Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

Performance of Motorcycle Radiator at High Working Temperatures

[1]Ashish Kalra,
M. Tech.,
Manav Rachna International University,
Faridabad

[2]Sandeep Srivastava,
Faculty of Engineering & Technology,
Manav Rachna International University,
Faridabad

[3]Ruchi Gupta,
Department of Mathematics,
Manav Rachna University,
Faridabad.

***Abstract*: Radiator is one of the key components of the automobile engine cooling system as it is responsible for the dissipation of the excess heat due to combustion of fuel in the engine. The study was carried out on a motorcycle radiator test rig and the motorcycle radiator was tested at fixed flow rate of coolant with different fan rpm to maximize the cooling of radiator fluid.**

Key words: Radiator, Engine cooling system, Test rig.

INTRODUCTION

Radiator is one of the crucial part of the liquid cooled motorcycle cooling system as it is responsible for dissipation of the excess heat form the engine to the atmosphere, its prime purpose is to dissipate the waste heat energy into atmosphere and to prevent accumulation of heat in the engine and to protect the components of engine from failure, to prevent engine lubricant breakdown, to prevent cease of engine due to high temperatures. Various studies have been done on the radiators which primarily focus on optimization of the performance of the radiators. Studies on the different parameters were conducted at high working temperatures which influence radiators performance and its effectiveness at variable fan speed. Study was done on the effect of mass flow rate of air on heat transfer rate in automobile radiator by CFD Simulation using CFX carried out by P.K Trivedi et.al. Study on the compact heat exchanger was done deploying Nano fluid concept by P. Gunnasegaran et.al. Study was conducted on enhancing of heat transfer by utilizing the concept of twisted tape by Chintan Prajapati et.al. Concept of mini channel in scooter radiator was also incorporated to increase the performance of radiator by Thanhtrung Dang et.al. In this study, a test rig has been developed which focus on simulating the conditions close to the actual working conditions so that the desired objectives can be achieved.

Objective

To increase the cooling of the radiator fluid of liquid cooled motorcycle by controlling the mass flow rate of the ambient air through the matrix of the radiator fins by increasing rpm of fan of radiator.

Material

In this study, it was observed that the radiator material is aluminium which makes radiator [Fig-1] light weight and less prone to corrosion. CPVC and metal pipes [Fig-2] are used in this setup due to high working temperatures.

Fig-1Radiator

Fig-2 CPVC and metal pipes

The material chosen for fabrication of tank [Fig-3] is steel sheet as it can bear high temperatures without facing melting problems as seen in plastic tanks. Mono block ½ HP direct drive water pump [Fig-4] with aluminium blades is selected for this setup due to high operating temperatures.

Fig-3 Tank

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

Fig-4 Water pump

Heavy duty electrical wiring is done which is able to bear load up to 4KW. High temperature analogue thermocouples [Fig-5] are deployed in control panel with working range of (40-110) ° C. Metal gate valve [Fig-6] is deployed in the setup to control the mass flow rate of coolant in radiator.
3 KW heating element [Fig-7] is deployed in tank for coolant heating purpose. Complete setup is shown in [Fig-8].

Fig-5 Thermocouples

Fig-6 Metal gate valve

Fig-7 Heating element

Fig-8 Complete setup

Coolant Specifications.
The coolant used in this study is Motocool expert which can work flexibly with working range of -37ºC to 135ºC and coolant must not be diluted with water or any other solvent. Contains Ethylene glycol.

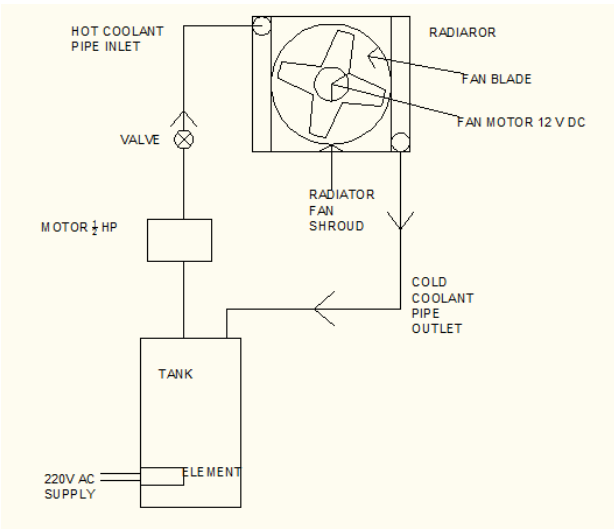
Formula Ethylene glycol $C_2H_6O_2$ Molar mass 62.07 g/mol Boiling point 197.3 °C Density 1.11 g/cm^3 Melting point pure -12.9 °C
Assumptions

It is supposed mass flow rate of coolant is constant during the operation of the system.
No change in phase of the coolant in the system.
No pipes in the radiator are chocked due to any reasons like debris etc.
The radiator system is operated when the system achieves steady state condition.
It is assumed that the value of thermal conductivity of the metal of radiator is constant.

Dimensions of Radiator
Dimensions of radiator are listed in Table-1 and project layout is displayed in Fig-9.

PARTS	DIMENSIONS
Pipe Diameter Inlet / Outlet	17 mm
Thickness of 1 fin Width of fin Diameter of cooling pipe	0.8 mm 28.5 mm 2 mm
Radiator core height (aluminium part only)	210 mm
Radiator core length (aluminium part only)	160 mm
Number of fins in single column	176
Number of fin columns	20
Total number of fins	3520
Total number of pipes	19
Distance between 2 pipes	5.1 mm
Distance between 2 fins	1.9 mm
Diameter of fan	14 cm

[Table-1 Radiator Dimensions]



[Fig-9 Project layout]

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

Observations.

The radiator setup was run for a run time of 15 minutes and following observations were observed at company configuration.

At 1200 fan rpm inlet and outlet air temperature is shown in Table-2 and inlet coolant temperature and outlet coolant temperature is shown in Table-3.

Sr. No.	Run Time	Inlet Air Temperature (ºc)	Outlet Air Temperatures (ºc)
1	15 Minutes	40	50
2	15 Minutes	40.1	49
3	15 Minutes	40	51
4	15 Minutes	39.8	49.5
Sr. No.	Run Time	Inlet Air Temperature (ºc)	Outlet Air Temperatures (ºc)
5	15 Minutes	40.3	49

[Table-2 Air temperature comparison at 1200 fan rpm]

Sr. No.	Run Time	Inlet Coolant Temperature (ºc)	Outlet Coolant Temperatures (ºc)
1	15 Minutes	100	62
2	15 Minutes	106	64
3	15 Minutes	103	61
4	15 Minutes	100	66
5	15 Minutes	105	62

[Table-3 coolant temperature comparison at 1200 fan rpm]

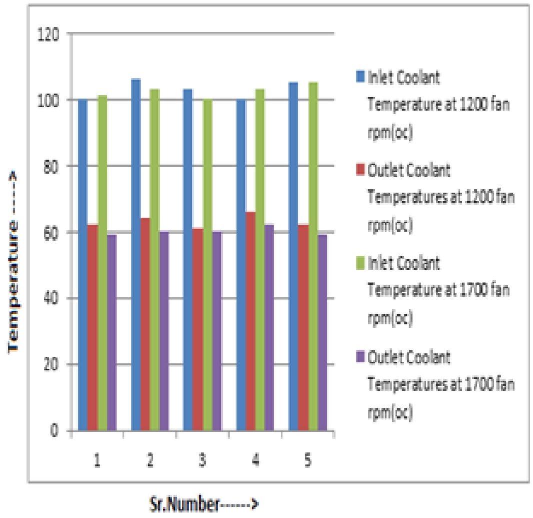
At 1700 fan rpm inlet and outlet air temperature is shown in Table-4 and inlet coolant temperature and outlet coolant temperature is shown in Table-5.

Sr. No.	Run Time	Inlet Air Temperature (ºc)	Outlet Air Temperatures (ºc)
1	15 Minutes	41	55
2	15 Minutes	41.5	52
3	15 Minutes	42	56
4	15 Minutes	41.8	55
5	15 Minutes	42	55.9

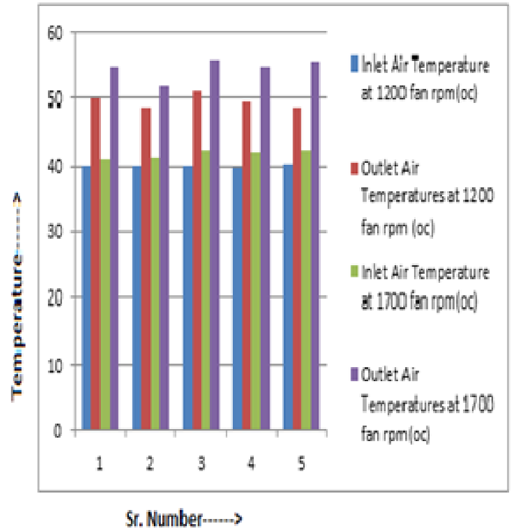
[Table-4 Air temperature comparison at 1700 fan rpm]

Sr. No.	Run Time	Inlet Coolant Temperature (ºc)	Outlet Coolant Temperatures (ºc)
1	15 Minutes	101	59
2	15 Minutes	103	60
3	15 Minutes	100	60
4	15 Minutes	103	62
5	15 Minutes	105	59

[Table-5 coolant temperature comparison at 1700 fan rpm]



[Fig-10 Graphical representation of inlet out let coolant temperatures]



[Fig-11 Graphical representation of inlet and outlet air temperatures]

Calculations

1st step is to calculate the velocity of air generated at 1200 rpm of the fan.

$$velocity\ of\ air = 1.5\ m/s\ \ at\ 1200\ fan\ rpm$$

$$velocity = \frac{v(l*b)}{((cross\ sectional\ area\ of\ fin)*total\ number\ of\ fins)}$$

$$velocity\ = \frac{(1.5*.210*.160*1000000)}{(0.8*5.1*3520)}$$

$$velocity = 3.509\ m/s$$

2nd Step is to calculate the Reynolds number of air.

$$Re = \frac{\rho v D}{\mu}$$

$$D = 4(^{A}/_{P})$$

$$D = 4\left(\frac{(5.1*.8)}{2*(5.1+.8)}\right) = 1.383mm$$

$$Re = \frac{(1.2*3.509*1.383)}{(15.06*10^{-6})*1000}$$

$$Re = 386.68$$

Reynolds number of air less than 2100.
That's why the air flow is laminar.
3rd step to determine the Prandtl number of air

$$\Pr = .7$$

4th step to calculate the Nusselt number for laminar flow.

$$Nu = 3.66 + \frac{((.065\, Re \Pr(\frac{D}{L}))}{(1 + .04(Re \Pr(\frac{D}{L}))^{\wedge}2/3)}$$

$$Nu = 3.66 + \frac{((.065 * 386.68 * .7 * ((.048))}{(1 + .04(386.68 * .7 * .048)^{2/3})}$$

$$Nu = 3.66 + .6980 = 4.35$$

5th step to calculate the value of convective heat transfer coefficient (h).

$$Nu = hl/k$$

$$4.35 = h(\frac{(1.383/1000)}{.025})$$

$$h = 78.51\ W/_{m^2 {}^\circ c}\ Approximate$$

To Increase Convective Heat Transfer Coefficient.
1st step is to calculate the velocity of air generated at 1700 rpm of the fan.

$$velocity\ of\ air = 2.2m/s\ \ at\ 1700\ fan\ rpm$$

$$velocity = \frac{v(l * b)}{((cross\ sectional\ area\ of\ fin) * total\ number\ of\ fins)}$$

$$velocity = \frac{(2.2 * .210 * .160 * 1000000)}{(0.8 * 5.1 * 3520)}$$

$$velocity = 5.14m/s$$

2nd Step is to calculate the Reynolds number of air.

$$Re = \frac{\rho v D}{\mu}$$

$$D = 4(A/_P)$$

$$D = 4\left((5.1 * .8)/_{(2(5.1 + .8))}\right) = 1.383mm$$

$$Re = \frac{(1.2 * 5.14 * 1.383)}{(15.06 * 10^{-6}) * 1000}$$

$$Re = 566.42$$

Reynolds number of air less than 2100.
That's why the air flow is laminar.
3rd step to determine the Prandtl number of air

$$\Pr = .7$$

4th step to calculate the Nusselt number for laminar flow.

$$Nu = 3.66 + \frac{((.065\, Re \Pr(\frac{D}{L}))}{(1 + .04(Re \Pr(\frac{D}{L}))^{\wedge}2/3)}$$

$$Nu = 3.66 + \left(\frac{(.065 * 566.42 * .7 * (.048))}{\left(1 + .04(566.42 * .7 * .048)^{2/3}\right)}\right)$$

$$Nu = 3.66 + .962 = 4.622$$

5th step to calculate the value of convective heat transfer coefficient (h).

$$Nu = hl/k$$

$$4.622 = h\left(\frac{1.383/1000}{.025}\right)$$

$$h = 83.560\ w/m^2{}^\circ c$$

Mass flow rate of air
Mass flow rate of air at 1200 rpm

$$Density\ of\ air = 1.2\ {}^{Kg}/_{m^3}$$

$$Area = .210 * .160\ m^2$$

$$v_{air} = 1.5\ {}^{m}/_{s}\ Approximate$$

$$Mass\ flow\ rate\ of\ air = density\ of\ air * area * v_{air}$$

$$= 1.2 * .210 * .160 * 1.5$$

$$= .0604\ {}^{Kg}/_{sec}$$

Mass flow rate of air at 1700 rpm

$$Density\ of\ air = 1.2\ {}^{Kg}/_{m^3}$$

$$Area = .210 * .160\ m^2$$

$$v_{air} = 2.2\ {}^{m}/_{s}\ Approximate$$

$$Mass\ flow\ rate\ of\ air = density\ of\ air * area * v_{air}$$

$$= 1.2 * .210 * .160 * 2.2$$

$$= .0887\ {}^{Kg}/_{sec}$$

Mass flow rate of liquid.
2 lit liquid collected in 30 seconds in bottle.
Then the water bottle is weighted on the electrical weight scale.
2 liter volume = 2 kg mass of the liquid (water).

$$mass\ flow\ rate\ of\ liquid = {}^{2}/_{30} = .06\ {}^{Kg}/_{sec}$$

CONCLUSION

The present study was successfully carried out on a motorcycle radiator test rig at fixed flow rate of coolant with different fan rpm to maximize the cooling of radiator fluid. It was observed that by increasing fan rpm from 1200 to 1700, convective heat transfer coefficient has been increased from 78.51 w/^{0}C m^2 to 83.51 w/^{0}C m^2 respectively. It is concluded that faster cooling can be achieved by increasing fan rpm in a motorcycle radiator test rig.

REFERENCE

[1] P.K.Trivedi, N.B.Vasava, "Study of the Effect of Mass flow Rate of Air on Heat Transfer Rate in automobile radiator by CFD simulation using CFX", International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181, august – 2012.

[2] P.Gunnasegaran, Shuaib, M. F. Abdul Jalal, and E. Sandhita, "Numerical Study of Fluid Dynamic and Heat Transfer in a Compact Heat Exchanger Using Nanofluids", International Scholarly Research Network ISRN, Volume 2012, Article ID 585496, doi:10.5402/2012/585496

[3] Chintan Prajapati, Mrs. Pragna Patel, Mr. Jatin Patel and Umang Patel, "A review of heat transfer enhancement using twisted tape", International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974

[4] "Designing a More Effective Car Radiator", the challenge: To determine the design parameters of a smaller radiator assembly capable of dissipating the same amount of heat as the original assembly. Maplesoft, a division of Waterloo Maple Inc., 2008.

[5] Hamid Nabati ,Malardalen University Press Licentiate Theses No. 88 "Optimal pin fin heat exchanger surface", 2008, ISSN 1651-9256 ISBN 978-91-85485-95-6.

[6] Salvio Chacko, Dr. Biswadip Shome and Vinod Kumar, A.K. Agarwal, D.R. Katkar "Numerical Simulation for Improving Radiator Efficiency by Air Flow Optimization", Engineering Automation Group, Tata Technologies Limited, Pune, India.
[7] Cooling System Principles by meziere racing saldana products.
[8] Pawan S. Amrutkar, Sangram R. Patil, "Automotive Radiator Performance Review" International Journal of Engineering and Advanced Technology (IJEAT), ISSN: 2249 – 8958, Volume-2, Issue-3, February 2013.
[9] S. D. Oduro, "Assessing the Effect of Blockage of Dirt on Engine Radiator in the Engine Cooling System", Design and Technology Department, University of Education Winneba, Kumasi Campus, Ghana sethodurod
[10] James Klett, Bret Conway,"Thermal management solutions utilizing high thermal conductivity graphite foams", Carbon and Insulation Materials Technology Group, Metals and Ceramics Division, Oak Ridge National Laboratory, Oak Ridge TN, 37831-6087 Performance Research Inc.
[11] D.B Mackay, Cp Bacila,"Space Radiator Analysis And Design" October 1961 flight accessories laboratory contract af 33(616)-7635 project number 6148 task number aeronautical system division air force system command united states air force write-Patterson air force base Ohio.
[12] https://en.wikipedia.org/wiki/Prandtl_number
[13] M.H. Salah, P.M.Frick, J.R.Wagner, D.M.Dawson, Hydraulic actuated automotive cooling systems—Nonlinear control and test, Control Engineering Practice, 17, 2009.
[14] K.Y. Leong, R. Saidur, S.N. Kazi, A.H. Mamun,"Performance investigation of an automotive car radiator operated with Nano fluid based coolants (Nano fluid as a coolant in a radiator)", Applied Thermal Engineering , 30, 2010.
[15] JP Yadav and Bharat Raj Singh,"Study on Performance Evaluation of Automotive Radiator", S-JPSET: ISSN: 2229-7111, Vol. 2, Issue 2, 2011
[16] Vishwa Deepak Dwivedi, Ranjeet Rai,"Modeling and Fluid Flow Analysis of Wavy Fin Based Automotive Radiator", Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 5, Issue 1(Part 1), January 2015, pp.17-26.
[17] Vikas Sharma, R.Nirmal Kumar, K.Thamilarasan, G. Vijay Bhaskar, Bhavesh Devra-"Heat Reduction From Ic Engine By Using Al2o3 Nano fluid In Engine Cooling System", American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-03, Issue-04, pp-173-177, 2014.
[18] Rafa Krakowski,"Internal Combustion Engine Cooling System With Elevated Cooling Temperature Research On The Model Test Stand", Journal of KONES Powertrain and Transport, Vol. 20, No. 4 2013.
[19] V. L. Bhimani, Dr. P. P. Rathod and A. S. Sorathiya, "Improving the Cooling Performance of Automobile Radiator with TiO2/Water Nano fluid", IJSRD - International Journal for Scientific Research & Development| Vol. 1, Issue 2, 2013 | ISSN (online): 2321-0613.
[20] Thanhtrung Dang et.al, "A Novel Design for a Scooter Radiator Using Minichannel" International Journal of Computational Engineering Research Vol, 03 Issue, 6 June 2013
[21] Devendra Vashist, Sunny Bhatia, Ashish Kalra. "Some Studies on the Performance of Automotive Radiator at Higher Coolant Temperature" - Krishi Sanskriti Publications Journal of Basic and Applied Engineering Research Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 1, Number 3; October, 2014 pp. 41-46