EXPERIMENTAL INVESTIGATION OF PERFORMANCE CHARACTERISTICS OF RADIATOR

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ABSTRACT

The radiator is one of the important heat exchanger. In this experiment the performance of copper radiator and copper brass radiator is tested and the results have been compared. The Copper brass is a technology in which brass tubes are used along with copper fins in radiator. This radiator retains strength at high brazing temperatures. This radiator is light weight and stronger. Copper brass radiators are more cost effective than copper radiator. The fin and tube material is copper in copper radiator. This radiator is suitable for higher operating temperatures. The copper radiators provide better heat transfer rate than the copper brass radiators and therefore give better performance. When the mass flow rate of radiator increases the heat transfer, effectiveness and pressure drop also will increase. When the mass flow rate of radiator decreases the heat transfer, effectiveness and pressure drop also will decrease. The mass flow rate of radiator initially 0.2kg/sec at this stage pressure drop 0.62bar and effectiveness 0.67. After the mass flow rate of radiator decrease 0.16kg/sec at this stage pressure drop 0.48bar and effectiveness 0.5.

Keywords: radiator; copper brass; mass flow rate; heat transfer

INTRODUCTION

Radiators are heat exchangers used to transfer thermal energy from one medium to another for the purpose of cooling and heating. The majority of radiators are constructed to function in automobile vehicles, buildings and electronic equipment. The radiator is always a source of heat to its environment, although this may be for either the purpose of heating this environment or for cooling the fluid or coolant supplied to it, as for engine cooling. Radiators generally transfer the bulk of their heat via convection, not by thermal radiation, though the term "convector" is used more narrowly.

Copper brass is a copper-alloy heat exchanger technology for harsh temperature and pressure environments such as those in the latest generations of cleaner diesel engines mandated by global environmental regulations. The technology, developed by the International Copper Association (ICA), is licensed free of charge to heat exchanger and radiator manufacturers around the world.

Applications for copper brass include charge air coolers, radiators, oil coolers, climate control systems, and heat transfer cores. Copper radiator is particularly suited for charge air coolers and radiators in capital intensive industries where machinery must operate for long periods of time under harsh conditions without premature failures. For these reasons, copper radiator is being specified for off-road vehicles, trucks, buses, industrial engines, generators, locomotives, and military equipment. The technology is also amenable for light trucks, SUVs and passenger cars with special needs.

LITERATURE SURVEY

Y.L. Shabtay et al. [1] investigated new brass and copper alloys offer high strength as well as excellent retention of strength at elevated operating temperatures. The high thermal conductivity and high strength of new copper and brass alloys have changed the rules of design for heat exchangers. Lightness, strength and efficiency are the desirable properties of these materials for heat exchangers. The thermal conductivity of the Copper brass copper-fin alloy after brazing is 377 W/m ˚C, which compares to 222 W/m ˚C for aluminum. The operating temperature is increased from 0 to 300 ˚C the tensile strength of the brass-tube alloy decreases from 400 to 260 N/mm² and the tensile strength for copper-fin alloy decreases from 350 to 260 N/mm². Similarly, the fin and tube alloys retain much of their yield strength at 300˚C.

D. Ganga Charyulu et al [2] investigated The characteristics of the radiator have been analyzed for different tube rows with varying air mass velocities to enable the design engineer to select the size depending upon the requirement and application. The study also examines the effect of different materials of construction of fins and tubes.

K. Gansan et al [3] found that the rate of heat dissipated is high in present type flow tube when compared to single flow tube with curved flow tube. So usage of air type cooling flow dual type flow tube in compared in to best performance to satisfaction in curved type flow tube.

C.O. Olsson et al [4] investigated the thermal and hydraulic performance of ten radiator tubes has been investigated. Isothermal pressure drop data were taken for Reynolds numbers in the range of 5000-6000. Water is flowing around the tube in cross flow with a speed of approximately 1m/s.

S. Vithayasai et al [5] The effect of electric field on the performance of automobile radiator is investigated in this work. The degree of heat transfer enhancement depends on the value of the voltage supplied. Increasing the supplied voltage results in higher enhancement of the heat transfer rate.

C. Oliet et al [6] A complete set of numerical parametric studies on automotive radiators has been presented in detail in this paper, analyzing the influence of those parameters on the full thermal and hydraulic behavior of the heat exchanger.

Agustin Menéndez-Diaz et al [7] The role of a stoneware panel attached to the front of a hot water radiator has been investigated during the heating and cooling processes. The stoneware panel takes longer to reach the steady-state temperature than the aluminium radiator.

MikkMaivela et al [8] investigated the radiators with parallel and serial connected panels in test room to quantify the possible energy saving of serial radiator. Measured results needed recalculation for the comparison, and simulations were used for annual performance assessment. Serial radiator showed 4˚C higher and 3˚C lower temperatures of the front and rear panels at 50˚C flow temperature. Parallel radiator had slightly faster dynamic response and its 3% higher heat output at ΔT 50˚C increased to about 10% at ΔT 25 ˚C.

EXPERIMENTAL FLOW DIAGRAM

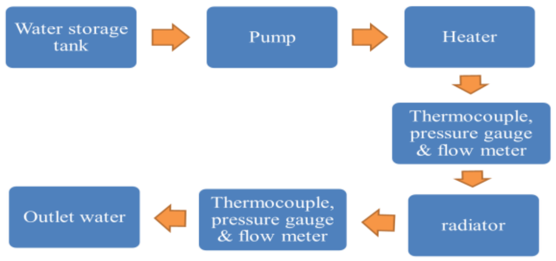

Fig1. Experimental flow diagram

The experimental setup contains water storage tank, pump, heater, thermocouple, pressure gauge, flow meter and radiator.

The cold water is delivered from tank to the pump. Then which is forced by pump. The forced water is supplied to the heater which will be heated.

The hot water is then supplied to the radiator inlet. The temperature, pressure and flow rate of the inlet and outlet is measured using thermocouple, pressure and flow meter respectively. The hot water is circulated to the radiator where the heat of the water is absorbed.

EXPERIMENTAL SETUP

RADIATOR FIN AND TUBE

A finned tube heat exchanger will typically have tubes with fins attached to the outside of them. There will usually be a liquid flowing through the inside of the tubes and air or other gas flowing outside of the tubes, where the additional heat transfer surface area due to the finned tube, increases the heat transfer rate. For a cross flow fin tube exchanger, the fins will typically be radial fins either square or circular.

HEADER

There are two headers per radiator. Headers are perforated plates through which each tube protrudes. Headers hold the matrix of the fin and the tube together and ultimately provide a mechanical means to attach the tanks to the aluminium core.

TANKS

A radiator tank besides the coolant container is an important structural member. It not only supports and connects a radiator core to the automobile vehicle, but it also supports the fan, motor and shroud assembly (engine side),condenser and possibly transmission oil cooler; sometimes even a power steering, and hydraulic fan coolers as even as inter coolers. Each radiator has two tanks: an inlet tank for receiving hot coolant from engine, and an outlet tank for directing cooled coolant back to the engine.

GASKET

A gasket plays a major role in a radiator. There are two gaskets used per radiator. The main purpose of a gasket is to help in maintaining a leak proof between the tank and the header of the radiator.

PRESSURE CAP

Pressure caps are placed on the radiator to increase the pressure on cooling system, reduces the cavitation, protect the radiator hoses and prevent or reduces surging. It is very important to maintain a constant pressure on the cooling system.

DRAIN COCK ASSEMBLY

Drain Cock assembly constitutes a drain cock stem with threads on it & a rubber O-ring. It is usually placed in the outer tank and acts as a point for draining of coolant during servicing of radiator.

PUMP

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps. The pump is fixed between the tank and heater.

RADIATOR FAN

A radiator fan exchanges heat in the engine. When an engine is running it produces heat, and that heat dissipate so that the engine does not become too hot and overheat. The cooling fans are part of the cooling system and their design helps to keep a cooler temperature in the engine. The cooling fans, with between 4 and 6 blades, spin rapidly to provide cooler air to the engine.

FLOW METER

Flow meter is used to measure the quantity of fluid flow through the pipe. Two flow meters fixed in this setup. First flow meter is fixed in inlet side of the radiator. Another one flow meter is fixed in outlet side of the radiator.

THERMOCOUPLE

A thermocouple is a device consisting of two dissimilar conductors or semiconductors that contact each other at one or more points. A thermocouple produces a voltage when the temperature of one of the contact points differs from the temperature of another, in a process known as the thermoelectric effect. Thermocouples are a widely used type of temperature sensor for measurement and control and can also convert a temperature gradient into electricity.

Two thermocouples fixed in this setup. First thermocouple is fixed in inlet side of the radiator. Another one thermocouple is fixed in outlet side of the radiator.

RESULTS AND DISCUSSIONS

NTU method:

Pressure drop = P1-P2

Heat transfer, Q = $mc_p \Delta T$

Capacity rate, C = $m*c_p$

Number of transfer units NTU=U/Cmin

Effectiveness = (T1-T2) / (T1-t1)

These formulas take from HMT data book. The NTU value is taking from graph (cross flow, both fluids unmixed) in HMT data book.

SPECIFICATION DETAILS

Type of radiator tube = rectangular tube

Breath of tube = 0.01m

With of tube = 0.003m

Number of tubes = 68

OTHER CALCULATION DETAILS

Specific heat of water = 4.187KJ/kg k

Specific heat of air = 1.010KJ/kg k

Density of water = 1000 kg/m³

Table 1: Radiator pressure drop for different mass flow rate

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S. no	Mass flow rate (kg/sec)	Inlet pressure (bar)	Outlet pressure (bar)	Pressure drop (bar)
1	0.2	0.9653	0.34475	0.62055
2	0.18	0.9653	0.48265	0.48265
3	0.16	0.9653	0.5516	0.4137

When the mass flow rate of radiator increases the pressure drop also increased. It means that more pumping power is required for higher mass flow rates.

Table 2: copper brass radiator heat transfer rate for different temperature

S. no	Mass flow rate (kg/sec)	Inlet temperature (k)	Outlet temperature (k)	Heat transfer, Q (KJ/sec)	Overall heat transfer co-efficient, U (W/m²K)
1	0.2	333	309	20.09	411.07
2	0.18	333	312	15.82	280.2
3	0.16	333	314	12.72	224.2

Table 3: copper radiator heat transfer rate for different temperature

S. no	Mass flow rate (kg/sec)	Inlet temperature (k)	Outlet temperature (k)	Heat transfer, Q (KJ/sec)	Overall heat transfer co-efficient, U (W/m²K)
1	0.2	333	314	15.91	242
2	0.18	333	317	12.058	168.1
3	0.16	333	319	9.378	132.6

The copper radiator provides high heat transfer rate compare to the copper brass radiator in same mass flow rate. The reason is thermal conductivity of copper is high compare to brass. When mass flow rate increases the heat transfer rate also increased. When mass flow rate decreases the heat transfer rate also decreased.

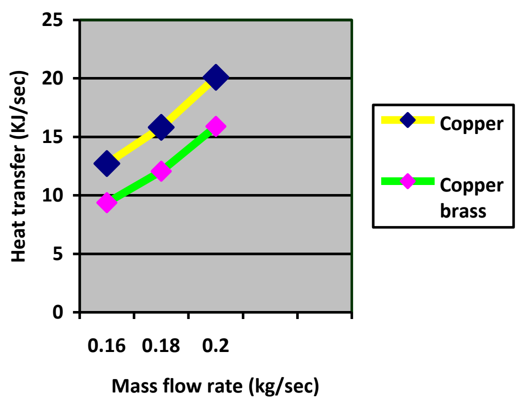

Fig2. Mass flow rate vs heat transfer

This graph is providing heat transfer rate for different mass flow rate. The heat transfer changes are explained for copper and copper brass radiator. The copper radiator gives high heat transfer rate than copper brass radiator. The reason is thermal conductivity of copper is high compare to brass. Initially the heat transfer is low after the mass flow rate increases the heat transfer rate is increased.

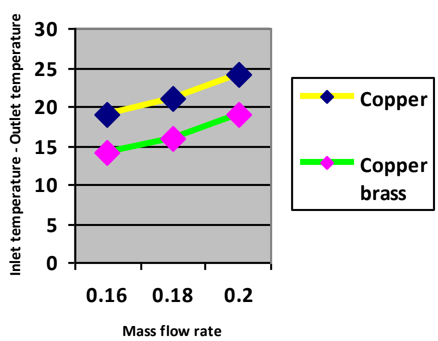

Fig3. Mass flow rate vs temperature drop

This graph is providing temperature drop for different mass flow rate. The temperature drop changes are explained for copper and copper brass radiator. The copper radiator provides high temperature drop compare to the copper brass radiator in same mass flow rate.

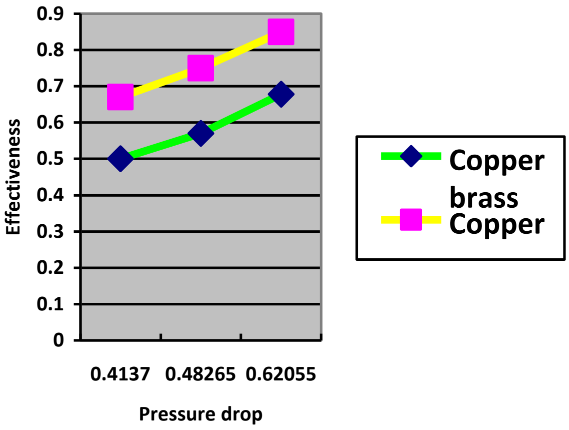

Fig4. Pressure drop vs effectiveness

This graph is providing effectiveness for different pressure drop. In this experiment the pressure drop of the radiator increases the effectiveness is increased.

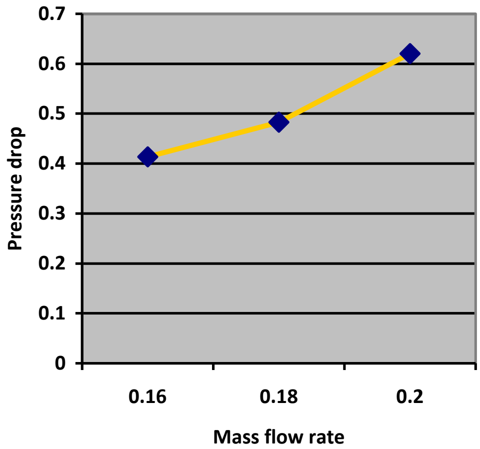

Fig5. Mass flow rate vs pressure drop

This graph provide pressure drop for different mass flow rate. In this graphs mass flow rate of radiator increases the pressure drop is increased.

CONCLUSION

The copper radiators provides better heat transfer rate than the copper brass radiators. When the mass flow rate increases the heat transfer, effectiveness and pressure drop also increased. When the mass flow rate of copper brass radiator decreases the heat transfer, effectiveness and pressure drop decreased. The mass flow rate of radiator initially 0.2kg/sec at this stage pressure drop 0.62bar. After the mass flow rate of radiator decrease 0.16kg/sec at this stage pressure drop 0.48bar. The result was obtained from copper and copper brass radiator. The mass flow rate of 0.2kg/sec the copper and copper brass radiator heat transfer rate is 20.09KJ/sec and 15.91KJ/sec. After the mass flow rate decreased 0.16kg/sec the copper and copper brass radiator heat transfer rate decreased 12.72KJ/sec and 9.378KJ/sec.

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