‘Saya akui bahawa telah membaca
karya ini dan pada pandangan saya karya ini
adalah memadai dari segi skop dan kualiti untuk tujuan penganugerahan
Ijazah Sarjana Muda Kejuruteraan Mekanikal (Automotif)’

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INVESTIGATION OF PRESSURE AND TEMPERATURE CAUSE BY FROM TURBO SYSTEM IN VEHICLES

ABDUL HAKIM BIN ROHHAIZAN

Laporan ini dikemukakan sebagai
memenuhi sebahagian daripada syarat penganugerahan
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"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya jelaskan sumbernya"

Tandatangan : ………………………….

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ABSTRACT

In vehicles system, there are many type of energy flow from fuel as a chemical energy to the exhaust system as a thermal energy. Without realize, there have a lots of wasted energy been occurs when the engine starts running. In fact, there only 15 percent of the energy from the fuel from tank gets used to move car down the road or run useful accessories. The rest of the energy is lost to engine, idling, accessories, driveline, aerodynamic drag, rolling resistance and overcoming inertia or braking. Such as in exhaust system, the temperature at the exhaust manifold can reach around 900 ºC and this heat will lose to atmosphere. So, the recovery system must be creating to solve this problem. One of the systems is "Turbo System" which uses the energy losses from the exhaust system by convert to electric energy. In this system, the energy that flow to the exhaust will rotating the turbine and the turbine will drive the addition alternator. This alternator functions to produce current by converting from the mechanical energy to electric energy. The current produced can be stored to the battery and maybe the electric energy can use as an energy source of hybrid vehicles.

ABSTRAK

Di dalam sistem kenderaan, terdapat pelbagai jenis tenaga yang mengalir dari bahan api (tenaga kimia) kepada sistem ekzos (tenaga haba). Tanpa kita sedari, terdapat banyak tenaga yang hilang terhasil bermula daripada enjin berfungsi atau bergerak. Fakta ada menyebut, hanya 15 peratus tenaga daripada bahan api di dalam tangki digunakan untuk menggerakkan kenderaan atau menggerakkan aksesori. Tenaga yang selebihnya hilang kepada enjin, terbiar, aksesori, pemanduan, heretan aerodinamik, rintangan beralun, dan inersia yang hadir. Seperti contoh di dalam system ekzos, suhu dalam kebuk ekzos boleh mencapai sehingga 900 ºC and haba ini akan hilang ke atmosfera. Oleh itu, satu sistem pemulihan perlu diwujudkan untuk menyelesaikan masalah ini. Salah satu sistem yang boleh digunakan iaitu “Sistem Turbo” di mana ia menggunakan semula tenaga yang hilang daripada system ekzos dengan menukarkan kepada tenaga elektrik. Di dalam system ini, aliran tenaga yang melalui ekzos akan memutarkan turbin dan turbin tersebut akan menggerakkan penjana tambahan. Penjana ini berfungsi untuk menghasilkan arus dengan menukarkan tenaga mekanikal kepada tenaga elektrik. Arus yang terhasil boleh disimpan ke dalam bateri dan mungkin tenaga elektrik ini dapat digunakan sebagai sumber tenaga untuk kenderaan “hybrid”.

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LIST OF SYMBOL

W_b	=	Brake work of one revolution, J
V_d	=	Volume displacement, m^3
n	=	Number of revolution per cycle
$\dot{W}$	=	Power, W
N	=	Engine speed, rev/s
τ	=	Torque, N-m
m_a	=	Mass of air, kg
m_f	=	Mass of fuel, kg
$\dot{m}_a$	=	Mass flow rate of air, kg/s
$\dot{m}_f$	=	Mass flow rate of fuel, kg/s
υ	=	Velocity, m/s
g	=	Gravity acceleration, m/s^2
h	=	Height, m
p	=	Pressure, Pa
ρ	=	Density, kg/m^3
π	=	Constant value (3.142)
Nmax	=	Maximum Engine Speed
Vmax	=	Maximum Velocity
Pmax	=	Power maximum
Tmax	=	Torque maximum

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CHAPTER I

INTRODUCTION

1.1 Project Background

Generally, energy losses occur from engine to the exhaust system in vehicles. Only about 15 percent of the energy from the fuel you put in your tank gets used to move your car down the road or run useful accessories, such as air conditioning. The rest of the energy is lost to engine and driveline inefficiencies and idling. The energy losses in vehicle can be recycling in increasing the engine efficiency. Turbocharger and supercharger are the recovery system for this wasted energy by using the waste energy that flow through the exhaust system and been used again in engine performance.

A recovery system has been discovering called “Turbo System”. This system uses the flow of wasted energy from exhaust system to rotate the turbine in this system. It changes this wasted energy from mechanical energy to electric energy by using an addition alternator. Turbo system is the once of the system that only used a turbine without compressor for increase performance of the engine. This system has been installed to the 4A-GE engine that used in my research for investigation about pressure and temperature in the system and makes a comparison between the natural aspired engines. It is different from turbocharger because this system only use turbine at exhaust manifold and the compressor at the intake manifold terminated.

Normally in turbocharger, the rotational of the turbine will rotate the shaft that connected to the compressor blade but in turbine system the shaft that connected to the compressor before will be drive the alternator‟s pulley. So, the turbine functions to move the alternator in producing current.

1.2 Project significant

The significant of this project is developing a system recovery for the wasted energy in vehicles. This wasted energy has a potential to increase the efficiency of the engine and also get the better performance of the engine. From this recovery system, the electric energy can be produced for the future function such in hybrid car. The electric energy can be stored in one device such as battery and can be use for multi-function in vehicles that used electric as their energy source. So, it become suffer lose if this wasted energy did not been used for improvement and this project is very significant to the new era of automobile in our country with the increasing of petroleum price.

1.3 Objective

To investigate pressure and temperature from turbine system in vehicle due to recovery of the wasted energy at exhaust manifold.

1.4 Scope

In this research, the experimental must be developed and the result of the experiment analyzed. Below are the scopes for this project:

- Develop experimental rig to investigate the turbine performance.

- Conduct an experiment to determine pressure and temperature.
- Analysis data and make comparison

1.5 Problem Statement

Nowadays, there are many kind of systems that been installed into the natural aspirated engine to increase the performance of the engine such as supercharger and turbocharger. Supercharger is a compressor mounted in the intake system and used to raise the pressure of the incoming air. Turbocharger in vehicle is the solution for the supercharger and used to boost the power output of the engine. Turbine at the exhaust section runs the compressor to increase air intake into the combustion chamber and increase the power or performance of engine.

Therefore, once system from turbocharger concept called „Turbo System‟ was developed by using the rotational of the turbine in producing current by using an alternator. Main target of this system is to rotate the alternator to produce more current and the current can be store for the other function in the vehicle. The current stored can be as a future function such as hybrid vehicle or something else. However, the investigation for this new system must be carried out with data and analysis to see the engine performance. If there have a reducing performance with the engine, the determination of how much of the reduction of the performance such as power, torque, pressure or temperature will be analyzed.

The investigation is required to determine how much pressure and temperature that can be produced from the turbine in turbo system.

CHAPTER II

LITERATURE REVIEW

2.1 Energy Losses in Vehicles

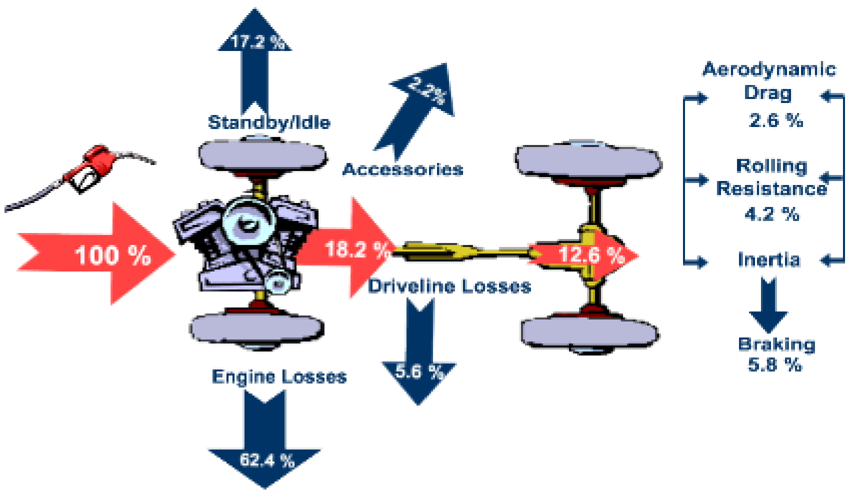

Figure 2.1: Flow of losses energy in vehicles [1]

Only about 15 percent of the energy from the fuel you put in your tank gets used to move your car down the road or run useful accessories, such as air conditioning. The rest of the energy is lost to engine and driveline inefficiencies and idling. Below are the percentages fractions of the energy losses in vehicle.

- Engine Losses - 62.4 %

In gasoline-powered vehicles, over 62 percent of the fuel's energy is lost in the internal combustion engine (ICE). ICE engines are very inefficient 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. In addition, diesels are about 30-35 percent more efficient than gasoline engines, and new advances in diesel technologies and fuels are making these vehicles more attractive.

- Idling Losses - 17.2 %

In city driving, significant energy is lost to idling at stop lights or in traffic. Technologies such as integrated starter/generator systems help reduce these losses by automatically turning the engine off when the vehicle comes to a stop and restarting it instantaneously when the accelerator is pressed.

- Accessories - 2.2 %

Air conditioning, power steering, windshield wipers, and other accessories use energy generated from the engine. Fuel economy improvements of up to 1 percent may be achievable with more efficient alternator systems and power steering pumps.

- Driveline Losses - 5.6 %

Energy is lost in the transmission and other parts of the driveline. Technologies, such as automated manual transmission and continuously variable transmission, are being developed to reduce these losses.

- Aerodynamic Drag - 2.6 %

A vehicle must expend energy to move air out of the way as it goes down the road less energy at lower speeds and progressively more as speed increases. Drag is directly related to the vehicle's shape. Smoother vehicle shapes have already reduced drag significantly, but further reductions of 20-30 percent are possible.

- Rolling Resistance - 4.2 %

Rolling resistance is a measure of the force necessary to move the tire forward and is directly proportional to the weight of the load supported by the tire. A variety of new technologies can be used to reduce rolling resistance, including improved tire tread and shoulder designs and materials used in the tire belt and traction surfaces. For passenger cars, a 5-7 percent reduction in rolling resistance increases fuel efficiency by 1 percent. However, these improvements must be balanced against traction, durability, and noise.

- Overcoming Inertia; Braking Losses - 5.8 %

  To move forward, a vehicle's drive train must provide enough energy to overcome the vehicle's inertia, which is directly related to its weight. The less a vehicle weighs the less energy it takes to move it. Weight can be reduced by using lightweight materials and lighter-weight technologies (e.g., automated manual transmissions weigh less than conventional automatics). [1]

2.2 Internal Combustion Engine

The internal combustion engine (ICE) is a heat engine that converts chemical energy in a fuel in to mechanical energy, usually made available on a rotating output shaft. Chemical energy of the fuel is the first converted to thermal energy by means of combustion or oxidation with air inside the engine. This thermal energy raises the temperature and pressure of the gases within the engine and the high-pressure gas then expends against the mechanical mechanisms of the engine. This expansion converted by the mechanical linkage of the engine to a rotating crankshaft, which is output of the engine. The crankshaft, in turn, is connected to a transmission or power train to transmit the propulsion of a vehicle.

There are so many different engine manufacturers, past, present and future, that produces and have produced engine which differ in size, geometry, style and operating characteristics, that no absolute limit can be stated for any range of engine characteristics such as size, number of cylinders and stroke in a cycle. Internal combustion engine, the type of ignition can be classified into two types and they are:-

1. Spark Ignition (SI)

   An SI engine starts the combustion process in each cycle by use a spark plug. The spark plug functions to give a high-voltage electrical discharge between two electrodes which ignites the air-fuel mixture in the combustion chamber.

2. Compression Ignition (CI)

   The combustion process in a CI engine starts when air-fuel mixture self-ignition due to high temperature in the combustion chamber caused by high compression.

For the SI ignition engine, they have two type of engine cycle and they are four-stroke cycle and two-stroke cycle. These basic cycles are fairly standard for all engines, with only slight variations found in individual designs. Below, the mechanism about four-stroke and two-stroke cycle can be determined.

2.2.1 Four-stroke SI engine cycle

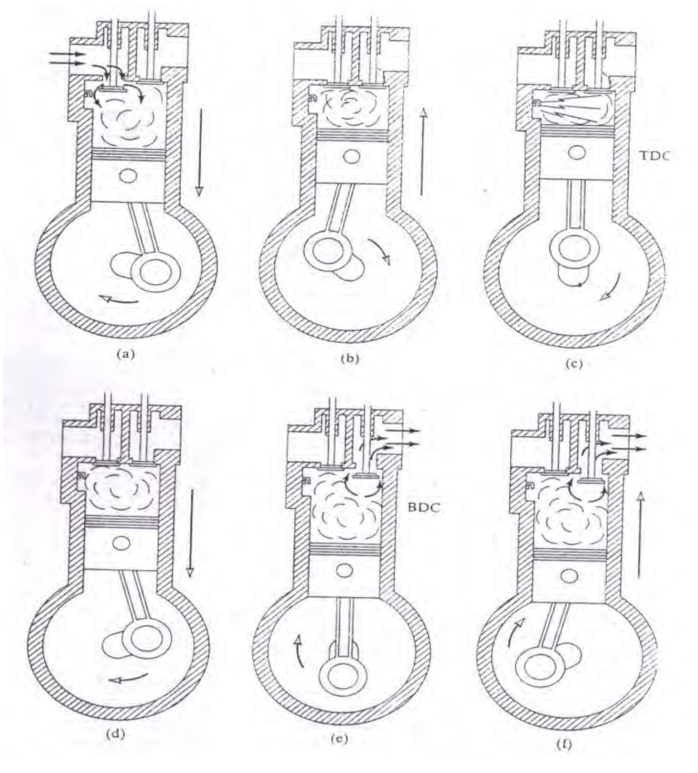

Figure 2.2: Four-stroke SI engine cycle
(Willard W. Pulkrabek, 2004)

At the first stroke, the piston travels from top dead centre (TDC) to bottom dead centre (BDC) with the intake valve open and exhaust valve close. This creates an increasing volume in the combustion chamber. The resulting pressure differential through the intake system from atmosphere pressure on the outside to the vacuum on the inside causes air to be pushed into the cylinder. As the air passed through the intake system, fuel is added to it in the desired amount by means of fuel injector or a carburetor.

For the second stroke, when the piston reaches the BDC, the intake valve closes and the piston travels back to the TDC with all valve closed. This compresses the air-fuel mixture, raising both the pressure and the temperature in the cylinder. Near the end of the compression stroke, the spark plug is fired and combustion initiate. Combustion of the air-fuel mixture occurs very short but finite length of time with the piston near TDC. It also changes the composition of the gas mixture to that of exhaust products and increases the temperature in the cylinder to a very high peak value.

The third stroke known as expansion stroke happen with all valve closes and the high pressure created by combustion process pushed the piston away from TDC. This is the stroke which produces the work output of the engine cycle. Late in the expansion stroke, the exhaust valve is opened and exhaust blow-down occurs. Pressure and temperature in the cylinder still high relative to the surrounding at this point, and a pressure differential is created through the exhaust system which is open to atmospheric pressure.

Last stroke known as exhaust stroke by time the piston reaches BDC and exhaust blow-down is complete but the cylinder is still full of exhaust gases at approximately atmospheric pressure. With the exhaust valve remaining 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, the intake valve starts to open and so that it is fully open by TDC when the new intake stroke starts the next cycle.

2.2.2 Two-stroke SI engine cycle

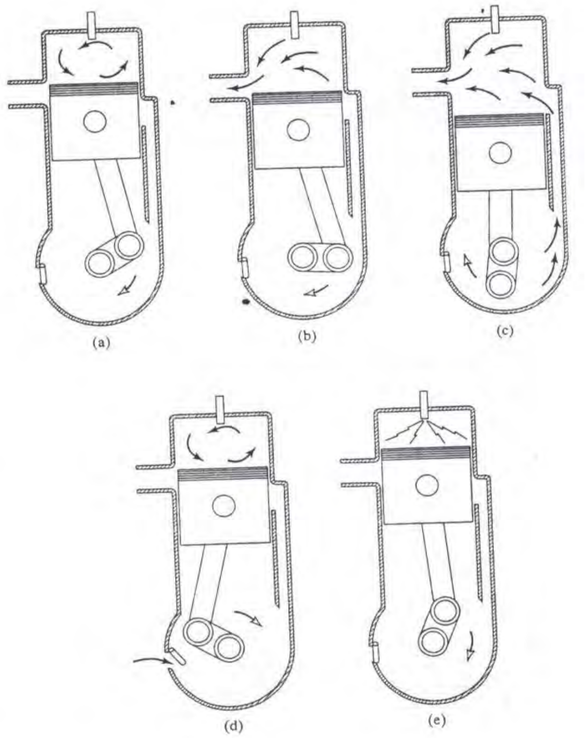

Figure 2.3: Two-stroke SI engine

(Willard W. Pulkrabek, 2004)

For the first stroke, very high pressure created by the combustion process forces the piston down in the power stroke. The expanding volume of the combustion chamber causes pressure and temperature to decrease as the piston travels toward BDC. At exhaust blow-down, at about 75º bBDC, the exhaust valve opens and blow-down occurs. The exhaust valve may be a poppet valve in the cylinder head, or it may be a slot in the side of the cylinder remains filled with exhaust gas at lower pressure.

When the blow-down is nearly complete, at about 50º bBDC, the intake slot on the side of the cylinder is uncovered and intake air-fuel mixture enters under pressure. This incoming mixture pushes much of the remaining exhaust gases out the open exhaust valve and fills the cylinder with a combustible air-fuel mixture, a process called scavenging. The piston passes through the BDC and very quick cover the intake pot and then the exhaust port.

At second stroke, all valve closed and the piston travels toward TDC compresses the air-fuel mixture to a higher pressure and temperature. Near the end of the compression stroke, the spark plug is fired; by the time the piston gets to TDC, combustion occurs and the next engine cycle begin.

For this research, four-stroke SI engine has been chosen and all the type and specification about this engine will be covered at the next sub-topic.

(Willard W. Pulkrabek, 2004)

2.3 History of 4A-GE Engine

Figure 2.4: 4A-GE Engine, Toyota (16-valve) [2]

Toyota has developed 4A-GE engine until fifth generation; the first-generation was introduced in 1983 replaced the *2T-G* in most applications. This engine was identifiable via silver cam covers with the lettering on the upper cover painted black and blue, as well as the presence of three reinforcement ribs on the back side of the block. It can produce 112 hp (84 kW) at 6600 rpm and 97 ft-lb (131 N-m) of torque at 4800 rpm.

The second-generation 4A-GE produced from 1987 to 1989 featured larger diameter bearings for the con-rod big ends (42 mm) and added four additional reinforcement ribs on the back of the engine block, for a total of seven.