International Journal of Engineering Research and Advanced Technology (IJERAT)

DOI: http://dx.doi.org/10.7324/IJERAT.2018.3229

E-ISSN : 2454-6135

Volume.4, Issue 4

April -2018

Design and Development of Portable Domestic Waste Burner

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ABSTRACT

Waste generation is a continuously growing problem at Global regional local levels. Improper disposal of various ways pollutes all the vital components of living environment. If proper collection of waste from authorities and disposal of waste is not carried properly, then the environmental and health issue will arise. The present work is made to fabricate a domestic purpose portable waste burner. The fabrication of incinerator Chamber different stages provided for wet and dry waste separately. To control various health hazard, contain during burning and flue gases, a Purolator filter is introduced, Further, a concept of Thermoelectric Generator (TEG) is placed in the inner chamber of the burner and 130^{0}C heat is converted into power of 5 to 8 volts. The performance test was carried out after the fabrication. 8kg of waste was burnt in the chamber and the time duration to burn is 25 minutes. The flue gases have passed through the filter and exhausted through the chimney. The burner was successfully burnt the waste with less time. Thermal analysis for the incinerator chamber was carried out analytically, numerically by using ANSYS and results are found to be validated with experimental values.

Keywords: *Waste, Iincinerator, Thermo Electric Generator (TEG), Burner.*

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1. INTRODUCTION

Fabrication of the incinerator chamber of different stages will be adopted for wet and dry waste separately. Incineration of waste material converts waste materials into ash, flue gases and heat [3]. When waste burns, different flue gases will generate which may contain some environmental and health hazards contents, which cause diseases and global warming. The flue gases must be cleaned of gaseous and particulate pollutant before they are dispersed into the atmosphere. To control various health hazard contents during burning and flue gases, an air bag filter will be introduced [6]. Further, a concept of Thermoelectric Generator (TEG) will be introduced in the burner to utilize the generated heat during waste combustion in the present work [7]. Some amount of heat generated by the burner or incinerator can be used to generate electric power with the help of the Thermoelectric Generator [4].

2. PROBLEM DEFINITION

As we all know that, Waste has become a major problem in Indian cities, which leads to many health issues and environmental issues like surface water contamination, soil contamination, pollution and leachate.

So, by considering all these issues, we came up with an idea which can reduce these problems by burning the waste in the incinerator and the exhaust gas produced will be filtered by adopting the filter and reduces the pollution. The blower is used for the complete combustion process. While burning the waste the heat produced, from that heat the electric power will be generated by installing Thermo Electric Generator.

3. OBJECTIVES OF THE STUDY

The main objective of the study is to burn the unwanted and environmental waste in the incinerator chamber and the flue gases produced will be filtered by using an air bag filter. The heat produced during the burning of waste is used to convert it into electrical energy with the help of Thermo Electric Generator (TEG).

Figure 1: Collection and Disposal of waste

People are busy in day to day life so they do not care of the waste. They dispose the waste everywhere. Each household waits for the garbage boy with two or three bags of trash, if he does not turn up the garbage becomes too much to store in the house [2]. To reduce to this problem an attempt is made to fabricate a "Domestic purpose Portable Waste Burner".

4. METHODOLOGY

Literature Review has been carried out by referring some of the journals related to solid waste management [1], Incinerator, Thermoelectric Generator and the Filter.

The conceptual and structural design of the Portable Domestic Waste Burner. Material selection and used for the fabrication of the model. Calculation of stresses and temperature distribution fulfilled and Step by step fabrication process of the model and type of materials used for the fabrication.

4.1 Working principle of the Portable Domestic Waste Burner

The basic components include Incinerator, Thermoelectric Generator and Filter, where the incinerator is used for burning the waste, TEG is used to convert the thermal energy into electrical energy and the filter is used to clean the dust particles from the exhaust gas and passes it to the atmosphere.

Thermal analysis of the incinerator chamber, how the temperature stresses are distributed in the incinerator chamber due to change in temperature is shown. The performance was conducted for the burner by burning 8kg of dry and solid wet waste and the results such as temperatures, time taken to burn the waste, and power generation are tabulated.

5. MATERIAL SELECTION

The waste burner is proposed to burn both dry and wet waste. The burner should be of a closed vessel and combustion has to take place within the chamber. The materials carefully chosen for different components and the material chosen for the implementation and fabricate is a mild steel, the properties for mild steel are given in the table 1.

Table 1: Selection of materials

COMPONENTS	MATERIAL	E(MPa)	FOS	α in / ℃
Barrel	Mild Steel	248	2.5	12×10^{-6}
Mesh	Mild Steel	248	2.5	12×10^{-6}

5.1 Dimensions

The main dimensions of the Burner are given below.

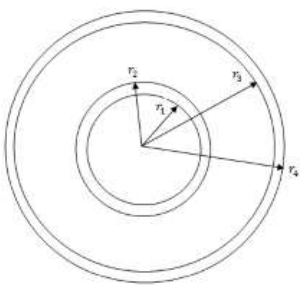
Diameter of outer barrel = 60 cm

Diameter of inner barrel = 39.5 cm

Height of the outer barrel = 86.5 cm

Height of the inner barrel = 79 cm

Thickness of the barrel = 4 mm



Length of the opening from top = 38 cm

Load or weight of the waste = 8 kg

For the capacity of the 8kg waste a barrel is suitable for incineration is selected.

6. CONCEPTUAL AND STRUCTURAL DESIGN

The conceptual model has designed and a CAED model was drawn using CATIA tool. Figure 2, shows that the drawing of the proposed model.

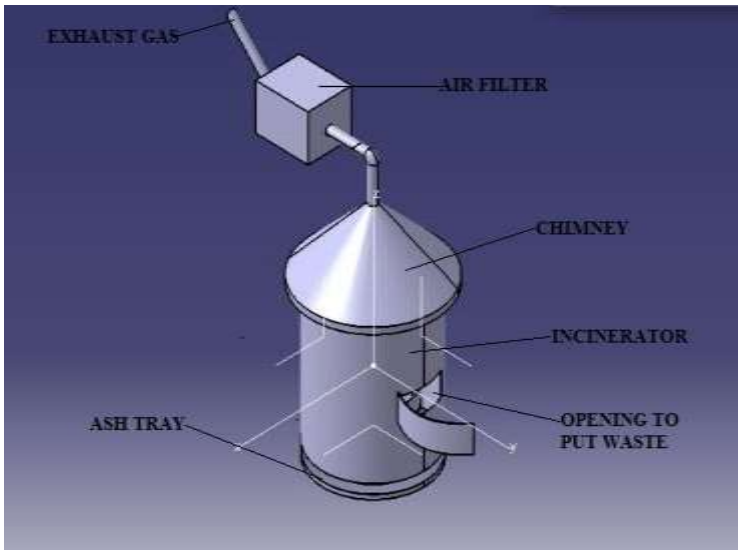


Figure 2: CAD model of Burner

The temperature is the major concern while combustion. The maximum temperature expected, while burning the proposed 8kg of waste is around 200℃. The materials are selected based on to withstand the required temperature of combustion and the capacity.

The thermal stress is given by,

$$\sigma_{th} = E\alpha t$$

$$\sigma_{th} = 206 \times 10^3 \times 12 \times 10^{-6} \times (250 - 220)$$

$$\sigma_{th} = 74.16\ Mpa$$

$$\sigma_{all} > \sigma_{th}$$

For the safe design, thermal stress should be less than allowable stress. Therefore, the design is safe.

Thermal expansion is given by,

$\Delta = \propto tl$ Where, Δ = change in length of the material due to changes in temperature.

$$\Delta = 12 \times 10^{-6} \times (250 - 220) \times 30 \times 2.54 \times 10$$

$$\Delta = 0.28 \text{ mm}$$

Heat transfer through complete wall from inner radius r_1 to outer radius r_4 ,

Inner surface of the inner barrel, r_1 = 193.5 mm

Outer surface of the inner barrel, r_2 = 197.5 mm

Inner surface of the outer barrel, r_3 = 297 mm

Outer surface of the outer barrel, r_4 = 300 mm

Length, L = 86.5 cm = 0.865 m

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Thermal conductivity, K_1 = 52 $\frac{w}{mk}$, K_2 = 0.036 $\frac{w}{mk}$

Heat transfer is given by

$$Q = \frac{T_1 - T_\infty}{\frac{1}{2\pi L}\left[\frac{1}{h_1 r_1} + \frac{\ln\left(\frac{r_2}{r_1}\right)}{k_1} + \frac{\ln\left(\frac{r_3}{r_2}\right)}{k_2} + \frac{\ln\left(\frac{r_4}{r_3}\right)}{k_3} + \frac{1}{h_0 r_4}\right]}$$

$$= \frac{200 - 28}{\frac{1}{2\pi \times 0.865}\left[\frac{1}{20 \times 0.193} + \frac{\ln\left(\frac{0.1975}{0.1935}\right)}{52} + \frac{\ln\left(\frac{0.297}{0.1975}\right)}{0.036} + \frac{\ln\left(\frac{0.3}{0.297}\right)}{52} + \frac{1}{7 \times 0.3}\right]}$$

Q = 77.4 W

To find temperature T_2 is given by, $q = \frac{T_1 - T_2}{\frac{1}{2\pi L}\left[\frac{1}{h_1 r_1} + \frac{\ln\left(\frac{r_2}{r_1}\right)}{k_1}\right]}$

T_2= 196.3℃ Similarly, T_3 = 30.55℃ T_4 = 30.5 ? ℃

7. ANALYSIS OF INCINERATOR CHAMBER

The thermal analysis of incinerator chamber is done by using ANSYS tools. The analysis is as shown in the following Figure 3 and 4. Total Number of Nodes created 200802 and number of created Elements 28525 in meshing.

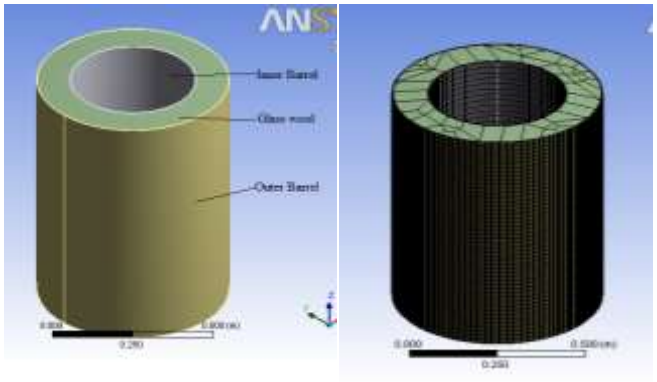

Figure 3: CAD model and Mesh model of incinerator chamber

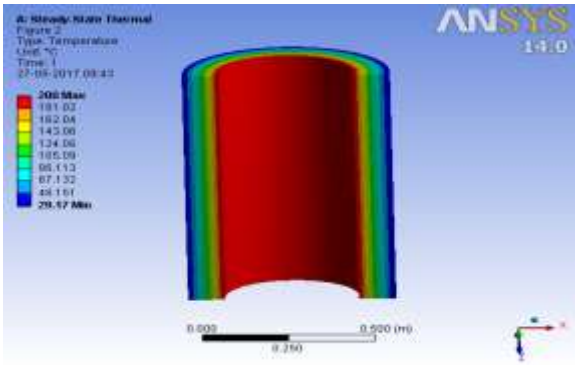

Figure 4: Temperature distribute on through chamber

The maximum heat transfer (Q) through the incinerator chamber is 88.995 W/m^2 and the minimum heat transfer(Q) through the chamber is 38.408 W/m^2. The analysis shows the maximum temperature generated in the inner chamber of incinerator is 200℃ and the minimum temperature of 30℃ (room temperature). The half section view of temperature distribution through the chamber wall is shown in above figure.

7.1 Thermoelectric Generator performance test

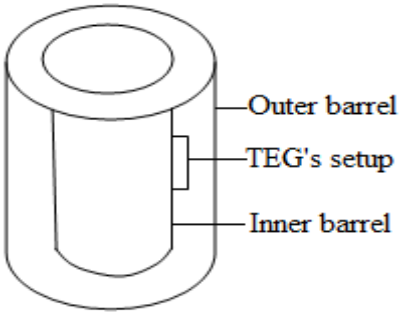

Figure 5: TEG's placement

Three tests were conducted for dry waste and three tests were conducted for wet solid waste. In three trials the temperature in the internal drum, time duration is taken to burn the waste and the power generated through TEG.

Also, three trials were conducted for the wet solid waste. The test results were tabulated as below,

Table 2: Results of dry waste

Trial	Waste (in kg)	Temperature (in degrees)	Time taken to burn the waste (in minutes)	Power generated (in volts)
1	8	206	30	11.9
2	8	188	20	9.3
3	8	210	27	11.96

Table 3: Results of solid wet waste

Trial	Waste (in kg)	Temperature (in degrees)	Time to burn the waste (in min)	Power (in volts)
1	8	183	40	9.4
2	8	180	35	9.1
3	8	190	37	9.5

The performance was conducted for the burner by burning 8kg of dry and solid wet waste and the results such as temperatures, and power generation are tabulated.

Table 4: Power generation of different temperatures

Trials	Temperature (℃)	Volts
1	50	2.88
2	100	5.5
3	150	8.6
4	200	11.7

8. CONCLUSION

The waste burner fabricated successfully for the capacity of 8 kg. The burner has two chambers inner and outer chambers. Outer chamber works as the body and the inner chamber as a burner. The gap on the inner and outer chamber is filled with glass wool through which the heat is restricted to transfer to the outer surface. The waste can be fed from the top of the burner. The filter is adopted and the flue gases pass through the filter and it filters these gasses. TEG is used for converting heat to electricity and 5 to 8 volts of the current is generated by 150℃. TEG which is an outstanding work and show 2.88 volts for the 50^0C and 11.7 volts for 200^0C. The thermal analysis result in maximum heat transfer (Q) through the incinerator chamber is 88.995 W/m^2 and the minimum heat transfer(Q) through the chamber is 38.408 W/m^2.

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