FLUID AND HEAT FLOW PERFORMANCE

IN HEAT EXCHANGER

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karya ini dan pada pandangan saya/kami* karya ini
adalah memadai dari segi skop dan kualiti untuk tujuan penganugerahan
Ijazah Sarjana Muda Kejuruteraan Mekanikal (Termal Bendalir)’

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ABSTRACT

Heat exchanger is a device used to transfer from one fluid to another without direct contact of the fluid. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical, chemical plants, petroleum refineries and natural gas processing. The methodology of this project consists of several approaches and procedures. The procedures that had been taken are referred from literature review through many journals and articles about the automotive heat exchangers. The experiment to obtain the flow and heat transfer performance of a heat exchanger is done by using the wind tunnel to determine the heat loss and also using CFD technique in order to define the flow inside the automobile radiator. Using this method, the fluid flow in the radiator can be measured only by using a complete sketch. The sketch is inserted into the program and then the fluid flow can be measured according to the fixed color code after simulation using FLUENT software. The simulation had been successfully created in two type which is 2d and 3D. According to the calculation of heat exchanger performance, APM radiator could dissipate heat more than Wira radiator. Meanwhile, for the compactness heat exchanger, APM radiator has an addition of 9.492% of compactness performance than Wira radiator.

ABSTRAK

Alat pemindahan haba digunakan untuk memindahkan haba daripada bendalir kepada bendalir yang lain tanpa persentuhan terus dengan bendalir tersebut. Ia diunakan secara meluas dalam ruang pemanasan, penyejukan, penghawa dingin, industri petroleum dan pemprosesan gas asli. Metodologi bagi projek ini mengandungi beberapa kaedah dan prosedur. Di antara prosedur yang telah dilakukan adalah dengan membuat kajian ilmiah melalui pelbagai jenis jurnal dan artikel tentang alat automotif pemindah haba. Selain itu, eksperimen untuk mengkaji aliran air dan udara serta kecekapan alat pemindah haba telah dilakukan dengan menggunakan "Wind Tunnel". Ia bertujuan untuk menguji kehilangan haba pada alat pemindah haba. Selain itu juga, CFD turut digunakan untuk mengkaji aliran air di dalam automotif radiator. Melalui kaedah ini, halaju aliran air di dalam radiator dapat dilihat dan diperolehi. Draft rekaan yang telah dilakar akan dipindah masuk ke dalam CFD dan proses simulasi akan dilakukan menggunakan perisian FLUENT. Proses simulasi telah Berjaya dilakukan dalam dua jenis bentuk iaitu 2D dan 3D. Berdasarkan pengiraan kecekepan pengubah haba, didapati bahawa radiator APM dapat mengurangkan haba lebih baik daripada radiator Wira. Sementara itu pula, bagi kepadatan pengubah haba menunjukkan bahawa radiator APM mempunyai kelebihan kepadatan sebanyak 9.492% berbanding radiator Wira.

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LIST OF SYMBOLS

α_a	=	Ratio of total heat transfer area of one side of the exchanger to its volume, m^2/m^3
A	=	Total heat transfer area, m^2
A_0	=	Free flow area of one side of exchanger, m^2
A_{fr}	=	Frontal area of one side of the exchanger, m^2
B	=	Air flow length in the exchanger, m
C_a	=	Stream heat capacity rate for air
c_p	=	Specific heat loss of coolant
C_w	=	Stream heat capacity rate for water
$C*$	=	Heat capacity rate ratio
C_μ	=	Specific heat at constant dynamic viscosity
$C_{p,a}$	=	Specific heat of air
$\in$	=	Heat exchanger effectiveness
f	=	Friction factor
g	=	Gravity
G_a	=	Core mass velocity
j_a	=	Multiplied factor of heat exchanger
L	=	Length of each tube
L_p	=	Louver pitch
m_c	=	Coolant mass flow rate
$N_{u,w}$	=	Nusselt's number
Q	=	Heat Loss
R_t	=	Ratio of the convection heat transfer characteristic to the convection mass transfer characteristic for the simultaneous convection heat and mass transfer for tube.

Re	=	Reynold's number
r_h	=	Fin radius
T_i-T_0	=	Temperature Drop
U_a	=	Air side area
V	=	Total volume of the exchanger, m^3
W_a	=	Specific thermal resistance of air
ρ	=	Water density
μ	=	Viscosity
μ_t	=	Viscosity in tube

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CHAPTER I

INTRODUCTION

1.1 Background of the Study

A heat exchanger is a device built for efficient heat transfer from one medium to another, whether the media are separated by a solid wall so that they never mix, or the media are in direct contact. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, and natural gas processing. One common example of a heat exchanger is the radiator in a car, in which the heat source, being a hot engine-cooling fluid, water, transfers heat to air flowing through the radiator.

Heat exchanger maybe classified according to their flow arrangement. In parallel-flow heat exchanger, the two fluids enter the exchanger at the same end, and travel in parallel to one another to the other side. In counter-flow heat exchangers, the fluids enter the exchanger from opposite ends. The counter current design is most efficient, so that it can transfer the most heat. In a cross-flow heat exchanger, the fluids travel roughly perpendicular to one another through the exchanger.

A cooling system is used to remove this excess heat. Most automotive cooling systems consist of the following components: radiator, water pump, electric cooling fan, radiator pressure cap, and thermostat. Of these components, the radiator is the most prominent part of the system because it transfers heat. As coolant travels through the engine's cylinder block, it accumulates heat. Once the coolant temperature increases above a certain threshold value, the vehicle's thermostat triggers a valve which forces the coolant to flow through the radiator. As the coolant flows through the tubes of the radiator, heat is transferred through the fins and tube walls to the air by conduction and convection.

Depending upon the size of the engine and the cooling requirements, one, two, three or four cores can be used. There is also an inlet and outlet tank. These tanks hold the coolant before it goes into the radiator or into the block. The inlet tank also has a hose connection to allow coolant to flow from the engine into the radiator. The outlet tank has a hose connection to allow coolant pass back to the engine. In addition, there is a filler neck attached to one of the tanks. The radiator cap is placed here.

1.2 Problem Statement

In an automobile, fuel and air produce power within the engine through combustion. Only a portion of the total generated power actually supplies the automobile with power, the rest is wasted in the form of exhaust and heat. If this excess heat is not removed, the engine temperature becomes too high which results in overheating and viscosity breakdown of the lubricating oil, metal weakening of the overheated engine parts, and stress between engine parts resulting in quicker wear, among other things.

From the laws of thermodynamics, we know that heat transfer increases as we increase the surface area of the radiator assembly. That said, the demand for more powerful engines in smaller hood spaces has created a problem of insufficient rates of heat dissipation in automotive radiators. As a result, many radiators must be redesigned to be more compact while still having sufficient cooling power capabilities. It is the objective of the project to untaken redesigning for compactness configuration and at the same time increasing the rate of heat dissipation.

1.3 Research Objectives

The objectives of this research are:

i. To compare the performance of the existing heat exchanger with the new design of heat exchanger.
ii. To simulate 2D CFD flow of the design.

1.4 Scope of the Study

The scopes of the studies are:

i. Heat exchanger system that will be used to conduct the experiment will be the automotive radiator.
ii. Experiments will be conducted to compare the fluid and heat flow of the existing exchanger system with a new circular heat exchanger design.
iii. Simulation of the fluid flow is using the Computational Fluid Dynamic (CFD) software.

CHAPTER II

LITERATURE REVIEW

2.1 Radiator

The radiator core is usually made of flattened aluminum tubes with aluminum strips that zigzag between the tubes. These fins transfer the heat in the tubes into the air stream to be carried away from the vehicle. On each end of the radiator core is a tank, usually made of plastic that covers the ends of the radiator,

On most modern radiators, the tubes run horizontally with the plastic tank on either side. On other cars, the tubes run vertically with the tank on the top and bottom. On older vehicles, the core was made of copper and the tanks were brass. The new aluminum-plastic system is much more efficient, not to mention cheaper to produce. On radiators with plastic end caps, there are gaskets between the aluminum core and the plastic tanks to seal the system and keep the fluid from leaking out. On older copper and brass radiators, the tanks were brazed (a form of welding) in order to seal the radiator.

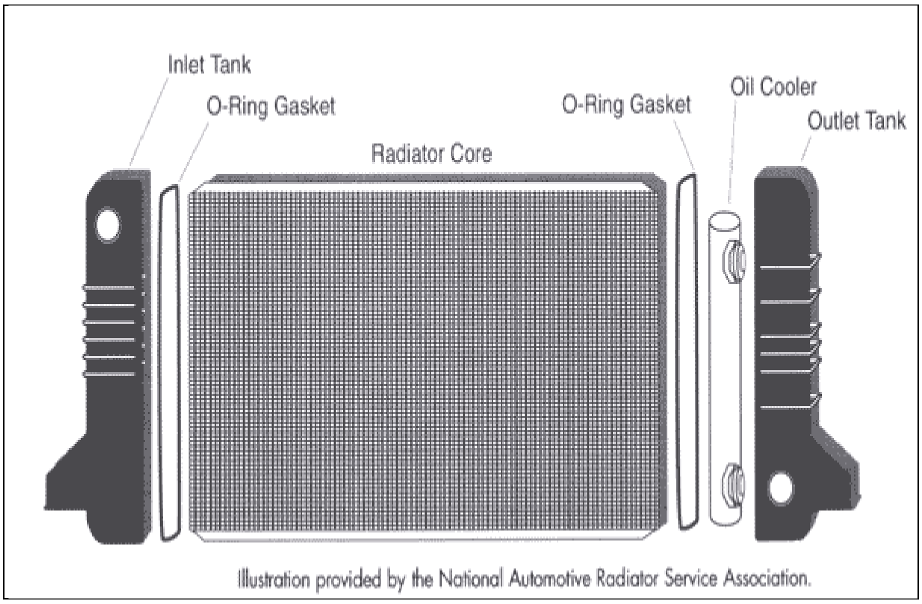

Figure 2.1: Radiator

The tanks, whether plastic or brass, each have a large hose connection, one mounted towards the top of the radiator to let the coolant in, the other mounted at the bottom of the radiator on the other tank to let the coolant back out. On the top of the radiator is an additional opening that is capped off by the radiator cap. More on this later.

Another component in the radiator for vehicles with an automatic transmission is a separate tank mounted inside one of the tanks. Fittings connect this inner tank through steel tubes to the automatic transmission. Transmission fluid is piped through this tank inside a tank to be cooled by the coolant flowing past it before returning the transmission.

2.1.1 Radiator Fans

Mounted on the back of the radiator on the side closest to the engine is one or two electric fans inside a housing that is designed to protect fingers and to direct the air flow. These fans are there to keep the air flow going through the radiator while the vehicle is going slow or is stopped with the engine running. If these fans stopped working, every time you came to a stop, the engine temperature would begin rising. On older systems, the fan was connected to the front of the water pump and would spin whenever the engine was running because it was driven by a fan belt instead of an electric motor. In these cases, if a driver would notice the engine begin to run hot in stop and go driving, the driver might put the car in neutral and rev the engine to turn the fan faster which helped cool the engine. Racing the engine on a car with a malfunctioning electric fan would only make things worse because you are producing more heat in the radiator with no fan to cool it off.

The electric fans are controlled by the vehicle's computer. A temperature sensor monitors engine temperature and sends this information to the computer. The computer determines if the fan should be turned on and actuates the fan relay if additional air flow through the radiator is necessary.

If the car has air conditioning, there is an additional radiator mounted in front of the normal radiator. This "radiator" is called the air conditioner condenser, which also needs to be cooled by the air flow entering the engine compartment. You can find out more about the air conditioning condenser by going to our article on Automotive Air Conditioning. As long as the air conditioning is turned on, the system will keep the fan running, even if the engine is not running hot. This is because if there is no air flow through the air conditioning condenser, the air conditioner will not be able to cool the air entering the interior.

Figure 2.2 : Radiator Fan

2.1.2 Pressure cap and reserve tank

As coolant gets hot, it expands. Since the cooling system is sealed, this expansion causes an increase in pressure in the cooling system, which is normal and part of the design. When coolant is under pressure, the temperature where the liquid begins to boil is considerably higher. This pressure, coupled with the higher boiling point of ethylene glycol, allows the coolant to safely reach temperatures in excess of 250 degrees.

The radiator pressure cap is a simple device that will maintain pressure in the cooling system up to a certain point. If the pressure builds up higher than the set pressure point, there is a spring loaded valve, calibrated to the correct Pounds per Square Inch (psi), to release the pressure.

When the cooling system pressure reaches the point where the cap needs to release this excess pressure, a small amount of coolant is bled off. It could happen during stop and go traffic on an extremely hot day, or if the cooling system is malfunctioning. If it does release pressure under these conditions, there is a system in place to capture the released coolant and store it in a plastic tank that is usually not pressurized. Since there is now less coolant in the system, as the engine cools down a partial vacuum is formed. The radiator cap on these closed systems has a secondary valve to allow the vacuum in the cooling system to draw the coolant back into the radiator from the reserve tank (like pulling the plunger back on a hypodermic needle) There are usually markings on the side of the plastic tank marked Full-Cold, and Full Hot. When the engine is at normal operating temperature, the coolant in the translucent reserve tank should be up to the Full-Hot line. After the engine has been sitting for several hours and is cold to the touch, the coolant should be at the Full-Cold line.

Figure 2.3 : Pressure Cap

2.1.3 Water Pump

A water pump is a simple device that will keep the coolant moving as long as the engine is running. It is usually mounted on the front of the engine and turns whenever the engine is running. The water pump is driven by the engine through one of the following:

- A fan belt that will also be responsible for driving an additional component like an alternator or power steering pump
- A serpentine belt, which also drives the alternator, power steering pump and AC compressor among other things.
- The timing belt that is also responsible for driving one or more camshafts.

The water pump is made up of a housing, usually made of cast iron or cast aluminum and an impeller mounted on a spinning shaft with a pulley attached to the shaft on the outside of the pump body. A seal keeps fluid from leaking out of the pump housing past the spinning shaft. The impeller uses centrifugal force to draw the coolant in from the lower radiator hose and send it under pressure into the engine block. There is a gasket to seal the water pump to the engine block and prevent the flowing coolant from leaking out where the pump is attached to the block.