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THE EFFECT OF HOLE PLATE ON AUTOMOTIVE WASTE HEAT EXTRACTION

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DECLARATION

"I declare that this report is done by my own exclude citation with the mentioned references for each."

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To My Parent And My Family

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ABSTRACT

Exhaust system is one of the important parts in the engine system. Exhaust system causes huge impact on the performance of the engine. When vehicle start, exhaust system will warm up caused by combustion inside the cylinder. The exhaust gasses from the combustion will be issued through exhaust system. Sometimes the temperature of the exhaust system increase and at the same time the heat is dissipated to the environment air. According to Dr Harald Bottner the temperature difference between the exhaust pipe and a pipe carrying engine cooling fluid can thus be several hundred degrees Celsius. Therefore, the heat dissipated can be converted to electricity by using thermoelectric materials. In this project, the front pipe is modified by installing hole plate inside it. By using front pipe that has hole plate, it is predicted, that the wall temperature of this front pipe will rise up. Thus, much more heat can be dissipated and converted to electricity. The 1.3L Proton Satria engine is used and the result indicated that the new design of front pipe with hole plate can increase the wall temperature of the front pipe more than 200 degree Celsius. Furture step is by conceptual design and fabrication to make front pipe that have hole plate inside the front pipe to boost pipe wall temperatures of the front pipe. Painting by sketches and three dimensional designs must be carried out to make sure this project going well. The 3D design can be made using the software as Solidwork and Catia to make sure the design strong and no leakage problem before started the fabrication step. In the fabrication, welding, cutting and drilling will be used to make the front pipe. There were three design of front pipe that need to be made to find out the effect of hole plate at the exhaust system. The analysis will be carried out after finish the fabrication.

ABSTRAK

Ekzos sistem adalah salah satu komponen yang penting dalam sesebuah enjin. Ekzos sistem memberi impak yang amat besar pada prestasi enjin kenderaan sama ada kereta mahupun motosikal. Apabila kenderaan dihidupkan sistem ekzos akan memanas disebabkan pembakaran di dalam enjin berkenaan. Pembakaran yang berlaku di dalam enjin akan dikeluarkan melalui sistem ekzos. Ada kalanya suhu sistem ekzos meningkat dan di masa yang sama haba terlepas ke persekitaran. Berdasarkan Dr. Harald Bottner (2004), perbezaan suhu di antara paip ekzos dan paip pembawa penyejukan enjin dijangkakan boleh melebihi ratusan darjah Celsius. Oleh itu, tenaga haba yang terhasil boleh diubah kepadatenaga elektrik menggunakan bahan thermoelektrik. Di dalam projek ini, paip hadapan diubahsuai dengan menambahkan kepingan besi berlubang di dalamnya. Dengan menggunakan rekabentuk yang terbaru, ia membayangkan bahawa suhu dinding paip hadapan akan meningkat. Oleh itu, lebih banyak tenaga haba akan dibebaskan dan diubah kepada tenaga elektrik. Enjin Proton Satria 1.3L digunakan di dalam kajian ini dan keputusan menunjukkan bahawa rekabentuk paip hadapan yang baru akan meningkatkan suhu dinding paip hadapan lebih daripada 200 darjah Celsius. Langkah seterusnya adalah dengan melukis dan membuat paip hadapan yang mempunyai kepingan besi berlubang didalamnye bagi meningkatkan suhu dinding paip hadapan. Lukisan secara lakaran dan tiga dimensi perlu bagi memastikan projek ini berjalan dengan lancar. Rekabentuk menggunakan perisian seperti Solidwork dan Catia perlu bagi membuktikan reka bentuk yang kukuh dan tiada sebarang masalah kebocoran pada paip hadapan. Proses pembuatan perlulah dijalankan bagi menghasilkan reka bentuk yang dikehendaki. Analisis daripada reka bentuk yang telah dihasilkan akan dijalankan apabila selesai proses pembuatan.

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CHAPTER 1

INTRODUCTION

The purpose of this chapter is to provide overview information on automotive exhaust system, heat transfer during experiment and the objective of the project and scope that will be conducted in this thesis. The overview of automotive waste heat extraction also will be explained in this chapter. Mainly this chapter will briefly explain about what will be discuss on other chapter.

1.1 Overview of Automotive Exhaust System

An exhaust system based on Tsuruta Yuuichirou (2004), is used to guide the waste gases away from combustion inside the engine. The system conveys burnt gases from the engine and includes one or more exhaust pipes. Depending on the overall exhaust system, the exhaust gas may flow through one or more of:

- Cylinder head and exhaust manifold.
- A turbocharger to increase engine power.
- A catalytic converter to reduce air pollution.
- A muffler or silencer to reduce noise.

In most production engines, the manifold is an assembly designed to collect the exhaust gas from two or more cylinders into one pipe. These design restrictions often result in a design that is cost effective but that does not do the most efficient job of venting the gases from the engine. Since cylinders fire at different times, exhaust leaves them at different times, and pressure waves from the gas emerging from one cylinder exactly might not be completely vacated through the exhaust system when another comes.

This creates a back pressure and restriction in the engine's exhaust system that can restrict the engine's true performance possibilities. The high pressure and high temperature that arrived through the pipe easily can be absorbed to change the energy to energy. From that, the energy goes out from the combustion inside the engine can perform a better energy and restore the energy for using to make another work.

1.2 Overview of Electricity from Exhaust Pipe

In an age of dwindling natural resources, energy savings is the order of the day. However, technical processes use less than one-third of the energy they employ. This is particularly true of automobiles, where two-thirds of the fuel remains unused in the form of heat. About 30% is lost through the engine block and a further 30 to 35% as exhaust fumes. Dr Harald Bottner (2004) stated that the temperatures in the exhaust pipe can reach 700 degrees Celsius or more. The heat energy from the exhaust system then converts the heat energy to the electrical energy using thermoelectric generators (TEGs). These devices convert heat into electrical energy by making use of a temperature gradient. The greater the temperature difference, the more current TEGs can produce. The temperature difference between the exhaust pipe and a pipe carrying engine cooling fluid can thus be several hundred degrees Celsius.

Researchers at the Fraunhofer Institute for Physical Measurement Techniques IPM in Erlangen, Germany, are developing thermoelectric materials, modules and systems to harness the residual heat in automobiles.

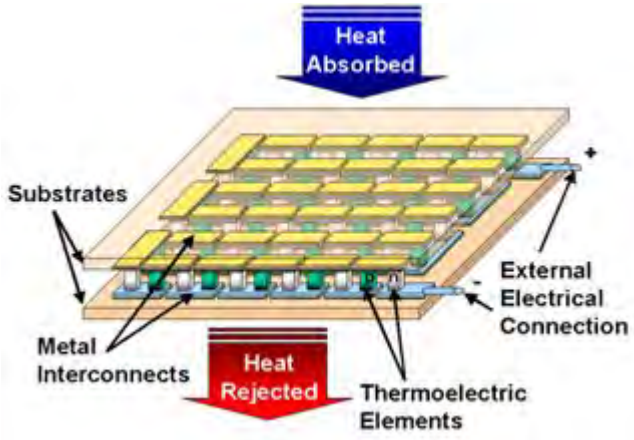

Figure 1: Illustrated of Thermoelectric module (Source: Thomas Johann Seebeck, (1821))

The thermoelectric converter makes use of this huge differential and driven by the flow of heat between the hot exhaust fumes and the cold side of a coolant pipe. The charge carriers pass through special semiconductors, thus producing an electric current similar to a battery. According to Jihui Yang (2008), the thermoelectric generator works when one side of its metallic material is heated, and excited electrons move to the cold side. The movement creates a current, which electrodes collect and convert to electricity. Dr Harald Bottner (2004) stated that TEGs could cover a significant proportion of a car's power requirements and it possible to cut gas consumption by between 5 and 7%.

Dr Harald Bottner (2004), stated that there are about 50 million licensed motor vehicles in Germany, each of which is on the road for an average of 200 hours a year. If their waste heat were utilized by TEGs during that time, with an output of one kilowatt sufficient to power parts of vehicle electronics, this would add up to ten terawatt hours of energy per annum. The researchers are still in the experimentation phase at present, but they plan to build the first prototypes very soon.

1.3 Problem statement

The study of effect of hole plate on the automotive waste heat extraction. In this project, the effect of the gasses flow through the hole plate will be discovered whether the temperature increasing or decreasing at the exhaust system. The performance of the engine and the temperature different at the exhaust system will be discovered. The flow of the exhaust combustion through the model will be showed using COSMOSFlowwork software.

1.4 Research Objective

The objective of this project is to increase the wall temperature of front pipe by using hole plate for automotive waste heat recovery.

1.5 Scope of the Project

I. Conduct literature review on automotive exhaust systems and heat transfer.

II. Conceptual design using software Solidwork of the front pipe of hole plate.

III. Fabrication of the front pipe.

IV. Perform experiment to investigate the effect of hole plate on the model.

V. Conduct on analytical analysis data gained from experiment.

CHAPTER 2

LITERATURE REVIEW

2.1 Manifold or Header of the Automotive Exhaust System

In most production engines, the manifold is an assembly designed to collect the exhaust gas from two or more cylinders into one pipe. Manifolds are often made of cast iron in stock production cars, and may have material-saving design features such as to use the least metal, to occupy the least space necessary, or have the lowest production cost. These design restrictions often result in a design that is cost effective but that does not do the most efficient job of venting the gases from the engine. Inefficiencies generally occur due to the nature of the combustion engine and its cylinders.

Since cylinders fire at different times, exhaust leaves them at different times, and pressure waves from gas emerging from one cylinder might not be completely vacated through the exhaust system when another comes. This creates a back pressure and restriction in the engine's exhaust system that can restrict the engine's true performance possibilities.

Figure 2: Exhaust manifold or header (Source: www.Wikipedia, October (2007))

A header (sometimes called extractor in Australia) is a manifold specifically designed for performance. During design, engineers create a manifold without regard to weight or cost but instead for optimal flow of the exhaust gases. This design results in a header that is more efficient at scavenging the exhaust from the cylinders. Headers are generally circular steel tubing with bends and folds calculated to make the paths from each cylinder's exhaust port to the common outlet all equal length, and joined at narrow angles to encourage pressure waves to flow through the outlet, and not back towards other cylinders. In a set of tuned headers the pipe lengths are carefully calculated to enhance exhaust flow in a particular engine revolutions per minute range (Source: www.Wikipedia, October (2007)).

Headers are generally made by aftermarket automotive companies, but sometimes can be bought from the high-performance parts department at car dealerships. Generally, most car performance enthusiasts buy aftermarket headers made by companies solely focused on producing reliable, cost-effective well-designed headers specifically for their car.

Headers can also be custom designed by a custom shop. Due to the advanced materials that some aftermarket headers are made of, this can be expensive. Luckily, an exhaust system can be custom built for any car, and generally is not specific to the car's motor or design except for needing to properly connect solidly to the engine. This is usually accomplished by correct sizing in the design stage, and selecting a proper gasket type and size for the engine (Source: www.Wikipedia, October (2007)).

2.2 Exhaust System Installation

According to Christopher Shortt and Elizabeth Hough (2004), the exhaust systems are designed for the vehicle they are in and the engine that is in the vehicle. In-line engines have a simple design that runs down one side of the engine. Called a single exhaust system, there is only one pipe to the rear of the car.

Single exhausts can be found on all engine sizes. A single exhaust system has one path for exhaust flow through the system. Typically, it has only one header pipe, a main catalytic converter, a muffler, and a tailpipe. This is the most common type of exhaust system.

V-type engines with dual exhaust have two pipes, two mufflers, and two catalytic converters. A dual exhaust allows better breathing when the engine is under load. A dual exhaust system has two separate exhaust paths to reduce the back pressure. A crossover pipe joins the two manifolds into one pipe as they leave the engine on a V-type engine's single exhaust system. A crossover pipe normally connects the right and left header pipes to equalize back pressure in a dual system. This also increases engine power slightly.

Through most cars and light trucks have exhaust systems with only a single catalytic converter, there are some with dual converters or piggyback converters. Service and repair procedures are pretty much the same on the dual-converter systems as those with only a single converter.

2.3 Heat Transfer of the Hole Plate

In the simplest of terms, the discipline of heat transfer is concerned with only two things such as temperature and the flow of heat. Temperature represents the amount of thermal energy available, whereas heat flow represents the movement of thermal energy from place to place. According to Richard Hedrick (2005), on a microscopic scale, thermal energy is related to the kinetic energy of molecules.

The greater a material's temperature, the greater the thermal agitation of its constituent molecules (manifested both in linear motion and vibration modes). It is natural for regions containing greater molecular kinetic energy to pass this energy to regions with less kinetic energy. In thermal physics, heat transfer is the passage of thermal energy from a hot to a colder body. When a physical body, e.g. an object or fluid, is at a different temperature than its surroundings or another body, transfer of thermal energy, also known as heat transfer, or heat exchange, occurs in such a way that the body and the surroundings reach thermal equilibrium. Heat transfer always occurs from a hot body to a cold one, a result of the second law of thermodynamics. Where there is a temperature difference between objects in proximity, heat transfer between them can never be stopped; it can only be slowed down (Source: www.wikipedia.org).

2.4 Automobile Exhaust System

According to Ryznic and John (1997), an automobile exhaust system comprises of various devices or parts of an automotive engine, which are used for discharging burned gases or steam. Exhaust systems consists of tubing, which are usually used for emitting out waste exhaust gases with the help of a controlled combustion taking place inside an automobile engine. All the burnt gases are exhaled from an engine using one or more exhaust pipes. These gases are expelled out through several devices like cylinder head, exhaust manifold, turbocharger, catalytic converter, muffler and silencer.

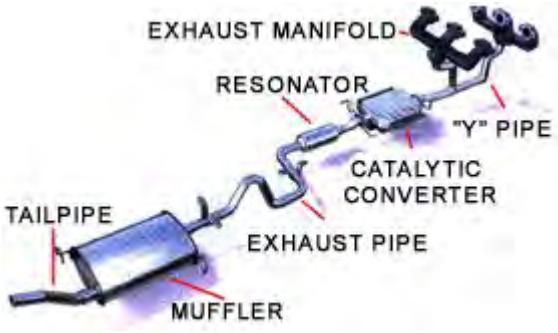

Figure 3: Exhaust system used in automobile (Source: John, (1997))

According to (Usui et al, (1985)), the major components used in a typical automobile exhaust system are exhaust manifold, resonator, catalytic converter, exhaust pipe, muffler, tail pipe, 'Y' pipe, ball flanges. All of these components are especially designed for providing suitable and effective exhaust flow, silencing, and emission levels. Exhaust Pipes are explicitly engineered to carry or transmit various toxic and noxious gases away from the users of the machine. Usually, exhaust gases are very hot, that is why exhaust pipes must be durable and heat resistant so that it does not get spoiled by heat. These double walled pipes are manufactured using different types of metals namely aluminized steel, stainless steel or zinc plated heavy-gauge steel. The exhaust pipes joins exhaust manifold, muffler and catalytic converters together.

Figure 4: Catalytic Converters (Source: John, (1997))

Catalytic Converters are the devices used for converting toxic and harmful hydrocarbons, carbon monoxide, and nitrogen oxides into harmless compounds. Converters transform hydrocarbons and carbon monoxide into carbon dioxide and water while separate nitrogen oxide into nitrogen and oxygen respectively. Catalytic converter is positioned underneath the passenger seat in most of the vehicles. The converter make use of various catalysts like platinum, palladium, and rhodium coated on a ceramic honeycomb structure which turns the dangerous gases into non toxic gases.

Figure 5: Exhaust manifold Gasket (Source: John, (1997))

Exhaust Manifold Gaskets consists of strong network of pipes that are used for collecting gases from cylinders and passes them directly to the exhaust pipe. Manifold gaskets are mostly made of cast or nodular iron, embossed steel, high temperature fiber material, graphite and other ceramic composites. The main function of exhaust manifold gasket is to seal the connection between the manifold and cylinder head. The design of exhaust gasket usually depends on the type of engine used and number of cylinders it has. It helps to prevent the leakage and allows exhaust gas to flow through catalytic converter easily and comfortably.

Figure 6: Exhaust clamps (Source: John, (1997))

Exhaust clamps are the components used for providing a strong connection between various pipe sections and other engine components. Mostly, steel is used for manufacturing exhaust clamps. It comes in wide array of sizes and can accommodate different sizes of exhaust pipes and connections. Exhaust brackets are a type of fastener generally made of steel and is used for providing support to different components used in an automobile exhaust system.

Figure 7: Exhaust flange (Source: John, (1997))

Exhaust Flange is a type of projecting rim used for attaching, joining or fastening tightly various exhaust pipes with the help of nuts and bolts. These flanges are mostly made of stainless steel, iron, aluminum, steel, carbon steel, alloy steel, and hardened steel.