# ANALYSIS OF AUTOMOBILE RADIATOR TEST RIG USING DIFFERENT COOLENTS

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## ABSTRACT

*Automotive engine produce extra heat during engine operation. Automotive engine cooling system regulates engine surface temperature for optimum efficiency. Recent advancement in engine for power forced engine cooling system to develop new strategies to improve its performance efficiency and to reduce fuel consumption along with controlling engine emission to mitigate environmental pollution norms.*

*Automobile radiator test rig is designed to evaluate the performance of automobile radiator. The modeling of radiator has been described by two methods, one is finite difference method and the other is thermal resistance concept. In the performance evaluation, a radiator is installed into a test setup and the various parameters including mass flow rate of coolant, inlet coolant temperature etc. are varied. In the present analysis dilution level of thee coolant is varied and higher efficiency is attained. Thermal efficiency V/S change in temperature , Inlet temperature V/S thermal efficiency and inlet temperature V/S outlet temperature graphs are obtained for both 50% and 75% dilution.*

***Keywords: Radiator, Coolant Efficiency , Dilution, Inlet And Outlet Temperature, Thermal Efficiency.***

## I. INTRODUCTION

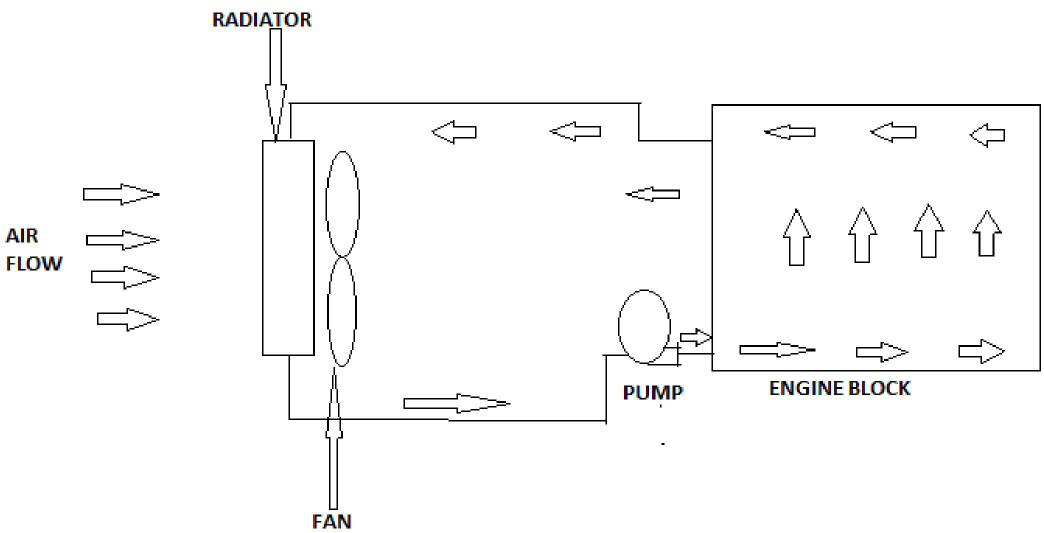
An internal combustion engine (ICE) is a heat engine where the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine the expansion of the high-temperature and high-pressure gases produced by combustion apply direct force to some component of the engine. The force is applied typically to pistons, turbine blades, or a nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy.

Internal combustion engine cooling uses either air or a liquid to remove the waste heat from an internal combustion engine. For small or special purpose engines, air cooling makes for a lightweight and relatively simple system. The more complex circulating liquid-cooled engines also ultimately reject waste heat to the air, but circulating liquid improves heat transfer from internal parts of the engine. Engines for watercraft may use open-loop cooling, but air and surface vehicles must recirculate a fixed volume of liquid.

Radiators are heat exchangers used for cooling internal combustion engines, mainly in automobiles but also in piston-engined aircraft, railway locomotives, motorcycles, stationary generating plant or any similar use of such an engine.

Internal combustion engines are often cooled by circulating a liquid coolant through the engine block, where it is heated and through a radiator where it loses heat to the atmosphere, and then returned to the engine. Engine coolant is usually water-based, but may also be oil. It is common to employ a water pump to force the engine coolant to circulate, and also for an axial fan to force air through the radiator.

A cooling system works by sending a liquid through passage in the engine block amd heads. As the coolants flow through this passage it picks up the heat from the engine. The heated liquid makes its way to the radiator through a rubber hose. This liquid is cooled by air stream entering the engine compartment from the grill in front of the car. A thermostat is placed betweean the engine and the radiator to make sure that the coolant stays above a certain temperature. If the coolant temperature falls below this temperature, the thermostat blocks the colant flow to the radiator , forcing the fluid instead through a bypass directly back to the engine. In order to prevent the coolant from boiling , the cooling system is designed to be pressurized. Under the pressure the boiling point of the coolant is raised considerably.However too much pressure will result to burst of hoses, so system is needed to relieve pressure if it exceeds a certain point, this work is done by radiator cap.




## II. LITERATURE REVIEW

**Priti Pramod Bodkhe and JP Yadav[1], Mechanical Department MITCOE Pune** in their studies, alsopresented parametric study on automotive radiator. In the performance study evaluation ,radiator is installed into a setup . the various parameters including mass flow rate of cooling ,inlet coolent temperature ;etc are varied. **Dittus, w.,&Boelter[2] , Pioneers in Heat Transfer in Automobile Radiator of Tubular type** the conclusion of their studies shows the heat transfer increases with nanoparticles volume concentration in the subchannel geometry . The highest heat transfer rates are detected , for each concentratiomn , corresponding to the higher Reynolds number . **John R Howell[3] , The History of Engineering Radiation in Heat Transfer** his research has centered on developing solution techniques for radiative transfer in participating media , solution of highly non-linear combined mode heat transfer problems and most recently inverse design and control of thermal system with combined –mode (non –linera)heat transfer. **Ying Gaun ,Hongjiang Cui , Minghai Li,[4]**Carried work on engine cooling system with heat load averaging capacity using passive heat load accumulator . Heat load accumulator is phase change material which stores heat generated during peak and dissipates stored heat during redused heat load condition This is achived by sacrificing phase change of PCM from solid to liquid or vice versa . This leads to compact heat exchanger for same heat rejection . Also it reduces load on cooling system.**Dzyubenko, B.V, Drester[5] , G.A, D.M. Dawson** discussed about hyraulic actuated cooling system . Actuators can improve temperature trackng and reduce prasiticlosses . Actuator based engine cooling system uses controller to control coolant pump and radiator fan operating condition s. It provides power to system component as per requirement . Thus it regulate power consumption of system component with cooling capacity . A non linear back steppingrobust controller is used to regulate engin coolant temperature in hydraulic based thermal management system. **K.Y.Leong[6], R. Saidur, S.N. Kazi ,A.H. Mamun[7]**described use of nanofluid based coolant in engine cooling system and its effect on cooling capacity . It is found that **565**nano-fluid having higher thermal conductivity than base coolant like 50%/50% water and ethylene glycol. It increases heat transfer. **Y Hirayana[8]**explained coventional radiator size is rectangular which is difficult for circular fan to cover whole surface area . It creates lower velocity zone at corners giving less heat transfer. Author has proposed to eliminate corners and develop circular shape radiator which is compact , more efficient and leads to minimum power consumption to drive fan and maximum utilization of air flow.

## III. COMPONENT SPECIFICATION

### 3.1 Automobile Radiator

- Size – 330*335*23 mm
- Material – Aluminum
- Downward flow type
- AI tubes, AI plates
- 37 plates, diameter of tube-10 mm
- Capacity- 3 liters

### 3.2 Cooling Fan

- Rpm:- 1200-2400 rpm
- 220/240 V
- Single pulse AC

### 3.3 Water Pump

- Submersible pump
- 165-220 V /50 Hz
- Power – 19W
- Output – 1100 L/H

### 3.4 Energy Wire

- 1 phase,2 wire
- AC 240V/50Hz
- I(max) -30A

### 3.5 Heating Elements

- Power -2000W,1500W

### 3.6 Reservoir

- Material-Plastic
- Capacity- 2.5-3.0L

### 3.7 Frame

- Material –MFD

### 3.8 Pipes

- Material-Polyurethane

## IV. EXPERIMENTATION

We need to evaluate the performance of an automobile radiator using a radiator test rig and temperature sensors using the following steps:-

1. Fill the reservoir with water upto indicated maximum level.
2. Switch on the main power supply and then switch on the heating element.
3. Allow the water to get heated upto 60-90$^0$C.
4. Switch on the fan and the power.
5. Note down the electricity consumed by fan and pump by energy meter provided in control panel
6. Note down the discharge of water from the water meter(L/min).
7. Note down the inlet temperature $T_i$ with the help of thermometer.
8. Note down the outlet temperature $T_0$ with the help of thermometer.
9. Note down the inlet and outlet temperatures by varying the pump discharge.
10. Plot the graph between discharge (Q) VS. T. △
11. Plot the graph b/w $T_i$ and $T_0$ .

## V. MATHAMETICAL RELATIONS

Temperature difference $\triangle T=T_i - T_0$

Thermal efficiency □$_t$ = $\triangle T/T_i$ .

Effectiveness of Radiator (**E** ) = Actual heat transfer / Maximum heat transfer

$= mcC_{pc}\ (t_{ci} - t_{co}) /\ maC_{pa}\ (t_{ci}/t_{ai})$

At 1LPM $m_c$= (1/1000*60) m$^3$/s

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=(1062/1000*60) kg/s ( for water + propylene glycol)

$Cp_c$=4.18 Kj /kg K(for water)=3.39 Kj/kg K (for 40% water + 60 % propylene glycol)

$Cp_a$=1.005Kj /kg K

$M_a$ = 1.49 kg/sec .

## VI. OBSERVATIONS

### 6.1 Using Coolant at 50 % Dilution

| S.NO | Inlet temp $T_I$ ($^0$C) | Outlet temp $T_0$ ($^0$C) | Time (seconds) |
|---|---|---|---|
| **1.** | 65 | 66 | 60 |
| **2.** | 70 | 64 | 120 |
| **3.** | 75 | 60 | 180 |
| **4.** | 80 | 61 | 240 |
| **5.** | 85 | 64 | 300 |
| **6.** | 90 | 66 | 360 |

**Calculation table**

$(\Delta T) = T_i - T_0$

$\square_t = \Delta T / T_i$

| S.NO | TEMPERATURE Δ (T)$^0$C | $\square_t$ |
|---|---|---|
| **1.** | 11 | 16.92 |
| **2.** | 1 | 18.75 |
| **3.** | 15 | 20 |
| **4.** | 19 | 23.75 |
| **5.** | 21 | 24.7 |
| **6.** | 24 | 26.67 |

### 6.2 Using coolant at 75% Dilution

**Observation table**

| S.NO | Inlet temp $T_I$($^0$C) | Outlet temp $T_0$ ($^0$C) | Time (sec) |
|---|---|---|---|
| **1.** | 65 | 58 | 60 |
| **2.** | 70 | 63 | 120 |
| **3.** | 75 | 66 | 180 |
| **4.** | 80 | 69 | 240 |
| **5.** | 85 | 72 | 300 |
| **6.** | 90 | 76 | 360 |

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**Calculation table**

$(\triangle T) = T_i - T_0$

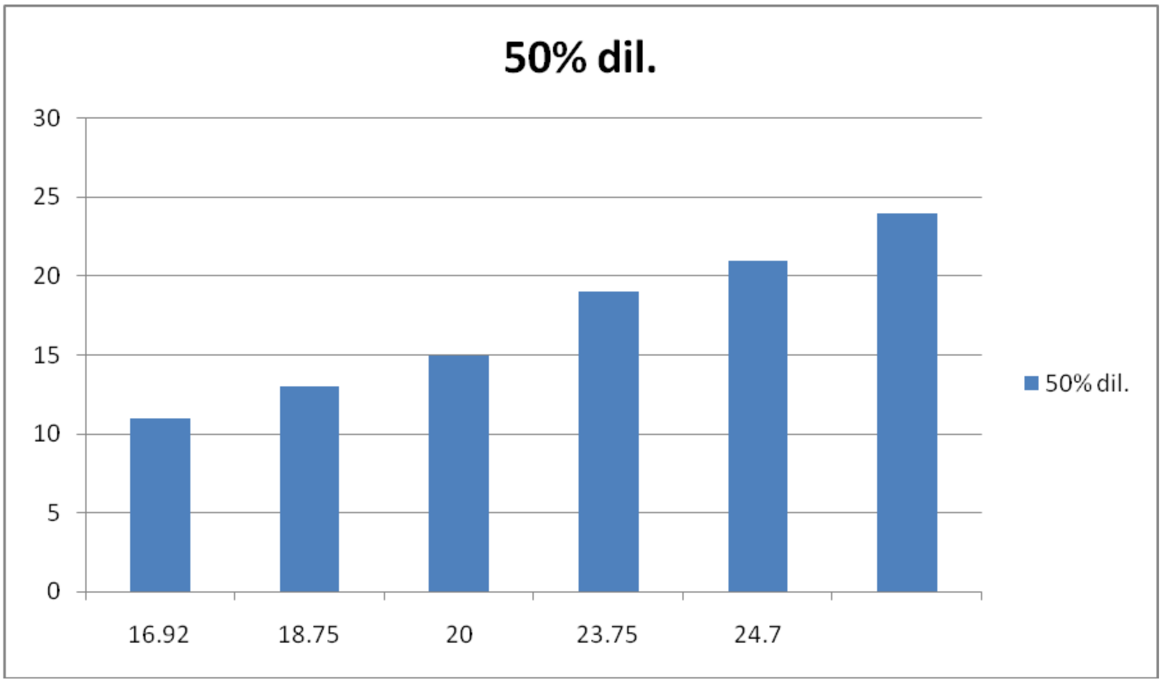
$\square_t = \Delta T / T_i$

| **S.NO** | **Temp ($\triangle$ T)$^0$C** | $\square_t$ |
|---|---|---|
| **1.** | 7 | 10.72 |
| **2.** | 7 | 10 |
| **3.** | 9 | 14.66 |
| **4.** | 11 | 13.75 |
| **5.** | 13 | 15.29 |
| **6.** | 14 | 15.56 |

**VII. CONCLUSION**

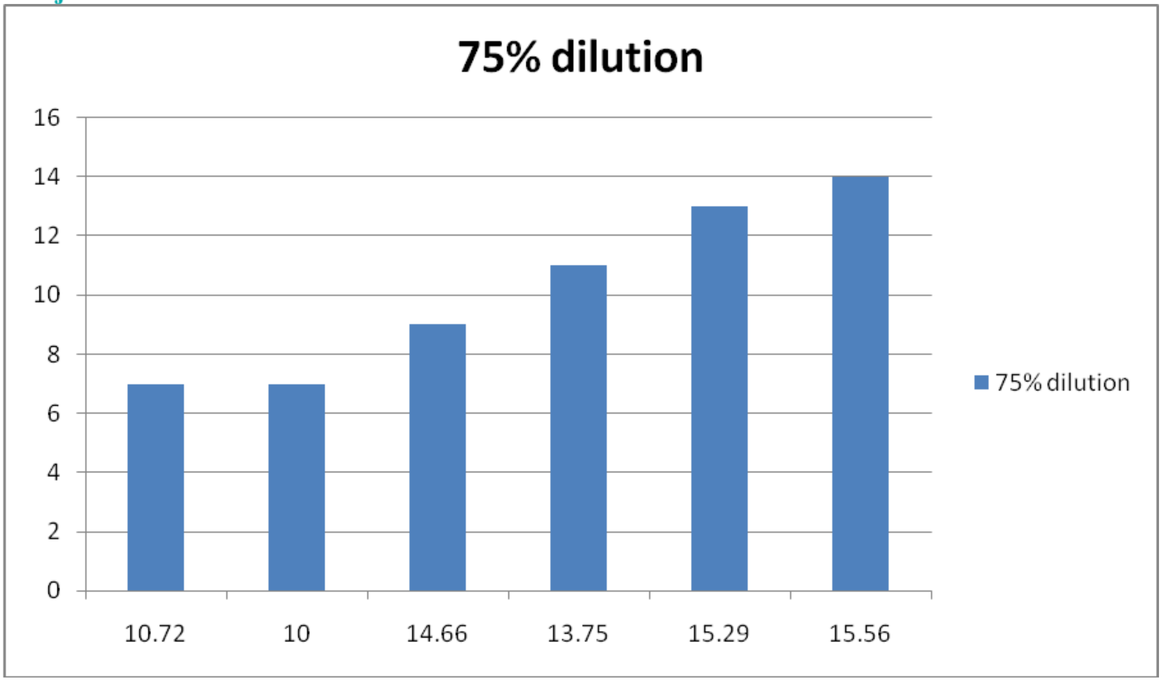
The efficiency of coolant has been checked by varying the dilution levels. Various readings are observed and graphs are plotted which describe the coolant efficiency at that particular dilution.

**Thermal Efficiency V/S Change In Temperature**

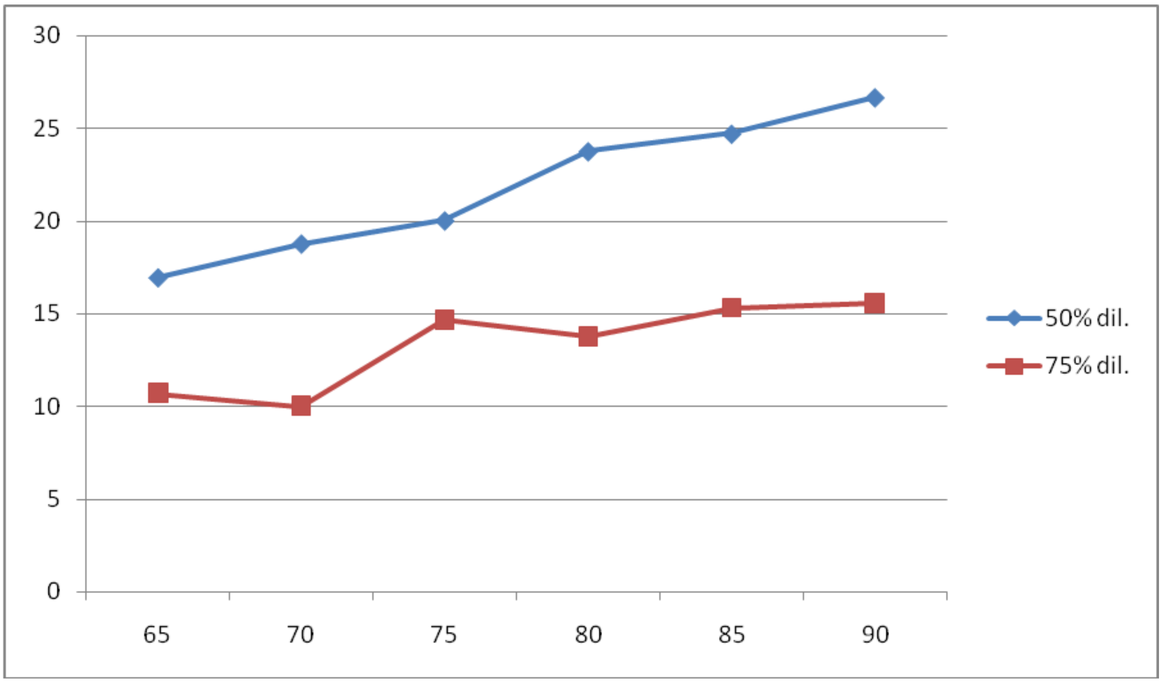



X axis = Thermal efficiency

Y axis = Change in temperature



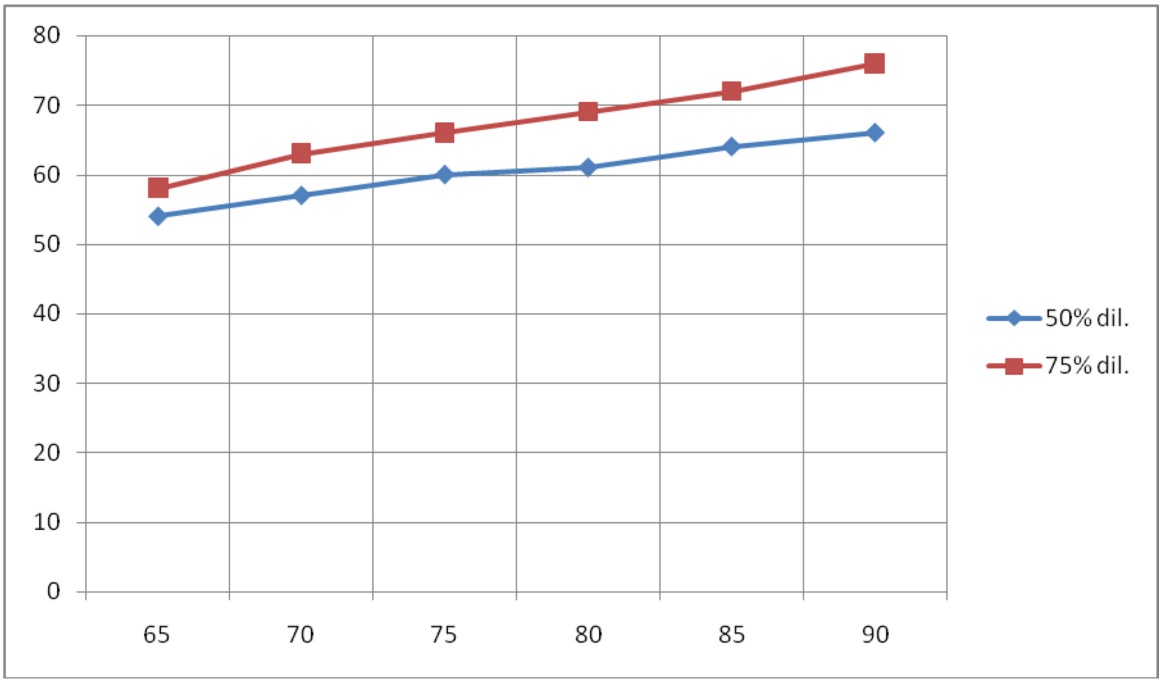

**Inlet Temperature V/S Thermal Efficiency**




X axis = inlet temperature

Y axis = thermal efficiency

**Inlet Temperature V/S Outlet Temperature**




X axis = inlet temperature & Y axis = outlet temperature

**NOMENCLATURE**

$M_c$= Mass flow rate of coolant in kg/s

$Cp_c$= specific heat capacity of coolant at constant pressure in KJ/Kg K

$Cp_a$ = specific heat capacity of air at constant pressure KJ/Kg K

$t_{ci}$= Inlet temperature of coolant

$t_{co}$ = outlet temperature of coolant

$t_{ai}$ = Inlet temperature of air

$T_i$ = inlet temperature

$T_0$ = outlet temperature

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