

# Design And Fabrication of Reheating Kit of Food Using Engine Exhaust Heat of A Motorcycle

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**Abstract-** In this era, the rate of online food delivery item is increased rapidly. The food item which is to be delivered to customer requires minimum 20 to 25 minutes from the time of preparation. During the delivery the food item gets cooled and therefore it loses its desired taste and quality. The present innovation counters this problem by providing an arrangement which will keep the food item warm even during the delivery process. The basic principle of working for this arrangement is transferring heat energy of waste exhaust gas, which is any ways going waste to the food chamber which will maintain the temperature of the food and it also reduces the exhaust heat. This innovation will be useful mainly for the online food delivery and also the fast food items delivery. This can be also use to transfer food from one place to another without losing it quality. In internal combustion engines the thermal efficiency is nearly 30 %, approximately 30% of the fuel energy is wasted in exhaust gases, and around 30% in cooling water and only 10% are unaccountable losses. Different techniques are made to use this 30 % energy of exhaust gases. If the heat energy which is wasted needs to be trapped and converted into usable energy, the overall efficiency of an engine can be improved. The present work deals with design & manufacturing of high insulation thermal box. The current model working on transportation or storage of any product at the range of one and half hour for specific size, we innovated the design by developing it into a thermal insulation used for delivery and storage

**Keywords-** Exhaust gas, Heat energy, Food delivery, Engine.

## I. INTRODUCTION

Online food ordering and delivering services have entered in the mainstream business now and with increasing rate of success they are achieving, they are planning to make their system more efficient. But hotels or food delivery services have to face a major problem that is they can only provide the food for specific distances. So they have to start new store in every prospective area or they have to bare the losses by not delivering food in that area. Also some Franchises like Dominos doesn't charge if the food is not delivered within 30 minutes so they might have to face a lot of losses. The main aim of this project is to build a reheating kit for food so that food will remain warm till delivery. Also the

kit will not use any external heating source as the waste heat from the exhaust will be used. Due to this food delivering at longer distances can be made possible resulting in profit of the service along with minimization in the waste of heat energy.

Heat engines are basically devices which produce only useful work. Waste energy in the form of heat is normally a by-product resulting from the irreversibility of the processes involved in the conversion of primary energy to mechanical or electrical energy. The efficiency of a modern internal combustion engine is about 37% in a normal spark ignition Engine. So engine efficiency can be improved by using this kit.

## II. BACKGROUND OF FOOD DELIVERY & NEED FOR REHEATING KIT

**1.1 Background:** People nowadays prefer ordering food through food delivery chains. Whenever food is ordered through online delivering application, it normally takes 25-30 minutes for the food to reach the customer. During this period, depending upon the traffic conditions the delivery of food can be delayed than the expected time. Because of this, the food might get cold. The basic aim of this project is to keep the food warm so that the food can be delivered at far away distance. The heat energy of the exhaust gas is wasted as it is directly get exposed to the surrounding. This waste heat energy can be used to reheat the food the make the food delivery at far away distances possible. Also the services which delivers the food have deal with some losses if the food is not delivered in time. During peak time, if the number of orders are more then, more time will be needed to prepare the food and most of the services have specific time limit for the delivery, so time remaining to deliver the food to the customer is less. Then there is possibility that the person who is delivering the food might rush to complete the delivery which can put the delivery person in danger as chances for accidents increases. This kit is specially designed to minimize all this and use the waste heat of the motorcycle which will result in the profit of the system along with the safety of the person making the delivery.

### 1.2 Need and Scope of Reheating Kit:

With an on-going and increasing demand of food delivery services, the need of efficient delivery system have arisen. Food delivery services need to have an efficient and most reliable delivery service for customer satisfaction. Also if they can keep the food warm for the longer period, then they can provide or deliver foods at longer distances allowing them to expand their service range with increase in their profit. Small scale food delivery services have limited range of food delivery as they cannot open the centres at many places due to investment problem. If they can use an efficient delivery system which can allow them to deliver the food at faraway places, they can expand their business. Based on this realization, we are aiming to make the device that maintain temperature and quality of food as well as same in dimensions and cost to existing system. This food delivery system can capable to fulfil requirement of quality and temperature in long distance. This new mechanism will indirectly boost any economy that depends on food delivery. This device is useful to the restaurants, pizza outlets, and other ecommerce food companies. It is also very useful to the food delivery boy. It is simple in operation and does not need skilled labour, rapid, safe operation and simple maintenance. It is portable, it can be easily assembled and disassembled and it can be carried from one place to another. It reduces the risk of rejection of food and increase the relation of customers and restaurants (pizza outlets, e-commerce food business). So our main object is to develop such type of device which deliver best quality of food to the customers and improving the existing system.

### III. LITERATURE REVIEW

There is major development in the field of food delivery starting from Dabbawala to improved insulated food delivery box all over the world. There are also new development of the corrugated box especially for the pizza. All the famous food delivering chain having motor cycles use a food-carrying box made of insulating material with the purpose of keeping the cooked meals as warm as possible. Since the motor cycle generally has to deliver the meals to more than one home & client, and the door of the box must be opened more than once, the heat of the meals is continuously lost. Therefore, the customers receive cold food and they need to warm of heat the food before consuming.

#### Initial phase of food delivery system

It was necessary to develop a system for delivering the food which satisfies the customer requirements. Some of such systems are described below.

#### Domino's Pizza Box (1960):

Since the 1940s pizza delivery was done with the pizza kept on a round cardboard base and covered with a paper bag. Domino's pizza chain introduced the modern corrugated flat square pizza box.

#### Ingrid Kosar, Delivery Bag (1984):

Bags used to keep pizza hot while being transported are commonly referred as hot bags. Hot bags are thermal bags, typically made of vinyl, nylon that passively retains heat. Heated bags supply additional heat through inserting externally heat from heat disks, electrical heating elements, or pellets which are heated electrically using magnetic waves.

#### Jose A. Rial (1994):

Jose A. Rial has made an arrangement for maintaining the food at a desired temperature for consuming, in a food-delivery motorized vehicle having a box for carrying the food, the arrangement comprising an isolating case with a heat exchanger therein, the hot coolant coming from the engine is circulated through the heat exchanger by a food-heating circuit and at least one fan is provided to remove heat from the heat exchanger.

## IV. OBJECTIVES AND PROBLEM DEFINITION

### 3.1 Objectives

- To maintain the temperature of the food kept inside the top box of delivery vehicle at the desired range.
- To utilize the waste heat of the engine exhaust to keep the food warm.
- To fabricate a kit which can be fitted easily on the food delivery vehicles rather than changing the full design of vehicle.
- To allow the different food delivery systems to deliver food at longer distances.

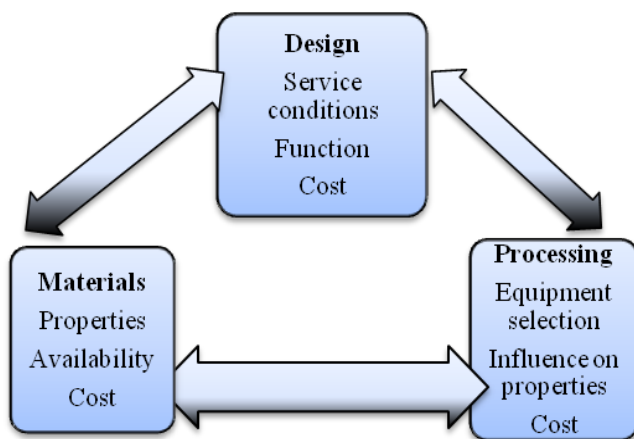
### 3.2 Problem Definition

Online food business is increasing day by day. There are many problem regarding food delivery like bad quality, poor packing, different taste, timing, etc. When delivering perishable items like food it is very important for every company to make sure it reaches their customers in fresh, hot (or chilled) condition and exactly in the way they want it to taste. But as we know that maintain temperature and quality of food in food delivery is the major problem. In a recent time, existing box as an insulating box is used, they are failed to maintain temperature in a long distance. Quality and taste of food is also affected by long distance. Nowadays there are

many methods available for deliver heated food but some are ineffective, some are complex and costly. There is need for the improvement in present methods of food delivery. These conventional methods are failed to maintain temperature and quality of food for a period of time.

## V. METHODOLOGY

The temperature of the exhaust gas of a motorbike varies from around 140° to 200 °C. This exhaust gas will be circulated in the heating box to maintain the food which has to be delivered in desired temperature. Exhaust gas will be bypassed directly from exhaust manifold so that high temperature exhaust gas can be utilized with less load on the engine



**Fig.1: Integrations of design, material & processing to produce a product**

### Manufacturing Processes Used:

#### ❖ Bending of Pipe

Bending of copper pipe was done to make coil shape form, since the exhaust gases were made to travel in a loop. Bending requires a uniform flow of material, so it is done using the bending springs such that there are no sharp curves and sudden change in curve.

#### ❖ TIG Welding

TIG welding is used at the joint where exhaust manifold exit outlet is welded with the copper pipe. From this joint the gases pass through the pipe and then to the delivery chamber. TIG welding is used because it avoids oxidation at high temperatures since the joint is always at high temperatures.

#### ❖ CO2 Welding

CO2 welding was done on the delivery box to fix it with the frame of the bike where it rests on top of it. CO2 welding is used because it is suitable for steels and other material also it is cheaper than other gas welding methods.

#### ❖ Drilling

Drilling was done using portable hand drilling machine. This process was used to drill holes in the heating box to make inlet and outlet for the copper pipe. Also drilling was used to make holes for the bolts in the frame which are used to mount the frame on the bike.

### Selected Material:

#### 1. Copper Pipe:

Properties of Copper:

- Excellent heat conductivity.
- Excellent electrical conductivity.
- Good corrosion resistance.
- Good bio fouling resistance.
- Good machinability.

#### 2. Mild Steel:

Properties of Mild Steel:

- Young's modulus- approx. 210,000 Mpa
- Good electrical conductivity.
- Better Machinability.

#### 3. Stainless Steel 304:

Properties of Stainless steel 304:

- High corrosion resistance.
- High heat resistance.
- Excellent weldability.
- Good mechanical properties at high and low temperatures.
- High ductility and formability.
- Excellent surface finish.

#### 4. Aluminium:

Properties of Aluminium:

- Light in weight.
- High Corrosion Resistance.
- Good Thermal Conductivity.
- Excellent Ductility.

- High Machinability.

**5. Glass Wool:**

Properties of Glass Wool:

- Light in Weight.
- Easy to Install.
- High Thermal Resistance.
- No Chemical Impurities.
- Less Expensive.

**6. Plaster of Paris Insulation:**

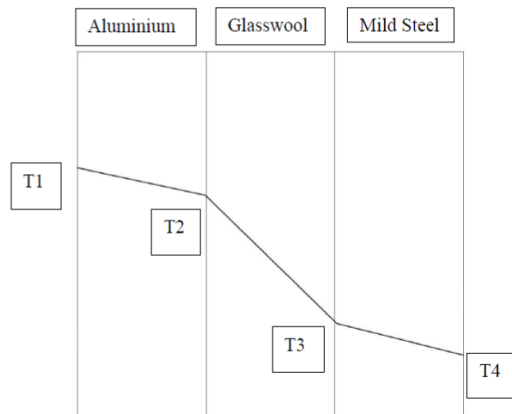
Properties of POP:

- High Thermal Insulation.
- High Thermal Resistance.
- Economical.
- High Strength.

**VI. DESIGN CONSIDERATION AND CALCULATION**

**Design of the Heating Box:-**

Considering the wall of box as composite wall. Thus we need to find heat flow through composite wall



**Fig.2: Heat flow through composite walls**

Here,

1. Inside material is Aluminium (Al) having thermal conductivity  $K_3 = 225$  W/mK
2. Using Glass wool as an insulating material having thermal conductivity  $K_2 = 0.03$  W/mK
3. Outside wall is made up of Mild steel having thermal conductivity  $K_1 = 33$  W/mK

Considering ambient temperature ( $T_4$ ) as  $28^\circ\text{C}$  i.e. 301K.

We get inside temperature as ( $T_1$ )  $50^\circ\text{C}$  i.e. 323K.

Selecting standard mild steel sheet and aluminium sheet to form a wall (composite) of delivery box having thickness of 0.015m and 0.02m respectively.

Selecting Glass wool thickness as 0.0127m.

Now,

We know that heat flow through composite wall is given by:

$$q = \frac{T_1 - T_4}{\frac{L_1}{K_1A_1} + \frac{L_2}{K_2A_2} + \frac{L_3}{K_3A_3}}$$

To find area, considering height as 0.381m (15 inches)

Therefore,

$$A_1 = 0.381 \times 0.002 = 0.000762\text{m}^2$$

$$A_2 = 0.381 \times 0.0127 = 0.004387\text{m}^2$$

$$A_3 = 0.381 \times 0.0015 = 0.0005715\text{m}^2$$

Hence we get,

$$q = \frac{323 - 301}{\frac{0.002}{225 \times 0.000760} + \frac{0.0127}{0.03 \times 0.004387} + \frac{0.0015}{33 \times 0.0005715}}$$

Thus,

$$q = 0.22777 \text{ W/m}^2$$

Heat flow from inside to outside of box i.e. heat loss is less. Hence dimensions are preferable.

**VII. COMPONENTS OF THE PROJECT**

**1. Reheating Box:**

Reheating box is basically a double walled container which has Glass Wool as an insulating material in between the walls. The Reheating box is made up of mild steel. It is divided into two sections from inside from which one is where food is kept and other consists of winding of copper coils. Size of the heating box is  $18 \times 18 \times 15$  inch. It is a two-walled structure with glass wool embedded in between to provide better insulation. Copper coils are at the bottom side of the heating box through which actual heating takes place. An outlet port is provided at one end of the box such that exhaust gas will be released in the surrounding. TIG welding is used to join the mild steel plates to form a heating box.

Specifications of Reheating Box:

- i. Length= 0.4572m
- ii. Width= 0.4572m
- iii. Height= 0.381m
- iv. Thickness of Mild Steel Plate= 0.015m
- v. Thickness of Aluminium Sheet= 0.02m
- vi. Thickness of Glass wool used= 0.0127m

## 2. Copper Tube:

Copper tube is used due to its excellent heat conductivity and high machinability. It also has high corrosion resistance which increases its working life. Copper tube of 8mm diameter is used to carry exhaust gas of the vehicle. This copper tube is fitted to the exhaust manifold by using CO<sub>2</sub> welding which is the most convenient welding for these two types of materials. Then this copper tube travels to the top box and it's wound in the spherical structure inside the heating box. Copper tube which is connected to the exhaust manifold is insulated with the help of Plaster of Paris which acts as a great insulator. Cutting and bending are the two processes done on the copper tube to get them in the desired shape and size.

Specification of Copper Tube:

- i. Diameter of Copper Tube= 0.008m
- ii. Length of Copper Tube= 6m

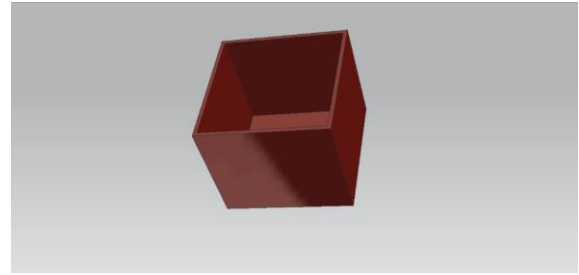
## 3. Box Frame:

Frame of the heat box is made up of Mild Steel due to its high machinability. A frame is made to carry the heat box over it. TIG welding is used to make the frame. Also drilling has been done to make the places for the bolts so that the frame can be easily fitted on the carriage of the motorcycle. Heat box frame is made in such a way that it should be convenient to mount or remove the frame.

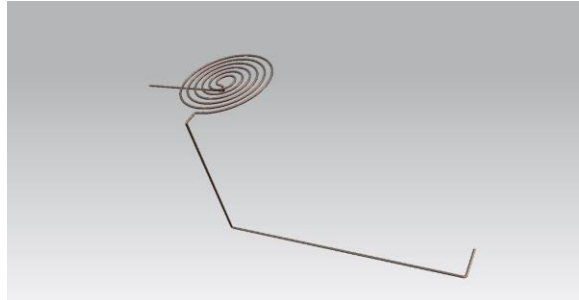
Specifications of Box Frame:

- i. Length= 0.47m
- ii. Width= 0.47m
- iii. Height= 0.0203m

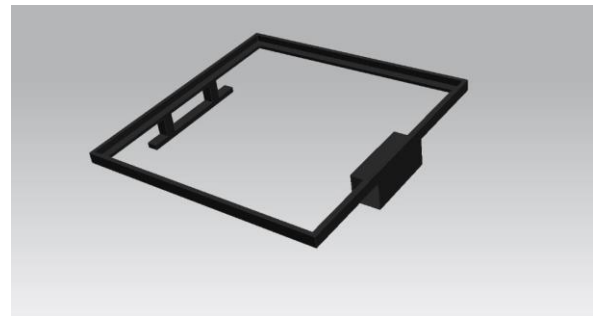
## VIII. CAD MODELS



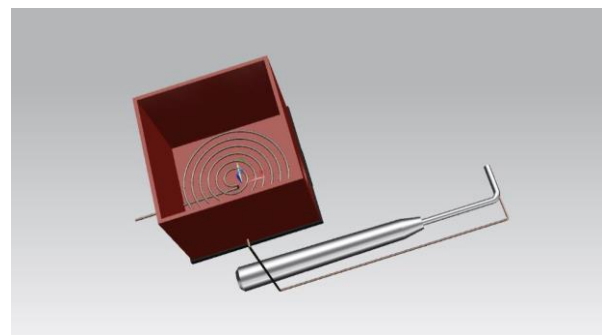
**Fig.3: Reheating Box**



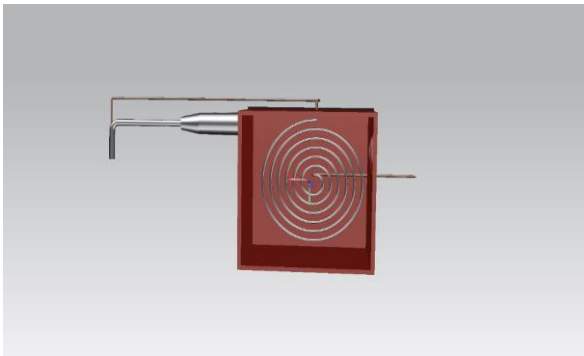
**Fig.4: Copper Tube**



**Fig.5: Box Frame**



**Fig.6: Assembly Auxiliary View**



**Fig.7: Assembly Top View**

## IX. RESULT

In this project the testing is done by keeping a vessel full of water inside the Reheating Box. The vessel contains water having initially room temperature. After keeping water vessel inside the box, the motorcycle engine is started. Then the engine was kept idle for some time. After some period of running at idle, the temperature of the water inside the box was measured with the help of a digital thermometer. Then the reheating box is allowed to cool till it reaches the ambient temperature of the surrounding. This process is then repeated for three times to get accurate readings of the temperature output.

Obtained Result:

### Test 1:

Initial Temperature of water: 25°C

Time for which test has been conducted: 10 min

Final Temperature of water: 39°C

### Test 2:

Initial Temperature of water: 25°C test has been conducted: 10 min

Final Temperature of water: 42°C

### Test 3:

Initial Temperature of water: 25°C

Time for which test has been conducted: 10 min

Final Temperature of water: 41°C

## X. CONCLUSION

The waste heat from engine is converted into various useful forms. Several accessories are being invented every day. Thus, the Reheating box that we have experimented can become a useful accessory in motorcycle. This can be a

revolutionary change in the food delivery systems as it will allow them to deliver food at longer distances without any use of the external energy source. Also exhaust gas will be used as a heating medium so energy which is going to be waste will be utilized. Our project can be summarized as follows:

1. Useful accessory in vehicles.
2. User friendly accessory.
3. No external power supplies.
4. Food delivery for longer distances.
5. Portable kit.
6. Easy mounting and dismounting.

At this stage, we can state that we have obtained a positive output. We have succeeded in getting some amount of exhaust gas to be circulated from the bypass circuit and were able to get a temperature higher than the surrounding in the Reheating box so that temperature of the food can be maintained at some level.

This project can be used by the food delivery chains for long distance delivery. This can be installed in the motorcycle simply.

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