AUTOMOTIVE RADIATOR PERFORMANCE

MOHD SYAHAR BIN MOHD SHAWAL

This thesis is submitted to Mechanical Engineering Faculty in partial fulfillment of the requirements for the award of Bachelor Degree in Mechanical Engineering (Thermal- Fluid)

Faculty of Mechanical Engineering
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"I hereby declare that this thesis entitled "Automotive Radiator Performances" is the result of my own research except as cited in the references"

Signature :

Name : MOHD SYAHAR BIN MOHD SHAWAL.

Date : 1 JUNE 2006

Dedicated to my beloved Mother, family and to

Mr. Md. Isa Bin Ali ,

for their love, support and prays

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First and foremost, I would like to thank Allah for His blessing. Without Allah's help I will not be able to complete this research as required and without the help and support from certain groups and individual it will be impossible for me to actually finish this research.

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Thank you.

ABSTRACT

Work reported in this study state an experimental study of the parameters that affect the radiator performance. There are two performances studied which is heat performance and physical performance. The experiment was carried out by using engine capacity of 1.5 L for Proton Wira (4 cylinders) for evaluating the working performance of different types of radiator (capacity engine 1.5 L). In this experiment, performance data of automotive radiator were acquired for analysis purpose to improve available radiator performance. Parameters of radiator performance that studied such as pressure, temperature, flow rate, material used and also radiator sizing. The influence of the air velocity, inlet coolant temperature, volume flow rate of coolant on heat dissipation and coolant pressure drop are also discussed in detail in this study.

Performance data of automotive radiator such as temperature, pressure, velocity and flow rate were acquired to find out the effects of operating parameters to radiator performances. The heat dissipation rate of the radiator increased as coolant volume flow rate increased. From this study, it was found that the heat performance of the radiator clearly depends on its operating parameters such as inlet coolant temperature, coolant volume flow rate, air velocity, temperature drop and also coolant pressure drop.

Meanwhile, the inlet coolant temperature hardly affected the coolant pressure drop of the radiator. Also found that the amount of heat loss by radiator with cooled fan was greater than amount of heat loss which produced by radiator without the cooled fan. Based on the results, Mitsubishi radiator was found as the most suited radiator to attach with engine capacity of 1.5 L for Proton Wira.

ABSTRAK

Kajian ini menerangkan satu kajian secara eksperimen tentang parameter-parameter yang mempengaruhi prestasi radiator. Terdapat dua prestasi yang dikaji iaitu prestasi haba dan prestasi fizikal. Eksperimen ini dijalankan dengan menggunakan enjin berkapasiti 1.5 L Proton Wira (4 silinder) untuk menilai parameter-parameter yang mempengaruhi radiator yang berlainan jenis. Dalam eksperimen ini, data prestasi untuk radiator automotif diperolehi untuk tujuan analisis bagi mempertingkatkan prestasi radiator yang sedia ada. Parameter-parameter prestasi radiator yang dikaji adalah seperti tekanan, suhu, kadar alir, bahan dan juga saiz radiator itu sendiri. Pengaruh halaju udara, suhu masukan penyejuk, kadar alir isipadu penyejuk terhadap kadar kehilangan haba dan perubahan tekanan penyejuk juga dibincangkan secara terperinci dalam kajian ini.

Data prestasi radiator seperti suhu, tekanan, halaju angin dan kadar alir diperolehi untuk mengenalpasti kesan-kesan parameter yang dikaji terhadap prestasi radiator. Kadar kehilangan haba radiator meningkat dengan peningkatan kadar alir isipadu penyejuk. Didapati bahawa prestasi haba bagi radiator adalah bergantung kepada parameter-parameter seperti suhu masukan penyejuk, kadar alir isipadu, halaju udara, perubahan suhu dan juga perubahan tekanan penyejuk.

Sementara itu, suhu masukan penyejuk adalah hampir tidak memberi kesan terhadap perubahan tekanan penyejuk radiator. Selain itu juga, jumlah kehilangan haba radiator berbantu kipas penyejuk adalah lebih besar daripada jumlah kehilangan haba yang dihasilkan oleh radiator tanpa berbantu kipas penyejuk. Berdasarkan keputusan, didapati bahawa radiator jenis Mitsubishi merupakan radiator yang paling sesuai digunakan pada enjin berkapasiti 1.5 L jenis Proton Wira.

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LIST OF SYMBOLS

SYMBOL	DEFINATION
Q	Heat Loss [kJ]
m_c	Coolant flow rate [kg/s]
ΔT	Temperature drop [K]
$\Delta P_{coolant}$	Coolant Pressure drop [Pa]
ΔP_{air}	Air pressure drop [Pa]
Q_{rej}	Heat rejection energy flow rate [kJ/s]
Q_{air}	Heat energy loss to the ambient [kJ/s]
Q_{rad}	Radiator heat transfer rate [kJ/s]
T_{eng}	Engine coolant temperature [K]
T_{air}	Intake air temperature [K]
T_{stat_min}	Minimum temperature for thermostat opens [K]
T_{stat_max}	Maximum temperature of thermostat to max lift [K]
T_{eng_out}	Coolant temperature input to the radiator [K]
T_{eng_in}	Coolant temperature at radiator to engine [K]
Lh	louver height
Ll	louver length
Lp	louver pitch
¢pL	radiator core pressure drop
f	core friction factor
Re	Reynolds number
T	time[s]
U	Overall heat transfer coefficient

h	Heat transfer coefficient [W/m2K]
k	Thermal conductivity [W/mK]
x	Tube thickness[m]

LIST OF APPENDIX

CHAPTER I

INTRODUCTION

1.1 Overview

A radiator is an important component in the cooling system of vehicles. Its main function is to radiate the excessive heat from the engine to the ambient so as to ensure reliable operation of the engine. Thus a lot of investigations into improving the operating characteristic performances of radiators have been conducted. Until now, the study methods concerned have been mainly theoretical analysis methods and experimental methods. Nowadays, the latter are popular for studying the complexity of a radiator's structural and the variability of its operating situations. The preceding research provides a basic for the theoretical analysis of heat performance and structural refinement of radiator. In this study, experimental research has been carried out on lab test of engine radiator performance. The results indicate that it is useful to improve radiator performance. The existing literature indicate that radiator's working performance includes heat dissipation rate, coolant pressure drop and air pressure drop mainly depend on it's operating parameters such as inlet coolant temperature, coolant flow volume rate and air velocity under given structural parameters and geometry.

1.2 Problem statement

a. The existing Proton Wira engine sometimes gets overheated due to the radiator not functioning up to the standard expectations.

b. Most cars designed today focused more on its aerodynamics, safety and styling factor and tend to forget about the significance of radiator. This causes the air flow velocity profile at the radiator face to be highly distorted, leading to potentially reduced airflow volume for heat dissipation.

1.3 Objectives of study

The main objective of this study is to acquire performance data of automotive radiator such as temperature, pressure and flow rate by using engine capacity of 1.5L. Collected data can be related between temperature, pressure, velocity and flow rate. The effects of operating parameters to radiator performances can be determined. From the data obtained, the best radiator to suite with engine for Proton Wira with capacity 1.5L can be determined.

1.4 Scope of study

In the work reported, experimental study has been carried out on the engine radiator performance test by using difference types of radiator. The scope of study involves various radiators with different construction material, design, compactness and sizes are fitted with or without fan assisted air flow while the engine is running at different revolution per minute. Also, this project is expected to initiate further in-depth study of each element effecting automotive radiator performance. Performance data can then be documented to assist our radiator manufactures to produce higher performance radiator for our national car industry.

CHAPTER II

LITERATURE REVIEW

S.P. Parsons state that the drop in static pressure in the air stream through a cellular radiator, and the pressure gradient in the air tubes, are practically proportional to the square of the air flow, for a given air density. The observed values of skin friction agree approximately with those found by other investigators for long pipes. These facts appear to indicate that the air flow is turbulent, even in the short tubes of the radiator. The difference between head resistance per unit area and the fall of static pressure through the air tubes of a radiator, noted by various observes is shown to be apparent rather than real. Radiators different types differ widely in the amount of contraction of the jet at entrance.

EY Ng and others described that the high complexity of vehicle front-end design, arising from considerations of aerodynamics, and styling, causes the air flow velocity profile at the radiator face to be highly distorted, leading to potentially reduced airflow volume for heat dissipation [Figure 2.1].Consequently, the heat transfer areas of radiator may be poorly utilized. It is emphasized that the radiator cooling air flow plays a key role in the radiator's heat transfer process, since the overall heat transfer coefficient of a radiator is predominantly influenced by the air-side heat-transfer coefficient. However; there are several factors that make measurement of cooling air flow very difficult. The factors include:-

1. The compactness of engine compartments
2. The complexity of air velocity, pressure and temperature fields in engine compartments.
3. The air flow velocities through radiators are typically low(of the order of a few meters per second)
4. The unknown flow directions(in some cases there are major separation sand flow reversals)
5. The cooling system location in an enclosed area, making measurement access difficult.

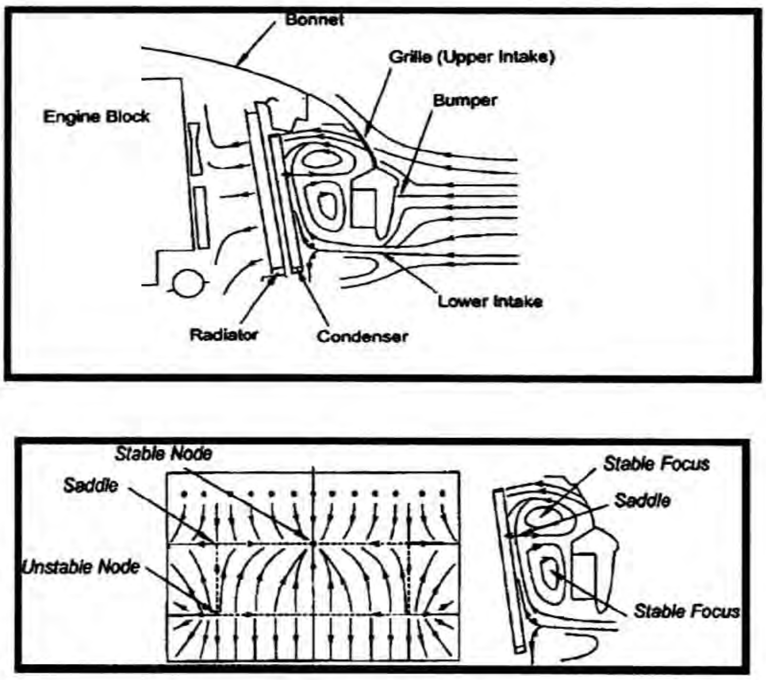

Figure 2.1: Under hood air flow profiles in a typical passenger car (reprinted from NG).

It is observed that airflow has non-uniformly distributed over the radiator and it was also noted that the bumper wake significantly influenced the cooling air flow with very limited from through the region of the core in the wake of the bumper bar.

A. Witry and members state that for the internal flow, heat transfer augmentation caused by the repetitive impingement against the dimple obstructions renders such geometries equal to those of aerospace industry pin-fin whilst lowering pressure drops due to the wider cross-sectional areas. For the external flows, the wider and wavy nature of the surface area increases heat transfer leaving the addition of extra surface roughness add-ons as an option.

J A Chen described that existing literature indicates that the radiator's working performance including heat dissipation rate, coolant pressure drop and air pressure drop mainly depend on it's operating parameters such as the inlet coolant temperature, coolant flow volume rate and air velocity under given structural parameters and geometry. In order to investigate the effects of inlet coolant temperature, coolant volume flow rate and cooling air velocity on heat performances of the radiator, the experimental scheme was designed with the ternary quadratic form polynomial regression combinatorial design method [Figure 2.2]. The regression equations could be obtained by using the optimization technique of experimental design.

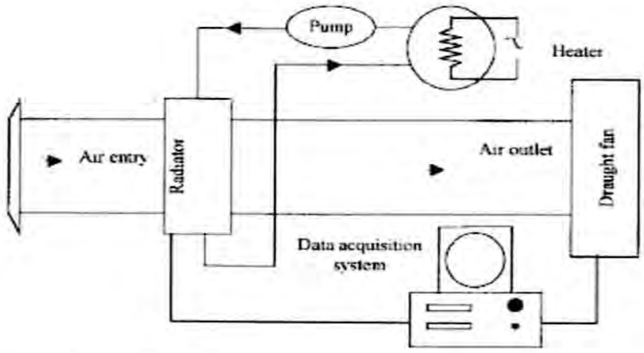

Figure 2.2: Schematic of the heat transfer characteristics of the radiator test system

From the result, J A Chen stated the discussions as below:-

1. Effects of operating parameters on heat dissipation rate.

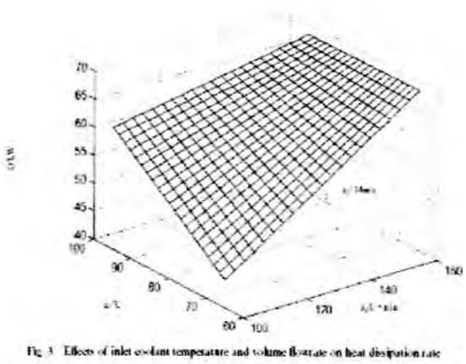

Figure 2.3: Effects of inlet coolant temperature and volume flow rate on heat dissipation

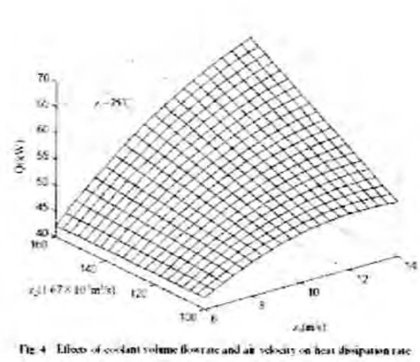

Figure 2.4: Effects of the coolant volume flow rate and air velocity on heat dissipation