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this thesis is enough from the aspects of scope and quality
for the award of
Bachelor Degree in Mechanical Engineering (Thermal & Fluids)"

Signature :

Supervisor : MD. ISA BIN ALI

Date : 31/5/06

RADIATOR HEAT DISSIPATION TESTING

MOHD SAIFUL HAKIMI BIN MAT LWI

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" I declare that this thesis entitle "Radiator Heat Dissipation Testing"
is the result of the work of myself except for the references which
I had clarified the sources"

Signature :

Author : MOHD SAIFUL HAKIMI BIN MAT LWI

Date : 31 / 05 / 2006

Specially dedicated to my family, friends and companion

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ABSTRACT

This study describe of an experimental approach to determine the best automotive radiator for Proton Wira 1.5L. The particular to be explored here are the heat dissipation of different types, sizes, materials and conditions of several radiators in order to come out with the best radiator that suit to the engine with the best performance.

Some original studies published only focusing on the radiator that had been used in four season countries. So the coolant in the radiator was added with antifreeze and some chemical liquid instead of water itself. But in Malaysia, the only coolant that had been used for years in radiators were basically water and if there were chemical liquid added, they were only for purpose of extending the radiator's life time. The testing done by replacing several different radiators which are Nissan, Ford, Honda, Mitsubishi and original radiator for Proton Wira 1.5L to the engine and run with and without fan conditions. The data taken were used to generate a set of curve for each radiator as the heat dissipation analysis.

The analysis fully focused on heat transfer by the radiators in two conditions; with fan and without fan. After conducting the experiment and evaluating the data, Mitsubishi's radiator was selected to be the best radiator that suit to Proton Wira engine based on the capability to dissipate heat due to several characteristics that contribute to the heat rejection. The heat dissipation will be increased as the temperature drop and coolant mass flow rate increased. The heat rejected also proportional to the engine speed, the heat loss rate will arise when the engine running at higher speed. Hopefully this approach will serve readers to concentrate on many applications of engineering especially in the automotive discipline focusing on cooling system.

ABSTRAK

Kajian ini merupakan eksperimen untuk mendapatkan radiator terbaik untuk enjin Proton Wira 1.5L. Perkara khusus yang akan dikaji adalah kadar pembebasan haba oleh beberapa radiator yang berbeza dari segi jenis, saiz, bahan binaan dan keadaannya untuk mendapatkan radiator yang terbaik dan sesuai dengan enjin dengan prestasi yang terbaik.

Kajian yang telah dilakukan sebelum ini adalah tertumpu kepada radiator kereta yang digunakan dalam negara yang mengalami empat musim. Jadi bahan penyejuk (air) telah dicampurkan dengan bahan antibeku dan sedikit bahan kimia. Tetapi di Malaysia, bahan penyejuk yang telah sekian lama digunakan adalah air dan sekiranya terdapat bahan kimia yang dicampurkan, ini adalah bertujuan untuk menambah jangka hayat radiator tersebut. Eksperimen dijalankan dengan menggantikan radiator yang berlainan iaitu radiator Nissan, Ford, Honda, Mitsubishi dan radiator asal untuk Proton Wira 1.5L kepada enjin dan ujikaji dilakukan dalam dua keadaan iaitu dengan menggunakan kipas dan tidak menggunakan kipas. Data yang diperolehi digunakan untuk melakarkan graf sebagai analisa kepada kadar pembebasan haba.

Analisa adalah sepenuhnya memfokuskan kepada kadar pembebasan haba oleh radiator dalam dua keadaan; menggunakan kipas dan tidak menggunakan kipas. Setelah menjalankan eksperimen dan menganalisa data, radiator Mitsubishi adalah dipilih sebagai radiator terbaik untuk enjin Proton Wira dari segi pembebasan haba disebabkan beberapa ciri yang menyumbang kepada pembebasan haba. Kadar pembebasan haba akan meningkat apabila jatuhan suhu dan kadar aliran air di dalam radiator meningkat. Kadar pembebasan haba juga adalah berkadar langsung dengan halaju enjin diamana kadar pembebasan haba akan meningkat apabila halaju enjin meningkat. Adalah diharapkan kajian ini dapat membantu pembaca untuk menumpukan perhatian dalam bidang kejuruteraan terutamanya dalam bidang automotif dengan memfokus kepada sistem penyejukkan.

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SYMBOLS	DEFINITION
Q	Heat loss
m_c	Coolant mass flow Rate
c_p	Specific heat of coolant
T_i	Coolant temperature inlet
T_o	Coolant temperature outlet
v_c	Volume flow rate

GREEK	DEFINITION
ρ_w	Water density

SUBSCRIPT	DEFINITION
$_{ave}$	Average

CHAPTER I

INTRODUCTION

1.1 Overview

As we go through the automotive cooling system, almost all of automotive manufacturer considered radiator as one of the principle components instead of fan, pump and water block. The main task of radiator is to keep the engine from overheating by transferring the heat produces in the engine to the air. The goal of cooling back the coolant to the initial temperature will show how good the radiator is. However, the best radiator will always come along with the best fan and pump, and if the water block fails to extract the radiator's heat then all of the cooling components will have no chance to perform.

A very first model of Proton Wira was launched by Proton in 1993 based on the Mitsubishi Lancer/Colt. The proton Wira 1.5 on road nowadays is equipped with Denso radiator as the main cooling components to dissipate heat from the engine block.

Radiators are installed in automobiles to remove heat from under the hood. When driving a car, the engine produces intense heat which must be dissipated or the engine will overheat. The use of higher output engines with tightly compacted underhood packaging, the addition of new emission components, and aerodynamic front end styling with narrower openings are creating a hostile thermal environment in the engine compartment. This results in a smaller volume of under hood cooling air. These conditions demand a better understanding of the complex cooling air flow characteristics and resulting thermal performance of the radiator and other heat generating components in the engine compartment.

The heat lost during testing will be determined using equation as below;

$$Q = m_c c_p (T_i - T_o)$$

where;

Q	= total heat loss (kJ/s @ kWatt)
m_c	= average coolant mass flow rate (kg/s)
c_p	= specific heat of coolant (4.186 kJ/kg°C)
T_i	= coolant temperature inlet (°C)
T_o	= coolant temperature outlet (°C)

Some study use Reynolds number to interpret their result because they were dealing with many parameters and factors that effect the result.

This study only interested into heat loss instead of other parameters to obtain the best radiator for the engine. Probably the initial radiator may be the most suitable for the engine, the study will investigate what will happen to the heat dissipation rate when using different radiators with different characteristics but running under the same environment. The testing will be done by replacing several different types and characteristics of radiators that will be attached to the engine. The data obtained will be used to generate a set of curve to interpret the results.

1.2 Objective

The objectives of this study are to:-

i. Determine the best radiator that suit to Proton Wira.
ii. Obtain the parameters and physical characteristics that affect the cooling rate of Proton Wira cooling system.
iii. Generate the heat dissipation curves for different radiators.

1.3 Scope of Study

i. Several types of radiators were tested on the actual Proton Wira engine for with and without fan condition.
ii. For each radiator, a set of curve will be generated for the heat dissipation analysis. The data recorded were; coolant mass flow rate m_c, coolant temperature inlet T_i and coolant temperature outlet T_o.
iii. The generated curve will consist of the relationships between:-
    a. Coolant mass flow rate (m_c) and Engine speed (rpm)
    b. Temperature drop (ΔT) and Engine speed (rpm)
    c. Heat loss (Q) and Coolant mass flow rate (m_c)
    d. Heat loss (Q) and Engine speed (rpm)

1.4 Problem Statement

The most common complain about Proton Wira cooling system is the failure of it radiator. Sometimes we heard that the engine was totally burn due to overheating cause by radiator failure to dissipate heat generated in the engine block into the air.

So, the radiator heat dissipation testing will come out with ratification either the radiator that located at the front of every single Proton Wira in Malaysia deserve to be located there or just need to be replaced with another better radiator. If the testing reveals that there is another radiator that can perform better than initial radiator, it can be concluded that the radiator of Proton's car must be reconsidered in order to enhance it quality and performance.

CHAPTER II

LITERATURE REVIEW

2.1 Previous Study

Back in 1970's, the very first generation of automobiles use copper/brass radiator with no concrete reason as the widely metal that available at that time was copper and brass. Then in the wake of world oil crisis, major automobile manufacturers in Europe and US tend to invent a lighter cars and trucks to cope with current situation and reduce the oil consumption. For radiators, this translated to aluminum which is lower in density compared to copper/brass and able to handle heat fairly well despite its many shortcomings. Further more, aluminum is less expensive than copper / brass. As a result, for the past 20 years aluminum has taken the first place as the metal for radiators for new cars.

Radiators also well known as compact heat exchanger are classified as plate-fin or tube-fin heat exchangers, R.K Shah et al. and F. Mayinger et al. define a compact heat exchanger as that which has over 700 m^2/m^3 heat transfer area to fluid volume area. These heat exchangers 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 air flow that causes the force convection. Anemometer is used to measure the air flow velocity. However, anemometer needs prior calibration on a flow stand over a wide range flow Rate and often require recalibration. The difficulties of measuring the air flow are cause 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.

As shown in Fig 2.1.1 it was observed that airflow was non-uniformly distributed over the radiator and it was also noted that the bumper wake significantly influenced the cooling airflow with very limited flow through the region of the core in the wake of the bumper bar.

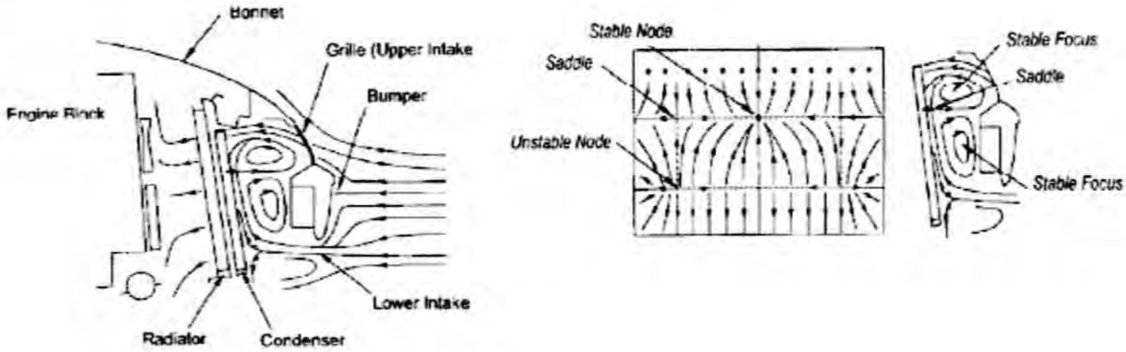

Fig 2.1.1 Underhood air flow profiles in a typical passenger car.

There are a lot of argument and opinion that can be taken from the internet that related to cooling system especially radiator. But the most interesting discussion on factors that affects the heat dissipation from a radiator is the coolant flow rate in the cooling cycle.

> *.......the lowest possible coolant (water) temperature will maximize the temperature difference – and therefore the heat transfer potential. As the efficiency of the radiator is greatest with the largest possible temperature difference, this would suggest lower coolant flow Rate to maximize the heat rejection by maximizing the contact time of the coolant and the radiator tube walls.*
>
> [http://www.ocforums.com]

The article states that by reducing the coolant flow rate, the time taken for the coolant to absorb heat from engine block and release it in the radiator will be expanded. Then the differential between temperature in and temperature out from the radiator will be at the highest stage. As the result, the heat dissipation from the radiator will be at the maximum point.

The online forum arguing about the performance of radiator with two main considerations;

> *.......more flows, better, more flow, more heat. Find the balance. The beautiful thing is that it takes a lot of energy to heat up water. As the water flows past the CPU, it does not pick up that much energy, so temp does not increase that much per pass. This means that small flow Rate are fine on the engine block side, and increasing Rate will decrease returns quickly. Radiators are different though. There is a lot of surface and tube to flow through in a radiator, so temp will drop significantly in a radiator per pass. So high flow rate is more important for radiators.*

…….there is an elementary equation from basic thermodynamics that 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 temp out minus fluid temp in).

$Q = M \times c_p \times \Delta T$

In other words, the rate of heat transfer is directly proportional to mass flow rate. You increase the flow rate; you 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.

[http://Overclockers.com/Cooling Forum.html]

So, the major problem here is to obtain either radiator with slower coolant flow rate or with fastest coolant flow rate will be the best radiator to dissipate at the maximum rate.

A different method for heat transfer enhancement could be that used by E. Grimson using tube banks or that offered by F. Mayinger using short pin fins. In both methods, heat transfer areas are increased whilst augmenting the flow, creating various secondary flows and simultaneously destroying the hydro-dynamic and thermal boundary layers created by the flow repetitively.