Exploration of Properties of Meat Waste Incinerated Fly ash / Cement / Sand Dust associated Fly ash Bricks

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Abstract. In this modern technology the generation of meat waste causes the considerable impact to the environment and it creates higher level of air pollution, water pollution and land pollution. These pollution causes ill effects to human beings and other living organisms by the creation of harmful micro-organisms which accounts to spreading of diseases. In order to addressing this issue and to utilize the waste as the part of waste management. The meat waste that are incinerated in the specially designed incinerator which does not create any pollution. The fly ash obtained from the incineration of meat waste was incorporated in the manufacturing of fly ash bricks along with the fly ash obtained from the thermal power plant and these mixture are mixed with the sand / stone dust by using cement as the binding agent. Under various proportions the brick was manufactured according to the NTPC guidelines for manufacturing Quality fly ash bricks. After manufacturing the bricks, Brick’s property such as Compression strength test, Water absorption test and the Efflorescence property test were conducted in order to identify the best sample out of all manufactured fly ash brick samples. On manufacturing these types of bricks the environmental caused by the meat waste was reduced drastically.

Keywords – Incineration, Meat waste, NTPC, Compression, Efflorescence, Water absorption.

1. Introduction

In the present system the incinerators that are handling the wastes are burnt inside the setup but through the exhaust manifold, the burnt gases travels are set free and released to the atmosphere. Because of that the harmful exhaust gases contains NOx, SOx, CO2, CO etc. are released to the surrounding atmosphere and thus creates the environmental pollution. This research primarily focus to reduce the environmental air pollution by treating the exhaust gases as harm free by sending the burnt gases through the smoke collector and particle collector setup and the remaining carbon content gases are made to pass through the tank that contains some amount of water for absorbing the gases. The remaining meat waste burnt fly ash was collected in the incinerator vessel itself and that can be used for manufacturing fly ash bricks under various proportions.
Pooja G. Nidoni “Incineration process for solid waste management and effective utilization of byproducts” - MSWI (Municipal Solid Waste incineration) was heat treated and the by-products obtained was incorporated to the plant growth was suggested in an Eco friendly manner with Air pollution control devices. [1]

Ankur tayal et al “Compressive Strength of Fly Ash Bricks” - Here the Fly ash imposed bricks are manufactured and also stated that the fly ash that are used in manufacturing of bricks has the great deal with that of mixing with the concrete, this literature also states the compression strength of various proportions of fly ash bricks. [2]

A. Sumathi et al “Compressive Strength of Fly Ash Brick with Addition of Lime, Gypsum and Quarry Dust” From this literature the compression strength of fly ash brick with addition of lime, gypsum and quarry dust. Here the authors made the fly ash bricks at various proportions and the test was taken.[3]

Tabin Rushad S et al “Experimental Studies on Lime – soil Fly ash Bricks” From this Literature It is Known that MDD – Maximum Dry Density then the standards and densitity of soil, Fly ash are understood then the manufacturing Methodology of Flyash Bricks and the test to be taken are understood.[4]

2. Design Modelling of the Incinerator
The 3D Model of incinerator was drawn using Solid works software by considering all the parameters. The Isometric view of the incinerator and the cut section view of the incinerator was shown in the figure 2. Here the meat waste placed on the arrangement as shown in the cut sectional view and subjected to burn. The meat waste on burning, leaves the gases outside with the help of exhaust gases arrangements and it is collected on the water tank arrangement through the exhaust manifold. So no gases are released outside. The harmful gas particles are stick on the particle collector arrangement. So that design confirms the minimised pollution. The prototype was made of mild steel materials.

The electrical connections are done separately for two exhaust fans, Electric heating coil arrangements.

Figure 1. Research Flow
3. ANSYS Modelling

The ANSYS modelling of incinerator was done for understanding the gas flow path, temperature, velocity analysis. The results shows the maximised value that are within the permissible limits and in the accepted criteria.

There was no pressure build up inside the incinerator vessel because the burnt gases are released to the surroundings and made to settle on the water tank which was set open to atmosphere. The heavier force from the exhaust fans in the pipeline made the burnt carbon content gases to dissolve in the water, only the remaining gases are send outside which were harmless gases. This ensures that there were no pressure build up in the vessels.

The gas flow path analysis indicates the flow of gases inside the incinerator and also it describes the behaviours of fluids on reaching the pipe and exhaust fans. The fluids (burnt gases) on reaching the narrow area, the velocity increases to a greater value. This was the observation from the above mentioned analysis.
The velocity analysis indicates the velocity at which the burnt gases are travelled inside the vessel. Here the velocity is low (8 m/s) in the area of water tank and also in the meat waste placing zone and the velocity is higher (32 m/s) in the area where the fluids reaches the plates.

The temperature analysis indicates the temperature level of the incinerator while burning, the temperature is of minimised level at the water tank arrangements (368 K) and the temperature is of medium level in the incinerator meat waste placing zone (506 K) and the temperature is of higher (570 K) on the place where the fluids passes the exhaust fan setup.
4. Experimental Setup

The entire experimental setup consists of Electric heater, smoke and particle collector setup, Exhaust fans and the ash depositing tank. The meat waste was dried and incinerated by using the prototype as shown above. The entire prototype is manufactured by using Mild Steel material.

5. Fabrication of Fly ash Bricks

Using the Fly ash obtained by above method. The meat waste incinerated fly ash and the fly ash obtained from the thermal power plant whose density \[4\] is of 800 kg/m\(^3\) are mixed with proportion of (25:75). Then the sand dust with the density \[5\] of 1788.07 kg/m\(^3\) and the cement with the density \[6\] of 1500 kg/m\(^3\) are mixed. The material requirement for the manufacturing of fly ash was calculated as follows.

5.1 Material Allocation

\[
\text{Weight of the brick Mixture} = L \times B \times H \times [\{\text{Percentage of Fly ash x Density of Fly ash}\} + \{\text{Percentage of Sand x Density of Sand}\} + \{\text{Percentage of Cement x Density of Cement}\}]
\]

(L, B, H are the Mould Specifications in m)

Bricks with Five samples of different proportions are made. The proportions allocation is given as follows. Proportion (a: b: c) indicates (Fly ash %: sand dust %: Cement %).

The proportions are made under the guidelines of NTPC guide for manufacturing quality Fly ash bricks.
Table 1. Samples and Proportions

| Sample | Proportion (a:b:c) |
|--------|-------------------|
| 1      | (50:40:10)        |
| 2      | (52:38:10)        |
| 3      | (54:36:10)        |
| 4      | (56:34:10)        |
| 5      | (58:32:10)        |

The material allocation is done by the following relations. The model calculation for sample 1 proportion is given as follows.

5.2 Weight of the brick Mixture

\[
\text{Weight of the brick Mixture} = 0.23 \times 0.1 \times 0.09 \times \left[ 0.5 \times 800 + (0.4 \times 1788.07) + (0.1 \times 1500) \right] \\
= 0.00207 \times [400 + 715.228 + 150] \\
= 2.618 \text{ kg}
\]

Similarly, for the samples 2,3,4,5 the material allocation was done and it is tabulated as follows.

Table 2. Table for Material Allocation

| Sample | Proportion (a:b:c) | Weight of Fly ash (kg) | Weight of Sand / Stone Dust (kg) | Weight of Cement (kg) | Total Material Weight (kg) |
|--------|--------------------|------------------------|----------------------------------|-----------------------|-----------------------------|
| 1      | (50:40:10)         | 1.309                  | 1.047                            | 0.261                 | 2.618                       |
| 2      | (52:38:10)         | 1.340                  | 0.979                            | 0.257                 | 2.577                       |
| 3      | (54:36:10)         | 1.377                  | 0.918                            | 0.255                 | 2.551                       |
| 4      | (56:34:10)         | 1.397                  | 0.848                            | 0.249                 | 2.496                       |
| 5      | (58:32:10)         | 1.423                  | 0.785                            | 0.245                 | 2.455                       |

Total Material Weight (kg) = 6.846 + 4.577 + 1.267 = 12.689 kg

Total Material Weight for Making 4 Bricks in each Sample in (kg) = 27.384 + 18.308 + 5.068 = 50.758 kg

5.3 Manufacturing of Fly ash Bricks

The Fly ash bricks are manufactured by mixing three products under 5 different proportions with the favour of brick mould. The bricks that are manufactured that are air cured and then water cured and subjected to test conditions.
6. Experimental Results
For the above brick samples made under various proportions, Water Absorption, Compression Strength and the Efflorescence test were done. The results of such tests are discussed as follows.

6.1 Water Absorption Test
For all the samples the water absorption test was conducted as per NTPC Guidelines and also as per IS 3495 (Part 2): 1976[7]. The brick was soaked in the cold water for 24 hours and the water absorption rate must not be greater than 20%.

\[
\text{Water Absorption Test (\%) = } \left( \frac{W_2 - W_1}{W_1} \right) \times 100
\]

Where \( W_1 \) and \( W_2 \) are the initial and final Weight of the brick samples in kg.

| Sample | Proportion (a:b:c) | \( W_1 \) (kg) | \( W_2 \) (kg) | \( W_2 - W_1 \) (kg) | \( \frac{W_2 - W_1}{W_1} \) | \( \left( \frac{W_2 - W_1}{W_1} \right) \times 100 \) |
|--------|-------------------|----------------|----------------|---------------------|----------------|---------------------------------|
| 1      | (50:40:10)        | 3.290          | 3.481          | 0.191               | 0.05805        | 5.805                           |
| 2      | (52:38:10)        | 3.281          | 3.486          | 0.205               | 0.06248        | 6.248                           |
| 3      | (54:36:10)        | 3.303          | 3.511          | 0.208               | 0.06297        | 6.297                           |
| 4      | (56:34:10)        | 3.284          | 3.494          | 0.213               | 0.06394        | 6.394                           |
| 5      | (58:32:10)        | 3.279          | 4.484          | 0.208               | 0.06251        | 6.251                           |

Water absorption test was conducted for samples of all the Proportions. All the samples are within the limit as stated in NTPC Guide lines for manufacturing quality fly ash bricks.
From table it was observed that the “Greater the Sand dust proportion will increase the weight of the bricks”. Out of these samples, Sample 1 can be used for the construction of water tank applications and other similar applications.

![Figure 8. Plot of Water Absorption Test](image)

**Figure 8.** Plot of Water Absorption Test

### 6.2 Compression Strength Test

For all the samples the Compression Strength test was conducted as per NTPC Guidelines and also as per IS 3495 (Part 1): 1976[8]. The brick was subjected to Compression Strength Test and whose value shall not be less than 7.5 N/sq.mm.

Area of the Bed = Length x Height of the brick

**Table 4.** Compression Strength Test Observation

| Sample | Proportion (a:b:c) | Dimensions | Area of the bed (mm²) | Maximum Load at Failure (KN) | Compression Strength (N/mm²) | (kg/cm²) |
|--------|--------------------|------------|-----------------------|-----------------------------|-------------------------------|----------|
| 1      | (50:40:10)         | 230        | 100                   | 90                          | 20700                         | 263.87   | 12.748 | 130 |
| 2      | (52:38:10)         | 230        | 100                   | 90                          | 20700                         | 253.74   | 12.258 | 125 |
| 3      | (54:36:10)         | 230        | 100                   | 90                          | 20700                         | 223.29   | 10.787 | 110 |
| 4      | (56:34:10)         | 230        | 100                   | 90                          | 20700                         | 202.98   | 9.806  | 100 |
| 5      | (58:32:10)         | 230        | 100                   | 90                          | 20700                         | 172.14   | 8.316  | 85  |
Compression Strength test was conducted for samples of all the Proportions. All the samples are within the limit as stated in NTPC Guide lines for manufacturing quality fly ash bricks[9].

From chart, it was observed “Greater the Fly ash content reduces the compression strength of the bricks”. Out of these samples, Sample 1 can be used for the construction of Tall Rise Buildings.

6.3 Efflorescence Test
For all the samples the Efflorescence test was conducted as per NTPC guidelines and also as per IS 3495 (Part 3) : 1976[9]. As per the standards the Effloescence rate shall not be more than that of Moderate.

Here none of the samples shows the white salty deposits on the bricks or the Efflorescence rate. All the samples are within the limit as stated by the Indian standard.

Table 5. Efflorescence Property Observation

| Sample | Proportion (a:b:c) | Efflorescence Rating |
|--------|--------------------|---------------------|
| 1      | (50:40:10)         | Nil                 |
| 2      | (52:38:10)         | Nil                 |
| 3      | (54:36:10)         | Nil                 |
| 4      | (56:34:10)         | Nil                 |
| 5      | (58:32:10)         | Nil                 |

Efflorescence test was conducted for samples of all the Proportions. All the samples shows no efflorescense i.e., there is no white / salt deposit on the bricks. So that the bricks conforms the NTPC guidelines for quality bricks.

All these samples can be used for construction purposes.
7. Results and Discussion

From the design modelling, none of the gases were settled inside the vessel because of the implementation of Exhaust fan for forcing the gases outside the vessel and the good quantity of Fly ash was collected from the vessel and it was utilized for the useful application of making fly ash.

From the ANSYS modelling of incinerator it was understood the gas flow path analysis, the way by which the fluid behaves within the vessel was understood by means of animated model.

The velocity of the Fluid path was understood by means of analysis model for velocity it was understood there was no sudden hitting or velocity drop within the incinerator here the maximum velocity reaches to 32m/s by providing the inlet velocity to a minimal value.

The temperature withstanding capacity of incinerator while burning the meat waste the temperature that was raised to the maximum of 570 K. Entire incinerator setup was manufactured by means of Mild Steel material which has the melting point around (1535 K).

As per the Experimental results obtaine by the above conducted tests, the Efflorescence property of the fly ash bricks was found good and all samples shows the same results. Then the compression strength and the water absorption test was analyzed and out of all the samples best sample was chosen as per analyses done below.

Water absorption strength need to be as low as possible for a quality Fly ash brick and the compression strength needs to be as high as possible for the construction of buildings.

**Table 6.** Final results of all the Observations

| Sample | Proportion (a:b:c) | Efflorescence Rating | Compression Strength (N/mm²) | Water Absorption Rate (%) |
|--------|-------------------|----------------------|------------------------------|---------------------------|
| 1      | (50:40:10)        | Nil                  | 12.748                       | 5.805                     |
| 2      | (52:38:10)        | Nil                  | 12.258                       | 6.248                     |
| 3      | (54:36:10)        | Nil                  | 10.787                       | 6.297                     |
| 4      | (56:34:10)        | Nil                  | 9.806                        | 6.394                     |
| 5      | (58:32:10)        | Nil                  | 8.316                        | 6.251                     |

Thus the research work concludes from graph. It was observed that the Sample 1 which holds the property of having “High Compression Strength and Low Water absorption Rate”. So out of all the samples on analysis basis Sample 1 with the proportion of (50:40:10) – (Fly ash: Sand / Stone Dust / Cement) was the best proportion of all the samples that were manufactured.

![Figure 10. Plot of Compression Strength vs Water Absorption](image)
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