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ENGINE EXHAUST POWERED FOOD HEATER

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Abstract
Numerous studies have been conducted to utilize the heat of exhaust gases coming out of the engine. So, our project is focused on using the heat rejected from the engine exhaust system for food delivery purposes. Generally, heat from the exhaust gas is wasted in the atmosphere but our project model is made using a heat exchanger-like box to utilize the heat wasted in the atmosphere. In our arrangement, a double-layer chamber is prepared in which there is an internal chamber for storing food and an external chamber. In between the doubled-layer chamber, the hot engine exhaust gas is passed through the passage where the exchange of heat occurs and is transferred to the area where food is kept. The food material, liquid or solid, mostly water is kept in the chamber. As the amount of exhaust gas passes through the chamber heat transfer results in the warming up of the food kept in the chamber and the flow of exhaust gas is maintained by an electric valve which automatically cuts the supply of exhaust gas when the desired temperature is achieved and is monitored using the device called a thermostat.
A CFD analysis has been done and a mathematical model and analysis of the arrangement was performed in ANSYS. which shows that the maximum heat transfer from the heat exchanger is observed to range from 60℃ to 70℃. The inner and outer walls of the heat chamber are nearly the same as those of theoretical and practical cases.
In practical analysis, it was observed that the heat exchanger's maximum heat transfer is 58℃.

Keywords: Heat, Temperature, Heat Exchanger, Food Delivery.

Introduction

Food safety refers to the handling, preparation, and storage of food in a way that reduces the risk of individuals getting sick from foodborne illnesses. There are various rules and routines that one should follow to maintain good health. In this way, food defense plays a role in preventing consumer health.

Foodborne illnesses are typically caused by bacteria, viruses, parasites, or chemical substances entering the human body through contaminated food, and they can be infectious or toxic.

Our idea for food safety is to utilize the heat of exhaust gases from motor vehicles to keep food warm and fresh while saving power and cost. This is an advanced concept that can revolutionize the food industry. It uses the bypass of engine exhaust heat which is naturally available without an external source. "It is a new approach to developing useful vehicle accessories."

The heat from the engine is channeled into a small chamber through a heat jacket, where it efficiently maintains the temperature of food.

In this work, heat is extracted from the exhaust heated gas with the help of a heat exchanger which otherwise goes to waste in the atmosphere. Also at the same time in the process, the temperature of exhaust gas drops significantly which will be helpful in environmental concern

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Methodology

In this project, we are creating a prototype for a device called an engine exhaust-powered food heater. The methodology is divided into two parts, which are explained as follows:

- Parts of the system
- Working

Parts of the system

There are three main parts of the system

- Heat exchanger box with circulation fan
- Diverting motorized valve
- Thermostat and power supply

(a) **Heat exchanger box with circulation fan**: It is a device that facilitates heat transfer between two or more fluids. It can be used for both heating and cooling processes.

(b) **Diverting motorized valve**: It is an automatic valve that operates based on an electrical signal from the thermostat. It allows exhaust gas to pass through until it reaches a safe temperature. If the desired temperature is exceeded, the device bypasses the flow of exhaust gas.

(c) **Thermostat control system**: A thermostat is a device that senses the temperature of a system and sends electrical signals to adjust the output

Working

- The temperature-dependent valve control system regulates the valve based on the temperature.
- The valve system keeps the wall connected to the heating chamber
- If the temperature inside the chamber is lower than the set temperature exhaust gas is allowed to flow inside the chamber and if the temperature gets higher than the set temperature the exhaust gas is bypassed to the atmosphere.

Analysis

Thermal Analysis of the model

Material: Aluminum

Length of the outer box	12inch
Thickness of the outer box	0.095inch or 1.5mm
Length of the inner box	10inch
Thickness of the inner box	0.095 inch or 1.5 mm
Diameter of inlet and outlet pipe	0.5 inch
Thickness of the coating layer of cotton rope	0.5 inch
Thickness of rexine	2.689tonne/mm3
Density	0.2735w/mm
Isotropic thermal conductivity	9.51+053/tone
Temperature	90℃
Convection	22℃
Convection coefficient	1.24-006cw/mm2

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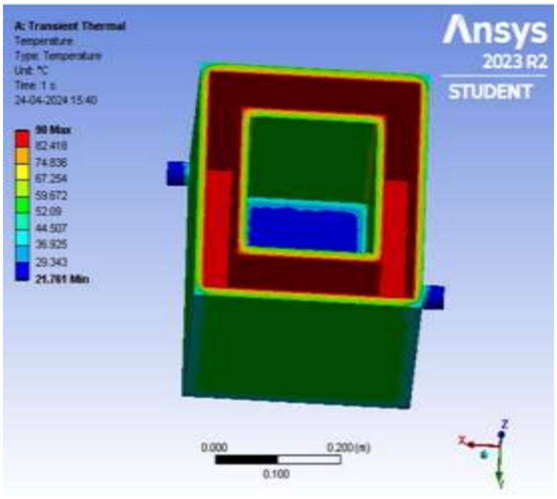

Fig. 1: Geometry of model

Box design
In ANSYS the mesh model is created and after meshing there are 4778 nodes and 19102 elements are made.

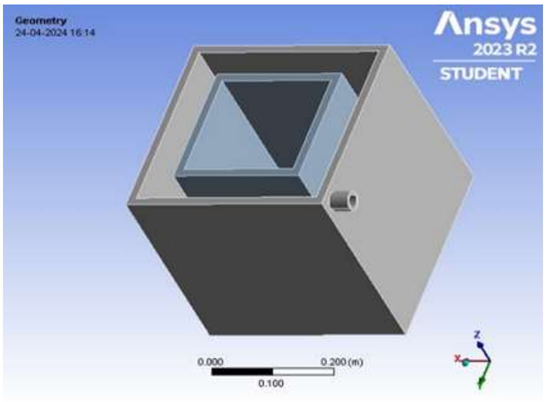

Fig. 2: Mess of the model.

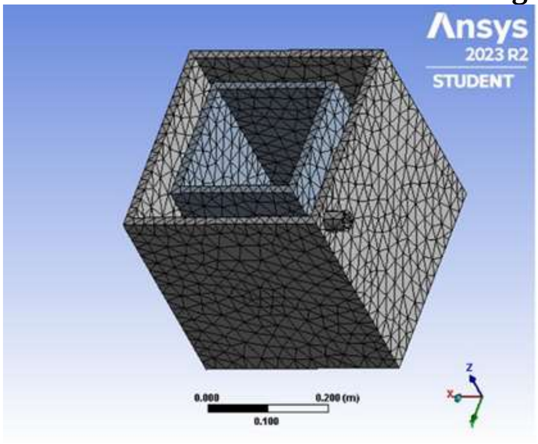

Fig. 3: Temperature and Convection Analysis
Figure 3 shows that the maximum temperature is 90°C and the minimum temperature is 20°C.

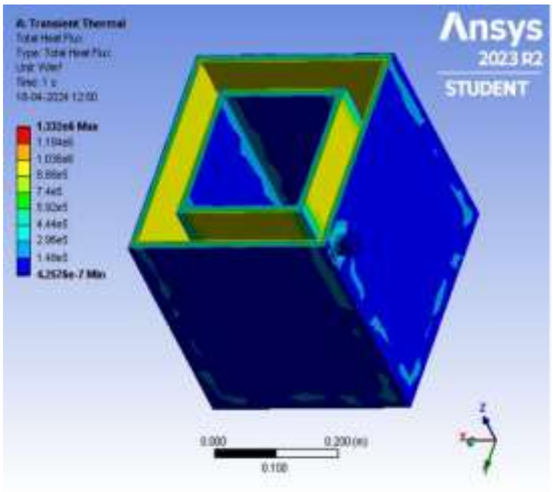

Fig. 4: Total heat flux

Figure **4** shows that the maximum value of heat flux is 1.332W/mm^2 by the z-axis inside the inner chamber.

Result of Thermal Analysis

The temperature obtained in the thermal analysis of the box inside the box is found to be 59℃.
The heat flux in the inner chamber is 1.332 W/mm^2.

CFD analysis of the model

"The boundary condition should be adjusted based on the specific climate and location."

Inlet Temperature	90℃
Velocity of hydrocarbon gasses	25m/sec
Atm pressure	1bar
Total heat flux	1.33W/mm^2
Direction of heat flux	1.0072W/mm^2

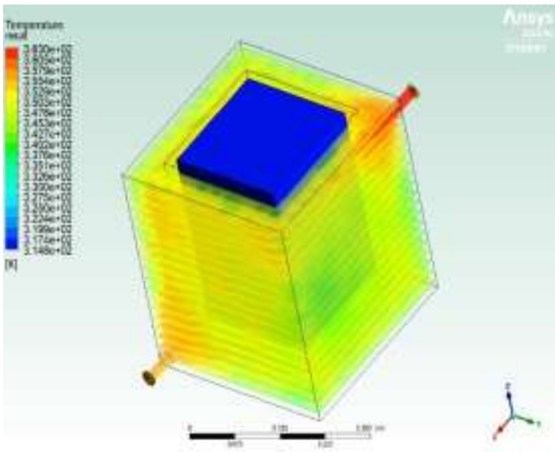

Fig. 5: Result Temperature-333K or 60℃

Calculation

From 1-D study isentropic flow equation
By logarithmic differentiation

$\frac{d\rho}{\rho} + \frac{dA}{A} + \frac{dV}{V} = 0$ ……………………………...Equation (1)

Diameter of exhaust pipe $=d_1 = 2cm$
Diameter of exhaust pipe $=d_2 = 1.5cm$
Velocity of gas at exhaust pipe(v_1) =18 m/s
Velocity of gas at inlet pipe(v_2) =19.7 m/s
Cross section Area of the exhaust pipe (A1) = $\frac{\pi}{4} * d^2{}_1$ $=3.14cm^2$
Cross section Area of the inlet pipe (A2) = $\frac{\pi}{4} * d^2{}_2$ $=1.76cm^2$
Temperature (T_1) at inlet = 47 ℃
Temperature (T_2) at outlet = 58 ℃

By integrating Equation (1)

$(\ln A)_{A_1}^{A_2} = (\ln v)_{v_1}^{v_2} - (\ln \rho)_{\rho_1}^{\rho_2}$
Or
$1.44-0.565=2.980 - 2.890 - \ln(\rho_2 - \rho_1)$
$\ln(\rho_2 - \rho_1) = - 0.488$
$(\rho_2 - \rho_1) = e^{-0.488}$
$\rho_2 - \rho_1 = 0.618$ ……………………… Equation (2)
From mass conservation law,
$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$
$\rho_1 * 3.14 * 1800 = \rho_2 * 1.76 * 1970$
$\rho_1 * 3.14 * 1800 = (0.618 + \rho_1) * 1.76 * 1970$ …...from equation [$\rho_2 - \rho_1 = 0.618$]
$\rho_1 = 0.995\ Kg/cm^3$
Hence,
$\rho_2 = 1.613\ Kg/cm^3$
Mass flow rate ($\dot{m}$),
$\dot{m} = \rho_2 A_2 v_2$
$\dot{m} = 1.613 * 1.76 * 10^{-4} * 19.7$
$\dot{m} = 0.00592\ Kg/sec$
For a mixture of exhaust gas, the specific heat capacity at constant pressure at steady state temperature 350 K is taken as,
C_p=1.009 KJ/Kg-K (Value of cp has been taken from physically based models for predicting exhaust temperature in SI engines by **Andrej Verma & Hiren Kerai,** LiTH-ISY-EX—16/4943--SE)
Heat absorbed by the heat exchanger can be calculated by…
$Q = \dot{m} C p \Delta T * t$
Here,
t = engine running time=10 minute
ΔT=Temperature difference between inlet and outlet
$Q = 0.00592 * 600 * 1009 * 11$
Q = 39.30 KJ/sec

Result And Discussion

During analysis, the model is fitted with the bike to evaluate its performance efficiency and monitor the temperature of the inner chamber over time.

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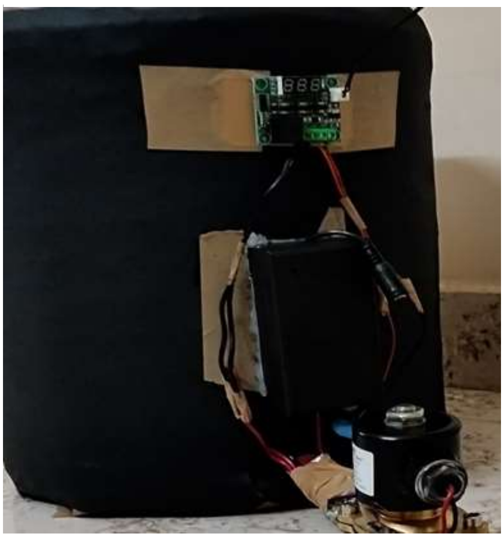
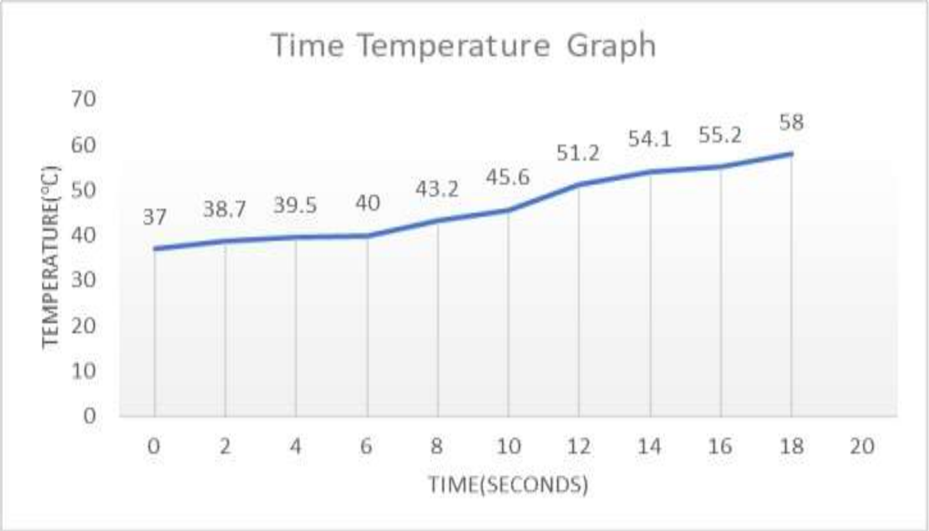
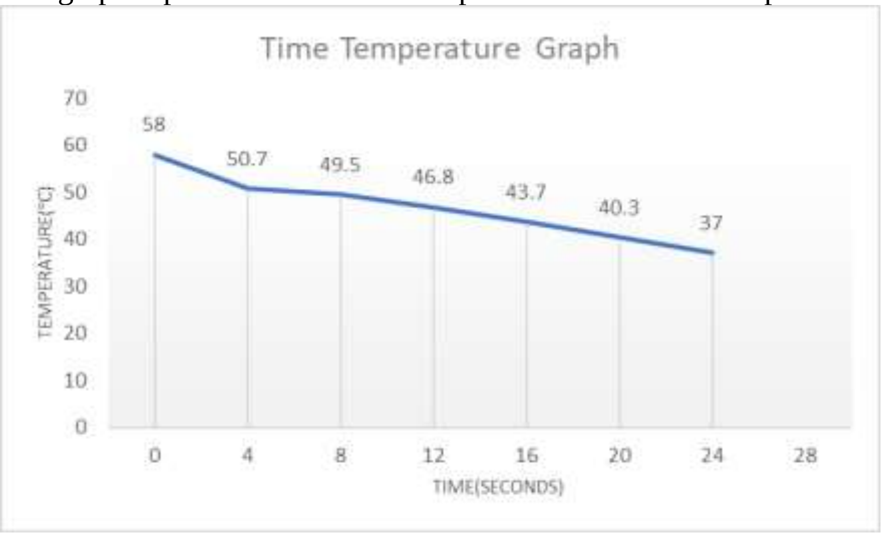


Fig. 6: Actual model.

Based on a comprehensive analysis, we have determined that the inner chamber begins at a temperature of 37℃ and reaches a maximum of 58℃ after running for 18 minutes without interruption. This information demonstrates the efficiency and effectiveness of our product and highlights the benefits it can bring to your daily life.



The graph represents the relationship between time and temperature when the engine is running.



The graph represents the relationship between time and temperature when the engine is stopped.

Conclusion

In today's generation, many people prefer to order food online. However, during delivery, the food often gets cold. Therefore, a device that helps to maintain the temperature of the food during delivery would be highly useful. Such a device would not only prevent the food from getting cold but also reduce the risk of foodborne illnesses caused by consuming unhygienic and cold food.

Utilizing the heat from the exhaust gas is an effective way to conserve energy that is often wasted. By implementing this concept, we can make a positive impact on our environment and save valuable resources.

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