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STUDY ON OPERATING ENGINE TEMPERATURE IN RELATION WITH ENGINE PERFORMANCE

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THIS THESIS IS SUBMITTED AS PARTIAL FULFILMENT OF REQUIREMENTS FOR THE DEGREE OF THE BACHELOR OF MECHANICAL ENGINEERING

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MEI 2009

"I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged"

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ABSTRACT

The objective of this report is to compile and report all information, findings, data and other gains from the research of this topic which is the study on operating engine temperature in relation with engine performance. One of the important systems in engine vehicle is cooling system. Cooling system is designed to provide optimum temperature in order to reach operating temperature quickly and also maintain that particular temperature. Cooling system is also responsible to remove excess engine heat. This research is conducted to study relationship between engine temperature and engine performance. In order to study that particular relationship, experiment must be conducted to know the standard condition of the vehicle operating temperature which is the moment the vehicle has already warm up and radiator fan already function. Then this vehicle will undergo the chassis dynamometer test to know the relation between the temperature and performance through a few series of dynamometer test run. After the standard condition has already known, DC motor speed controller is developed whereby it will be used in the next chassis dynamometer test to observe the relationship of the input which is voltage and the output temperature. The input voltage is related to the radiator fan. Therefore, from this experiment, we can notice the relationship of variable fan speed of radiator fan to the temperature of the engine using this DC motor speed controller as a medium to give variable input voltage. Finally, a concept study of Fuzzy Logic controller is conducted in order to develop the simulation model using this type of controller and also the automatic variable fan speed cooling system in future.

ABSTRAK

Objektif laporan ini ialah untuk mengumpul dan melaporkan segala data, penemuan dan juga maklumat yang diperoleh daripada topik kajian ini iaitu kajian tentang suhu operasi enjin dan hubungannya dengan prestasi enjin. Sistem penyejukan merupakan salah satu sistem yang penting dlm enjin kenderaan. Sistem penyejukan direkabentuk untuk menyediakan suhu optimum di dalam usaha untuk mencapai suhu operasi secepat mungkin dan juga untuk mengekalkan suhu tersebut. Sistem penyejukan berfungsi untuk menyingkirkan haba berlebihan. Selain daripada itu, kajian ini juga ialah untuk mengetahui hubungan antara suhu enjin dan prestasi enjin di mana untuk mengkaji hubungan ini, satu eksperimen dijalankan untuk mengetahui suhu keadaan piawai kenderaan pada saat kenderaan dibiarkan seketika dan kipas radiator telah berfungsi. Kemudian kenderaan ini akan melalui ujian dinamometer casis untuk mengetahui hubungan antara suhu dan prestasi enjin melalui beberapa siri ujian. Selepas keadaan piawai diketahui, 'DC motor speed contoller' disediakan untuk digunakan dalam eksperimen seterusnya iaitu untuk mengetahui hubungan antara input iaitu voltan dan juga output iaitu suhu enjin. Voltan input pula diketahui mempunyai hubungan dengan laju kipas radiator. Oleh sebab itu melalui eksperimen ini, hubungan antara variasi laju kipas radiator dan suhu enjin dapat diketahui melalui penggunaan medium 'DC motor speed controller' yang digunakan untuk memberi voltan input yang pelbagai. Setelah data diperoleh satu konsep kajian tentang 'Fuzzy Logic Controller' dilakukan di mana 'controller' ini boleh digunakan dalam usaha membangunkan system kawalan halaju kipas radiator secara automatik pada masa depan.

DEDICATION

My special dedication towards my beloved parents, family, Mr. Herdy Rusnaidy; my supervisor and all friends. May god bless them for all the help to complete this thesis.

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In the name of ALLAH s.w.t; I would like to express my first and foremost thankfulness for giving me the optimum health, courage and strength along the period of completing this project.

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CHAPTER 1

INTRODUCTION

Automobiles or vehicles engine need optimum operating temperature in order to have a better performance. Too much heat or higher temperature of engine can cause overheating and can damage the engine as well while an engine which is too low or not at proper operating temperature will make the vehicle run inefficiently and also run with rich air-fuel mixture. Too high of engine temperature will warp or bend out the natural shape of metal which will then lead to engine damage. Therefore, it is important for an engine to reach the optimum temperature for its operation.

In order to get and reach the optimum operating temperature, the cooling system plays the vital role to perform this job. Mostly, the vehicle engine has an operating temperature range and the cooling system maintains the temperature within that particular range. However, it is better to have a cooling system that can provide more accurate operating temperature or a cooling system that can control and maintain the engine to its operating or optimum temperature. In general, the normal engine operating temperature is in range of 83ºC to 92ºC. In order to control the temperature, there is a need to know the relationship between the variable fan speed and the engine temperature.

Besides to know the relationship between variable speed of the fan and also engine temperature through experiment using DC motor speed controller, this study is also conducted to know the relationship between the operating engine temperature and engine performance. Apart from that, through this study also the problem of engine failure due to overheating can be overcome through the conceptual study on fuzzy logic controller as a fan speed control whereby for future study, the fuzzy system can then be interpreted to programming or coding. The coding is then downloaded to microcontroller which receives a feedback from temperature sensor to control or to generate variable fan speed automatically.

Moreover, through out this study it is also known that engine consume more fuel if it runs below the most efficient operating temperature and thus this will help us to avoid it.

1.1 OBJECTIVE

1. To know the relation of variable fan speed to engine temperature through experiment of controlling fan speed using DC motor speed controller in chassis dynamometer test.
2. To do a conceptual study on Fuzzy Logic Controller and learn how to build the Fuzzy Logic Controller for the usage in future simulation model development.

1.2 PROBLEM STATEMENT

In order to increase the life span of the engine, the optimum operating temperature and the cooling system must be taken care of. This is because poor cooling system will contribute to engine overheating and engine that is not at proper operating temperature will run inefficiently. Thousands of cars are stranded on the side of the road due to these problems and therefore, precaution must be taken in order to avoid this from happen.

Because of that reasons, variable fan speed is important in order to bring the engine temperature to its operating temperature or to maintain it at its optimum temperature. In order to control the temperature for the specific car engine, it is needed to conduct some experiment on chassis dynamometer test to know the relationship between variable fan speed which is controlled by DC motor speed controller and the engine temperature.

1.3 SCOPE

1. Study on relationship between engine temperature and engine performance
2. Development and fabrication of a DC motor speed controller for the purpose of experiment to know the relationship of input voltage and radiator fan speed against engine temperature.
3. A concept study on Fuzzy Logic Controller and how to build the Fuzzy Logic Controller for the usage in future simulation model development.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In order to accomplish this project, we must gather some information that can help us to learn more about the topic that we are studying on and also give us knowledge about the key point that can be included in this project. Therefore the information which is related to the scope of this project must be considered.

Car engine need optimum temperature for their operation and the cooling system should provide that optimum temperature. In order to provide that optimum temperature, variable fan speed cooling system is going to be design as one of solution because by using this system, it can be believed that the best engine operating temperature can be reach and maintain for the purpose of engine operation. From that a study can be done to find out the relation between that optimum temperature with the performance of the engine vehicle.

2.2 SECONDARY COOLING SYSTEM

It is important to ensure that the application of the automatic variable fan speed cooling system doesn't affect the performance of the vehicle or even cause the power loss.

"According to D. Chalgran Jr Robert, Traczyk Timothy (2005), secondary cooling system design is best accomplished when considered as part of the total vehicle cooling system so that the full advantages of it can be utilized in component design and system integration. There are many ways to reduce the power loss during the development stages:

- Distributed cooling with electric fan to reduce the heat exchanger module stack concentrated in front of a mechanical fan.
- Decrease drives losses by decreasing the size and power of mechanically driven fan and pump.
- Decrease pumping losses by operating pumps and fans at optimal points with variable speed electric drives.
- Operate the secondary system at its optimal operating temperature through electronic control of the electric pump, valve and fan.
- Improved temperature control enables the use of more optimal engine calibration".

There are some benefits of using the electronic cooling system to the system life.

"According to D. Chalgran Jr Robert, Traczyk Timothy (2005), extended component / engine life benefits can be difficult to quantify in the short term, but the changes in operating characteristic possible with an electric cooling system improve the functional environment of the components".

2.3 COOLING SYSTEM

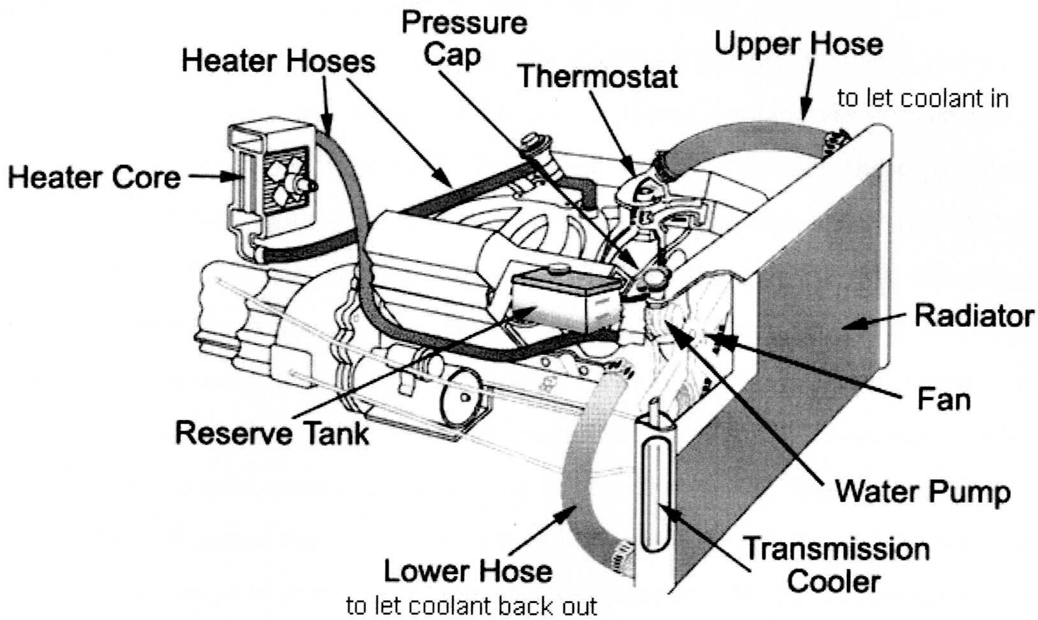

Figure 1: Components of an Automobile Engine Cooling System

"According to Ofria Charles, Short Course on Cooling System (2008), there are two types of cooling system found on motor vehicles such as air cooled and liquid cooled. Air cooled engines are used by a few older vehicle while nowadays most automobiles and trucks use liquid cooled system.

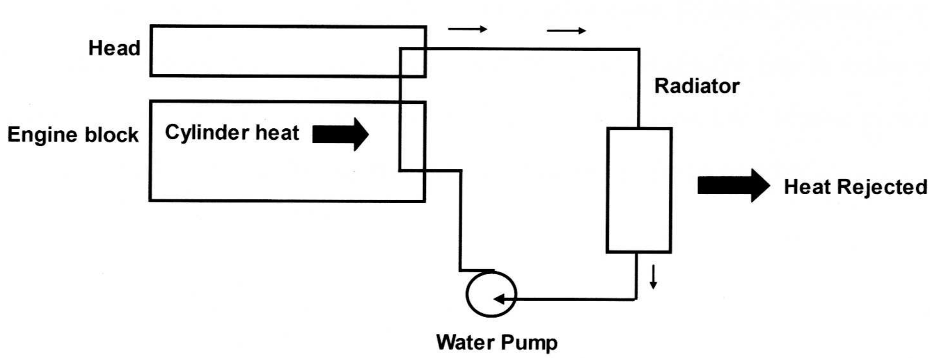

Figure 2: Liquid Cooling System

The cooling system is made up of the passages inside the engine block and heads while a water pump has a function to circulate the coolant. Besides that, a thermostat has a function to control the temperature of the coolant while a radiator cool the coolant and radiator cap controls the pressure in the system. Some plumbing consisting of interconnecting hoses which are to transfer the coolant from the engine to radiator. A cooling system functions and works by sending a liquid coolant via passages in the engine block and heads. As the coolant flows and circulates through these passages, it absorbs heat from the engine. The heated fluid then flows through a rubber hose to the radiator in front of the car. As the heated liquid flows through the thin tubes in the radiator, the heat is released and cooled by the air stream entering the engine compartment from the grill in front of the vehicle. After the fluid is cooled, it will return to the passages inside the engine to absorb more heat. This process continues with the circulation of the liquid coolant to the engine to absorb heat and then to the radiator to release the heat. Between the engine and the radiator there is a thermostat to make sure that the coolant stays above a certain preset temperature. If the temperature of the coolant falls below this temperature, the thermostat will block the coolant flow to the radiator, forcing the fluid instead through a bypass directly back to the engine. The coolant will continue to circulate like this until it reaches the design temperature, at which point where the thermostat will open a valve and allow the coolant back through the radiator.

In order to prevent the coolant from boiling, the cooling system is designed to be pressurized. Under pressure, the boiling point of the coolant is raised considerably. However, too much pressure will cause hoses and other parts to burst; therefore a system is needed to relieve pressure if it exceeds a certain point. Radiator cap is responsible to maintain the pressure in the cooling system. The cap is designed to release pressure if it reaches the specified upper limit that the system was designed to handle".

2.4 CIRCULATION

"According to Ofria Charles, Short Course on Cooling System (2008), the coolant follows a path that takes it from the water pump, through passages inside the engine block where it collects the heat produced by the cylinders. It then flows up to the cylinder head (or heads in a V type engine) where it collects more heat from the combustion chambers. It then flows out past the thermostat (if the thermostat is opened to allow the fluid to pass), through the upper radiator hose and into the radiator. The coolant flows through the thin flattened tubes that make up the core of the radiator and is cooled by the air flow through the radiator. From there, it flows out of the radiator, through the lower radiator hose and back to the water pump. By this time, the coolant is cooled off and ready to collect more heat from the engine.

The capacity of the system is engineered for the type and size of the engine and the work load that it is expected to undergo. Obviously, the cooling system for a larger, more powerful V8 engine in a heavy vehicle will need considerably more capacity then a compact car with a small 4 cylinder engine. On a large vehicle, the radiator is larger with many more tubes for the coolant to flow through. The radiator is also wider and taller to capture more air flow entering the vehicle from the grill in front".

2.5 FAN SYSTEM

2.5.1 Radiator Cooling Fan System

The radiator cooling fan is an important part of the cooling system operation. While a fan is not really needed while a vehicle is traveling down the highway, it is extremely important when driving slowly or stopped with the engine running. In the past, the fan was attached to the engine and was driven by the fan belt. The speed of the fan was directly proportional to the speed of the engine. This type of system sometimes caused excessive noise as the car accelerated through the gears. As the engine speed up, a rushing fan noise could be heard. In order to quiet down and place less of a drag in the engine, a viscous fan drive was developed in order to disengage the fan when it was not needed.

When computer controls came into being, these engine driven fans gave way to electric fan that were mounted directly on the radiator. A temperature sensor determined when the engine was beginning to run too hot and turned on the fan to draw air through the radiator to cool the engine. On many cars, there were two fans mounted side by side to make sure that the radiator had a uniform air flow for the width of the unit.

When the car was in motion, the speed of the air entering the grill was sufficient to keep the coolant at the proper temperature, so the fans were shut off. When the vehicle came to a stop, there was no natural air flow, so the fan would come on as soon as the engine reached a certain temperature.

2.5.2 Electric Cooling Fan

The electric cooling fan is typically mounted behind the radiator. On some vehicles with large, wide radiators, there may be two cooling fans, or there may be a separate fan for the air conditioning condenser. The fan only runs when needed to help cool the engine. The engine coolant sensor or a separate engine temperature switch is used to monitor engine temperature. Extra cooling is not needed when a cold engine is first started, so the fan does not turn on until the engine reaches normal operating temperature (90.6°C to 101.7 °C). The fan will then turn on and off as needed to maintain the coolant temperature. So the fan runs mostly at idle or low speed when the engine is at normal temperature.

2.5.2.1 Electric Cooling Fan Circuit

The fan's temperature-sensing power circuit only runs the fan when extra cooling is needed. On older applications, fan operation is usually controlled by a temperature switch located in the radiator or on the engine. When the temperature of the coolant exceeds the switch's rating (typically 90.6ºC to 101.7 ºC), the switch closes and energizes a relay in the engine compartment that supplies voltage to the fan. The fan then continues to run until the coolant temperature drops back below the opening point of the switch. A separate circuit turns on the fan when the A/C compressor clutch is engaged.

In newer vehicles with computerized engine controls, fan operation is often regulated by the power train control module (PCM). Input from the coolant sensor and in many cases the vehicle speed sensor too, is used by the PCM to determine when the fan needs to be energized. On some vehicles, the PCM may also select between high and low fan speeds to match the engine's cooling requirements.

2.6 RADIATOR HEAT TRANSFER

Radiators also well known as compact heat exchanger are classified as plate-fin or tube-fin heat exchanger, R.K Shah et. al. and F.Mayinger et al. (2000) define a compact heat exchanger as that which has over $700m^2/m^3$ heat transfer area to fluid volume area. This heat exchanger can provide a higher heat transfer coefficient in laminar flow than that offered by a highly turbulent flow in a plain tube situation.

A review of existing experiment by N.Y.Ng et al. stated that the alternative way to increase the heat dissipation from radiator is to control the airflow that causes the force convection. Anemometer is used to measure the airflow velocity. However, anemometer needs prior calibration on a flow stand over a wide range flow rate and often requires recalibration.

The difficulties of measuring the air flow are caused by several factors, the compactness of engine compartment, the airflow velocity through radiator are typically low which is a few meters per second, the unknown flow direction due to the major separation and reversal, the cooling system location is an enclosed area, making measurement access difficult.

Besides that, by referring to an elementary equation from basic thermodynamics it states that the rate of heat transfer (Q) equals the mass flow rate (m) times a constant (the specific heat of water) times the delta T (fluid temperature out minus fluid temperature in).

$$Q = m \times Cp \times \Delta T$$

In other words, the rate of heat transfer is directly proportional to mass flow rate. Increase the flow rate; will then increase the rate of heat transfer. Assume the engine block inserts a constant rate of energy (Q) into the cooling system. Then, from the relationship above, increasing the mass flow rate must result in a smaller delta T because Q remains constant. This smaller Delta T (fluid out-fluid in) also means that the average fluid temperature in the water block is somewhat lower even though the rate of heat transfer has not changed. [3]