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Waste Management on the Campus with an Incinerator with Heat Recovery System

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ABSTRACT: In normal incineration process the solid waste fed into the incinerator undergoes combustion to form hot flue gases which will be given out through exhaust and by product produced in form of ash. Whereas here in the proposed model the normal incinerator is modified such that the heat energy liberated during burning of waste is converted in a useful manner such that heat liberated can be used for making hot water used in other applications including domestic hot water application for cooking etc. This waste to energy technology is a sustainable system in which incinerator design is modified to extract the heat energy developed. This system mainly composed of a copper tube winding placed inside the incinerator combustion chamber.

KEYWORDS: Energy recovery, Solid waste, Incinerator, Copper tube windings

I. INTRODUCTION

Solid Waste is one of the major concerns nowadays. Solid waste including plastic, paper etc is the most common among them their disposal as well as management should be done in proper way. Improper disposal of municipal solid waste can create unsanitary conditions, and these conditions in turn can lead to pollution of the environment and to outbreaks of vector-borne disease—that is, diseases spread by rodents and insects. The tasks of solid-waste management present complex technical challenges. They also pose a wide variety of administrative, economic, and social problems that must be managed and solved. Waste dumping create landfills as well as soil pollution whereas burning of solid waste can lead to emission of harmful greenhouse gases which will adversely affect the ecosystem. Most common and effective approach for solid waste disposal is incineration. Incineration is the burning of waste in a specially designed combustion chamber. The idea of burning garbage is not new, but with the increase in knowledge about toxic chemicals known to be released during burning, and with the increase in the amount of garbage to be burned, incineration now is done under controlled conditions. It has become the method of choice of many waste management companies and municipalities. There are several types of combustion facilities in operation. At incinerators, mixed trash goes in one end unsorted, and it is all burned together. The resulting ash is typically placed in a landfill. At mass burn incinerators, also known as mass burn combustors, the heat generated from the burning material is turned into useable electricity. Mixed garbage burns in a special chamber where temperatures reach at least 2000°F (1093 °C). The by-products' are ash, which is land filled, and combustion gases. As the hot gases rise from the burning waste, they heat water held in special tubes around the combustion chamber. The boiling water generates steam and/or electricity. The gases are filtered for contaminants before being released into the air Populace. Modular combustion systems typically have two combustion chambers: one to burn mixed trash and another to heat gases. Energy is recovered with a heat recovery steam generator. Refuse-derived fuel combustors burn pre-sorted waste and convert the resulting heat into energy. Commonly used types of incinerators are rotary kilns, fluidised beds, and liquid injections due to their applicability to large-scale use and their versatility. Another feature common to all three incinerators (rotary kilns, fluidised beds, and liquid infusions) is that they can all operate in pyrolysis or anaerobic mode. The basic design consists of two thermal treatment chambers: a primary chamber that is slightly slanted and into which waste is fed (along with hot exhaust air containing oxygen), rotated, and thermally decomposed by heat radiation from the secondary chamber; and a re-combustion chamber that is located at the back of the kiln and into which the decomposition air and the remaining waste is completely burned with the supply of secondary air.

II. PROBLEM STATEMENT

Solid waste including paper, plastic, wood etc is one of the main concerns in our daily life. Proper disposal of waste and its treatment usually requires more time, space and money. In usual practice of open burning of waste can lead to many environmental problems including breathing issues for human beings. Those problems can be addressed by adopting technique of burning waste using incinerator and the heat energy liberated during the incineration process have to be converted in a useful manner.

III. METHODOLOGY

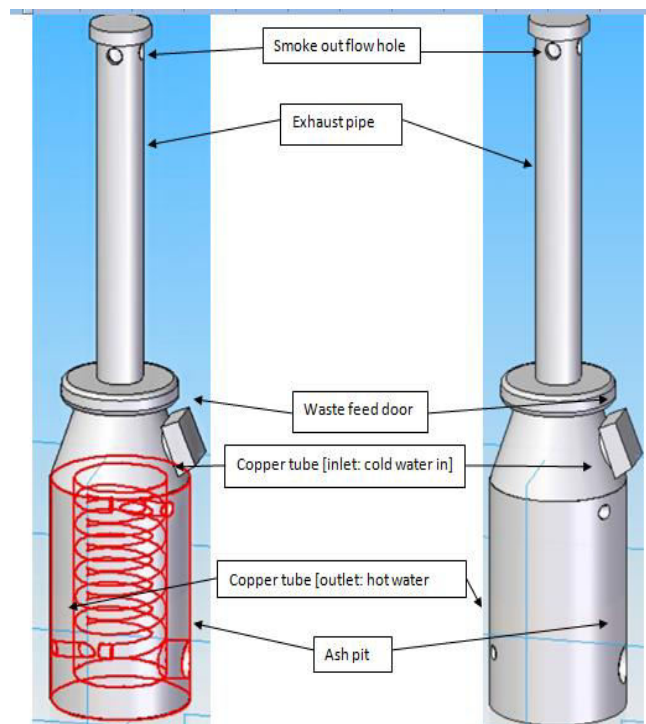


Figure1:3d model of the proposed design of incinerator.

Body of incinerator: Here we have used galvanized steel sheet of 0.6mm thick 360mm long for the body of incinerator. Steel sheet is rolled to make cylindrical body.

Ash tray: it composed of a mesh in order to collect ash produced by burning of solid waste in the incinerator

Copper tube: copper tube of outer diameter 15mm is wound into coil of height 30 cm. it consist of an outlet port and inlet port placed inside the main body of incinerator.

Stainless steel tube: steel tubes of rectangular cross section 2”-3” are used to make stand for the incinerator. Steel tubes 4 in number are used here.

Chimney: Exhaust pipe or chimney made up of steel pipe of about 2m is connected to the top of incinerator body.

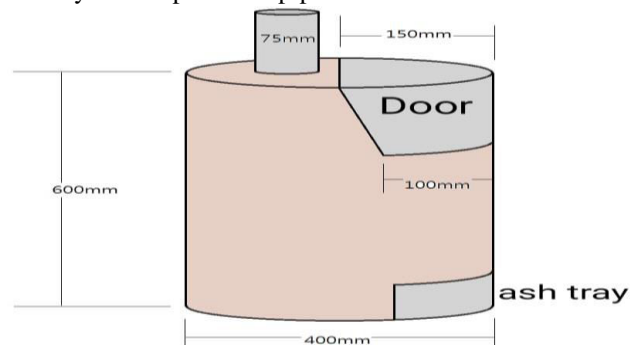


Figure2: Model of incinerator with dimensions



WORKING OF THE SYSTEM

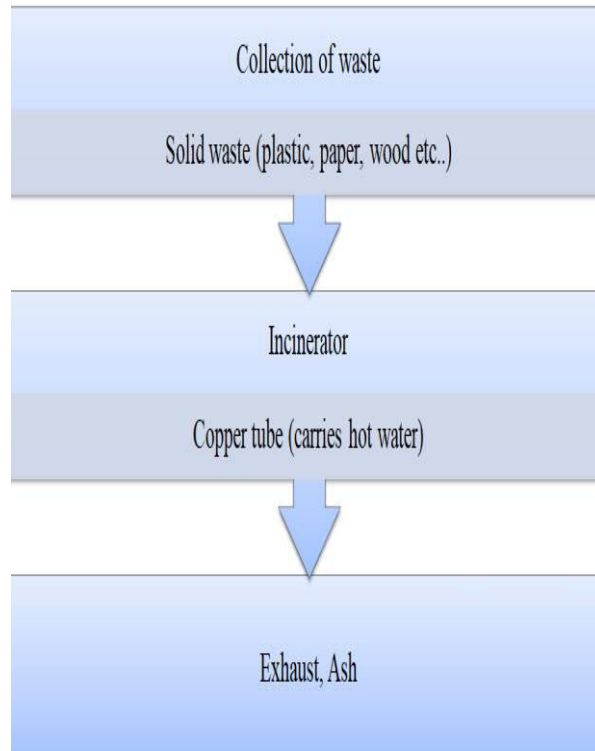


Figure3: Flow diagram showing working of the system

Solid waste composed of paper, wood, plastic, sanitary napkin etc collected is fed into the incinerator through waste feed door. Incinerator body composed of wounded copper tubes carrying water inside it. On burning the waste heat liberated is absorbed by the copper tubes in turn heats the water, can be used for hot water applications. Ash produced by burning can be used for agriculture, for making bricks in construction industry, to make ink using suitable solvent.



Figure4: completed model of the incinerator



FIELD STUDY AND VALIDATION

From the experimentations conducted in college hostel which will develop an amount of solid waste ranges from 10-15 kg. Waste composed of mixture of several components such as plastic, paper, wood etc. Waste can be incinerated without the need of additional fuel when it has a calorific value of 14.4 MJ/kg or higher. The challenge lies in calculation of calorific value of waste since different materials have different calorific values. Pvc plastic has a value of 41MJ/kg whereas paper has only 13.5MJ/kg. Since the waste fed here is mixture of several components we have to work out on the composition of those wastes. Generally speaking mixed domestic waste will have a calorific value of between 7 and 16MJ/kg.

Waste type	Calorific value	
	(MJ/kg)	(kcal/kg)
Medical waste	18-25	4530-5745
Domestic waste(un-processed)	7-16	1663-3813
Domestic waste(recycled)	10-14	2379-3335
Plastic(pvc)	41	9787
Wood	14,4	3431
Paper	13,5	3216

Table1: Type of wastes and respective calorific values

MOISTURE CONTENT OF WASTE

It's important to know the amount of moisture in your waste, as this can affect how the incineration process works. The less moisture your waste stream contains, the less fuel required for combustion. The moisture content of waste can be calculated by comparing the dry weight with the total weight. Different types of waste will have different levels of moisture content. Organic waste and food have high moisture content, whereas plastic, glass and metal have very low moisture content.

PARTICLE SIZE OF WASTE

Shredded RDF (Refuse Derived Fuel).The particle size of waste simply refers to the size of the individual items in waste stream. This will be dependent on the type of waste incinerating. Municipal Solid Waste could have a range of particles, from small cotton buds to large plastic containers. The size and shape of particles can affect combustibility rates. They affect how waste material moves across the grate during the combustion process. Some incinerators may have a maximum particle size in order for them to function efficiently. If particle size is too small, some incinerators may not be able to combust them, as they fall through into the ash grate.

STANDARDIZATION OF WASTE

There are many common types of waste streams, and standardization refers to a set of averages to ensure the waste mixture remains in roughly the same ratio.

IV. RESULTS AND ANALYSIS

In order to find the heat energy generated during incineration process or combustion of solid wastes its necessary to calculate calorific value of solid waste used for incineration process. Since here different types of wastes are used its difficult to estimate net calorific value of the waste mixture, thus energy balance is used to find out the amount of heat energy liberated or lost by the solid waste mixture by comparing it with the heat gained by the cold water fed through copper tubes which get heated up during incineration process.

We have the thermodynamic relation $Q = MC_p\Delta T$

Where Q is the amount of heat energy liberated, M is the mass flow rate, C_p is the specific heat and ΔT is the change in temperature or temperature difference. The relation is applied to the water passes through the copper tube in order to figure out amount of heat energy gained by the cold water as it passes through the copper tube and thereby we can compute the amount of heat energy lost by the solid waste during its incineration or combustion process. For finding mass flow rate of water passing through copper tube we have done trials about 2 to 3 times in which amount of water flowing out of the tube is measured using measuring beaker and time required is noted down with stopwatch. Specific



heat of water we have 4.186kJ/kg and the temperature gradient or difference is given by 100°C-30°C, whereas inlet temperature or ambient temperature of water is about 30°C and the outle temperature of water is about 100°C.

Trial number	Volume of water collected(ml)	Time(s)
1	300	22.1
2	300	18.5
3	300	20.5

Table2: Average mass flow rate calculation

Average flow rate is given by $M = \frac{300\text{ml}}{20.4\text{s}} = 14.7 \text{ ml/s}$

In order to convert this into kg/s, on multiplying we will get $300 \times 10^{-3} \times 10^{-3} \frac{\text{m}^3}{\text{s}}$ on multiplying this with 10^3 we will get the term in kg/s.

i.e.; mass flow rate $M = \frac{300 \times 10^{-3}}{20.4} = 0.0147 \text{ kg/s}$

Heat energy gained by water $Q = 0.0147 \times 4180 \times (98 - 32) = 4055.436 \text{ watts}$. This will be equivalent to the amount of heat energy lost by the solid waste burned in the incinerator on applying energy balance to the system.

V. CONCLUSION

Incineration is one of the most suitable, eco-friendly and sustainable means for waste disposal which is now being used by many firms including domestic usages such as in residential areas, houses as well as in industries, medical applications etc. the huge amount of heat energy liberated during the process of incineration is being lost without proper conversion into useful manner. Here an attempt to grab this heat energy liberated is made and is one of the most suitable, cost-effective technique to provide hot water for daily usage. This type of system already adopted in industrial sectors in large scale where incineration is coupled to boiler to provide steam which then expanded at turbines to provide energy output.

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