Design and Build for Car Radiator Test Equipment with Capacity of 1300 Cc and 1000 Cc

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Abstract. This research aims to design and build a radiator test equipment for cars with engine capacity of 1300 cc and 1000 cc. This tool can regulate the mechanism of the flow rate of air passing through the radiator, and the flow rate of water that integrates into the radiator which is useful for generating valid test data. This tool can read the ability of the car radiator to reduce the heat from the car engine and get the results of testing the car radiator using the temperature acquisition data tool. Car radiator test equipment was equipped with air conditioning and venturi meter. This study used the SNI 07 2054 elbow profile iron frame with a dimension of 40 x 40 x 4 mm to withstand the load from the airways and blow on it. The time needed to heat the water from an initial temperature of 27 °C to 80 °C with 20 liters of water and water heaters with 1000 watts of power is 37.1 minutes.

1. Introduction
Planning means to formulate a design to meet human needs. Certain requirements can be clearly stated [1]. A heat exchanger is a device where there is heat transfer from a higher temperature to another fluid at a lower temperature. Therefore, heat exchanger equipment is needed for cars, air conditioners, etc. This process can be done directly or indirectly [2].

The radiator device consists of the engine coolant in and out, a cooling fan installed in front or behind the cooling fins, radiator coolant, and radiator coolant. The coolant in this radiator plays a very important role in transforming the heat of the engine into the environment, allowing the engine to work at optimal temperatures that impact fuel savings. To analyze from the heat exchanger by testing all HE models for 500 cc to 2500 cc cars.

However, to achieve the benefit, the car’s cooling system must work optimally for cooling the engine. On the contrary, sometimes the radiators do not work optimally. Many factors that affect it, such as a fan that does not rotate, fluid circulation, and so on. This causes the radiator to function ineffectively. An overview of the effects used is widely used to analyze the comparisons of different types of heat exchangers in selecting the best types for performing a specific heat transfer [3].

Therefore, this study attempt to design and build a radiator test equipment for the car by adding the airways and venturi meters to the radiator test equipment. This study has also created a regulator for the flow of water entering the radiator and the regulator of the flow of air flowing into the radiator. In this study, also design a radiator test equipment for cars of 1300 cc and 1000 cc to decide the radiator's ability to convert heat provided by the engine to the environment.
The purpose of this study is to determine the effectiveness of the radiator, to compare two types of fluids economically, to compare the heat transfer rate of the water and air sides, and to determine a good water discharge for the radiator.

2. Literature review

2.1. Heat transfer
Heat transfer plays an important role in many design problems in the engineering field, such as aeronautical, chemical, civil, electrical, metallurgical, mechanical, and mechanical engineering [4]. In the field of mechanical engineering, various problems require solutions based on heat transfer analysis [6]. Hardening the surface of the machine after undergoing heating treatment requires the proper cooling rate [7]. To achieve good performance, engine-driven motors require a cooling system that involves careful analysis of heat transfer rates [4][8].

2.2. Mechanism of heat transfer
Generally, 3 heat transfer processes that occur, namely conduction, convection, and radiation. Conduction heat transfer occurs when using a medium of solid substances [9]. Convection heat transfer occurs when using a liquid or gas (fluid) intermediary, and radiant heat transfer without an intermediate or electromagnetic wave [10].

2.3 Calculate the fluid flow rate in the venturi meter

Calculates the fluid flow rate in a pipe using a venture meter, using the Bernoulli equation [8].

\[ P_1 + \frac{1}{2} \rho v_1^2 + \rho \cdot g \cdot h_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho \cdot g \cdot h_2 \]  \hspace{1cm} (1)

In a non-compressible fluid, the density of the fluid is always the same at every point it passes through. The mass of a fluid flowing in a pipe having a cross-section area A1 (large pipe diameter) within a specified time interval [5] :

\[ m_1 = \rho V_1 \]  \hspace{1cm} (2)
\[ m_1 = \rho A_1 V_1 t \]  \hspace{1cm} (3)

Similarly, the fluid mass flowing in a pipe having a cross-section area A2 (small pipe diameter) within a specified time interval:

\[ m_2 = \rho V_2 \]  \hspace{1cm} (4)
\[ m_2 = \rho A_2 V_2 t \]  \hspace{1cm} (5)

Since the flow is constant, the mass of the fluid enters the mass of the fluid coming out, then:

\[ m_1 = m_2 \]  \hspace{1cm} (6)
\[ \rho A_1 V_1 t = \rho A_2 V_2 t \]  \hspace{1cm} (7)

Therefore, in the non-compressible fluid, the continuity equation exists:

\[ Q = A_1 V_1 = A_2 V_2 = AV \]  \hspace{1cm} (8)
where:

\( A_1 \) = cross-section area 1 \((m^2)\)

\( A_2 \) = cross-section area 2 \((m^2)\)

\( V_1 \) = fluid flow rate at the cross-section 1\((m/s)\)

\( V_2 \) = fluid flow rate at the cross-section 2\((m/s)\)

The Bernoulli equation can be applied to point 1 and point 2 (see figure 1). The fluid to be measured flows at a point that has no height difference \((h_1 = h_2)\), therefore the equations:

\[
P_1 - P_2 = \frac{1}{2} \rho (v_2^2 - v_1^2)
\]  

(9)

From the equation of continuity of air in area \(A_1\) \((V_1)\) and in area \(A_2\) \((V_2)\) can be written as follows:

\[
V_1 = \frac{A_2V_2}{A_1}
\]  

(10)

Or

\[
V_2 = \frac{A_1V_1}{A_2}
\]  

(11)

Substituting equation (2) into equation (3), we have the following equation.

\[
P_1 - P_2 = \frac{1}{2} \rho \left[ \left( \frac{A_1}{A_2} \right)^2 V_2^2 - V_1^2 \right]
\]  

(12)

\[
P_1 - P_2 = \frac{1}{2} \rho V_1^2 \left[ \left( \frac{A_1}{A_2} \right)^2 - 1 \right]
\]  

(13)

By replacing equation (8) with equation (12,13) the following equation will be obtained.

\[
Q = \left( \frac{\Delta P}{\frac{1}{2} \rho \left[ \left( \frac{A_1}{A_2} \right)^2 - 1 \right]} \right)^{1/2} A_1
\]  

(14)

where:

\( Q \) = debit \((m^3/s)\)

\( \Delta P \) = pressure difference on the Manometer \((Pa)\)

\( A_1 \) = large pipe cross-sectional area \((m^2)\)

\( A_2 \) = small pipe cross-sectional area \((m^2)\)

\( \rho \) = fluid density in the flow tube \((Kg/m^3)\)

3. Research method

Following is the flow diagram of the radiator test equipment:

![Flowchart of design](image)

**Figure 2.** Flowchart of design
3.1. Scheme of the equipment

![Figure 3. Scheme of radiator test equipment](image)

3.2. Design of The Equipment

The design of radiator test equipment for cars carried out using Solidworks software can be seen in Figure 4.

![Figure 4. Design of radiator test equipment](image)

4. Research analysis and results

4.1. Design result

In the manufacture and design of the equipment, has produced a radiator test equipment for cars with engine capacity of 1300 cc and 1000 cc.

![Figure 5. Radiator test equipment](image)
4.2. Design of radiator test equipment frame
When designing frames, using 4mm thick steel. Following are some of the fundamental reasons in choosing the radiator test equipment frame profile for this car:

- The elbow iron is easy to find, strong, and not too heavy.
- Easy in terms of cutting and connecting.
- Elbows iron has different widths and thickness.

Frames are made with different dimensions. The following is a table of dimensions used.

| No | Dimension | Unit | Quantity |
|----|-----------|------|----------|
| 1  | 2.000     | mm   | 2        |
| 2  | 800       | mm   | 4        |
| 3  | 455       | mm   | 2        |

Following is an overview of the design of the radiator test equipment:

4.3. Calculation of heating system
In the design and manufacture of radiator test equipment for this car, it produces a design that is a water heating system. To determine the time required for a water heater to heat water from an initial temperature of 27 °C to 80 °C is.

Determine the density of water using the formula: Density = Mass/Volume

If an object has mass (m) and volume (v), then its density (ρ) is as follows [9].

\[ \rho = \frac{m}{v} \] (15)

Density units are (mass units) / (volume units) eg kilograms / liters, grams / cc, kilograms / m3, etc.

To convert from liters (L) to pounds (kg) using the density formula above, the formula for converting volume to mass is as follows: Mass = Density x Volume

\[ m = \rho \cdot v \] (16)

Water is defined as having a density of 1 kg/liter. The water is heated to 20 liters at an initial temperature of 27 °C and the desired hot water temperature is 80 °C. Thus a mass of 1 liter of water can be calculated in the following way. Therefore, 20 liters of mass water:

\[ m = \frac{1 \text{ kg}}{L} \cdot 20 \text{ L} \]

\[ m = 20 \text{ kg} \]

The calculation to determine the mass of water using a formula [4]:

\[ Q = m \cdot C_p \cdot \Delta T \] (17)
The water heater used has 1000 watts. This study used 2 water heater. Then the time required to heat 20 liters of water:

\[ P = \frac{w}{t} \]

\[ 2000 \, \text{J/s} = \frac{4.452.000 \, \text{J}}{t} \]

\[ t = 2.226 \, \text{s} \]

\[ t = 37.1 \, \text{min} \]

Therefore, the time required for a water heater to heat water in a tank with a capacity of 20 liters is 2,261 s or 37.1 minutes.

5. Conclusion

The findings of this study design and built a radiator test kit for cars of 1300 cc and 1000 cc to determine the radiator's ability to convert heat supplied by the engine to the environment. A radiator test kit designed using SNI 07 2054 steel profile elbow with length 2000 mm, width 455 mm, and height 800 mm. The time needed to heat the water from an initial temperature of 27 °C to 80 °C with 20 liters of water and water heaters with 1000 watts of power is 37.1 minutes.

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