it into a motorcycle (Shyam K. A. 2006). Otto's contributions were very historically significant, it was his four-stoke engine that was generally accepted for all liquid-fuelled automobiles successful advancing.