

## Potential of Effective Incineration of Solid Waste and its Utilization in Kolhapur City

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### ABSTRACT

*The huge amount of waste material occupies large land bed and makes various hazardous situations which effects on human life and its environments. Therefore there is need to control waste material and its seriousness on environment by using incineration treatment. Incineration is effective process of combustion of organic substance present in the waste material and forming various byproducts as heat, ash, flue gases which are useful in various fields. Incineration is best way to dispose the solid waste material and also heat produced during process will use for other purpose. Research has been conducted for selection of incineration of 160 ton municipal solid waste in Kolhapur city and formulates power generation capacity which utilize in resident and domestic purpose. Incineration can play an important role in waste control as well as provide contribution in electricity production. The main motive of this paper is to shine the importance of incineration to reduce waste solid mass and utilization of byproducts.*

**Keywords:** *Incineration, Solid Waste, Calorific Value, Net power etc.*

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### INTRODUCTION

Incineration process consists of burning of waste and reduces its quantity and effects. After the combustion remaining products are disperses into the environment through air, water and ash emissions. [1] The main outputs comes from incineration process are heat, flue gas and bottom ash, which release into atmosphere without any further treatment for usage. Heat which is in major percentage can be used to generate electric power. Incineration process produce continues and large amount of heat. Flue gases contain traces of nitrogen, carbon dioxide and sulfur dioxide, each of which has better utilization when used optimally. Nitrogen produced can be used as fertilizers to increase the productivity of crops, carbon dioxide can be used as fire extinguishers and sulfur once extracted from sulfur dioxide can be used in dental treatment to discompose waste amalgam without getting it exposed to outside air. Ash is obtained in the form of solid lumps which can be used for construction purposes.

Incineration refers as thermal treatment system because it is high temperature waste treatment process. Incinerators reduce the solid mass of the original waste by 80–85% and the volume by 95–96%. Waste reduction depends on composition and degree of recovery of materials such as metals from the ash for recycling. The main advantage incineration treatment is that destroyed the clinical wastes and certain hazardous wastes by high temperatures.

Waste combustion is particularly popular in countries such as Japan where land is a scarce resource. Denmark and Sweden have been leaders in using the energy generated from incineration for more than a century. [6] In 2005, waste incineration produced 4.8% of the electricity consumption and 13.7% of the total domestic heat consumption in Denmark. [7]

## PROBLEM DEFINITION

Now a day's waste management is major serious issue. The quantity of waste material over land to be increases tremendously which cause various problem that reduce quality of land, serious diseases, bad smell that pollute environment. Some waste like plastic has never been destructed and open burning of waste is creating more pollution. The incineration is better option to destroy the waste and also great source of energy if we utilize properly. Incineration is useful to reduce landfill for maximum utilization of land. Therefore incineration plant is good optional solution for adverse effect of land filling of solid waste.

## LITERATURE REVIEW

**Shyam Swaroop Nigam et al.** In that they concluded as incineration is the best process of combustion of Organic materials present in the waste and giving useful byproducts. Describe briefly how a low cost incinerator can be constructed and to utilize the byproducts obtained effectively. The byproducts evolved are released into the atmosphere which causes acid rain, infectious diseases and wastage of heat energy. The effective use of these byproducts is generation of electricity, growth in the production of crops, producing liquefied petroleum gas and road base construction. [1]

**Rohit R. Atwadkar et al.** In that they estimated a conceptual framework and methodological tool developed for evaluation of different waste to energy technology suitable for treating municipal solid waste, by introducing the multi criteria decision support method MATLAB computing software and demonstrating its related applicability via test application. [2]

**YanJun Hu, Guojian Li et al.** The bottom ash from a municipal solid waste incineration (MSWI) plant characterized to investigate the feasibility of recycling its fine and coarse fractions in road construction and assess their environmental impacts. [3]

**Ngoc-Hung Truong, Gerhard Krost et al.** In that the supplementary incineration of dehydrated sludge in a local boiler feeding a steam turbine-generator set can provide another quantity of electricity. Waste heat from both steam circuit and combustion engine can contribute to sludge drying, thus significantly increasing its heating value. [4]

**M. R. Wachter, I. Ionel et al.** In that they investigates the possibility to encapsulate the fly ash from the waste incineration process in dense slurry technology, which is used for handling of the raw and fly ash resulted from fired coal power plants. Dense slurry technology is already used in several countries in Europe and worldwide, and has proven its efficiency on the environment. [5]

## 1. INCINERATION

Write Incineration is process of combustion of waste material with presence of organic waste. It's a thermal treatment of producing waste to energy. Incineration process require large amount of air to burn large amount of municipal solid waste (MSW). Also requires proper method to entry of waste material, air supply and exit of remain products. Incineration is best for reduce huge amount of waste which difficult to destruct, covers large landfill. It able to reduced waste volume up to 95%. At sufficiently high temperature and residence time, any hydrocarbon vapour can be oxidised to carbon dioxide and water. Incineration is relatively simple devices capable of achieve very high removal efficiencies. Heat can be recovered that useful to form steam.

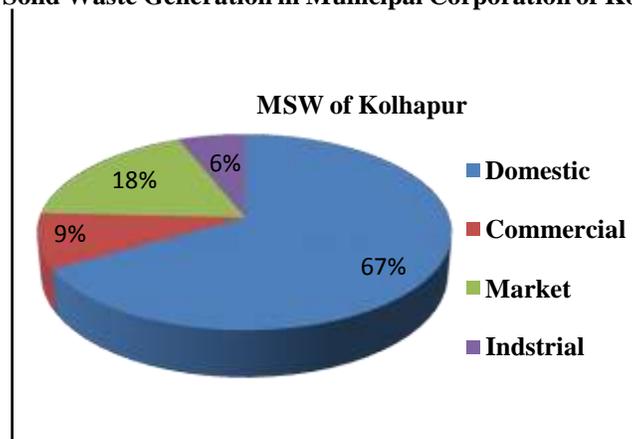
All MSW is collected from all region of city. Waste truck dump waste into a holding area at treatment facility. The waste is then picked up by grabs and dropped into bunker. Little by little, waste is slowly pushed into the burning chamber. Incinerator burns the waste at a temperature about 800 degree Celsius. Ash with heavy debris is collected in a basement chamber and electromagnet is passed over it to collect all the metal debris from the ash for further recycling. Heat produced by incineration process is given to the boiler for producing steam. By using steam power, the electricity is produced. Gases containing acid pollutants such as SO<sub>2</sub> and dioxins are treated in scrubber reactor. The gases go through a fine particulate removal system, where finer pollutants are trapped. Clean gases are then released through the chimney stack. [10]

## 2. STATUS OF SOLID WASTE GENERATION OF KOLHAPUR CITY

Total population of Kolhapur city according to 2011 census is 5, 49,283. About 165 metric ton / day and per capita per day generation are 300 gm. [2]

MSW Generated Per Day	MSW Generated Per Person Per Day
165 Metric Tons (MT)	300 gm

**Table-1: Solid Waste Generation in Municipal Corporation of Kolhapur [2]**



**Fig-1: MSW Generation in Kolhapur city (per day) [2]**

### 3. INCINERATION AND ITS TYPES

Incineration is process of waste treatment where combustion of organic substances occurs which present in waste material. We can simply say incinerator is a furnace for burning waste material collected from industries, houses, etc. The incinerator ashes contains heavy metals, unburned and new chemicals formed during the burning process, are then buried in landfill. Modern incinerators having pollution controlled equipment, which play their part in cleaning up the Flue gas. [1]

The most common four types are followed:

1. Fixed Grate
2. Moving Grate
3. Rotary Kiln
4. Fluidized Bed.

#### 3.1 Fixed Grate

It is the simplest of all the incineration processes. Feeding of waste materials are done from top and incombustible solids called clinkers are removed from opening on the other side. Clinkers are the waste material obtained from industrial processes. It forms black deposit of coke, coal, charcoal which can be reused in an effective way in the construction of roads. The size of waste materials collected from apartments and houses can be reduced by using waste compactors.

#### 3.2 Moving Grate

It is the most effective and mainly used incineration process. Moving grates are commonly known as incinerators of municipal solid waste. It is capable to handle near about 35 metric tons of waste every hour at treatment. It is having a good durability as it can run up to 8000 hours in a year without inspection or maintenance. Moving grate provides movement of waste at a controlled rate towards combustion chamber for efficient combustion. Waste is added from the top and ash is removed by water locking. Since this process generates lot of heat, combustion air or water is injected from below to cool the grate. Cooling of the grate is important to maintain the mechanical strength of the incinerator.

Secondary combustion air is introduced into the boiler at very high speed for better mixing and complete burning of the waste material. Incineration plants must be designed so that it reaches a temperature of 850 degrees Celsius for proper breakdown of organic substances present in the waste material. Primary combustion air is used to help cool the moving grate, and secondary combustion air facilitates combustion.

### 3.3 Rotary Kiln

Large industries and municipalities are mainly uses rotary kiln type of incinerator. It has two chambers i.e. primary and secondary. Primary chamber is inclined and its axial movement mixes the waste material in proper manner. Ash is remove through grate and gases are pass secondary chamber involves complete gas phase combustion reactions. Rotary Kiln incinerator is used for hazardous, medical and chemical waste. It is also possible to burn domestic waste, but the installation must be economical profitable. Operating temperature is 800 - 1400 degree Celsius. It's easily handles liquid, sludge, solid, gas in large quantities. [11]

### 3.4 Fluidized Bed

High speed airflow is continuously blown over a sand bed. The air flow causes sand to suspend and creating a fluidized bed. Then fuel and waste are to be introduced and allow to suspending with sand for combustion. Thus complete mixer of waste, sand and fuel to be circulated throughout the furnace and finally combusted materials are extracted for better utilization.

From all above type, for medium size incineration of municipal solid waste, the moving grate is more convenient and economical.

## 4. BY PRODUCTS FROM THE INCINERATION & ITS UTILIZATION

The collected wastes are burned at high temperature. The output from incineration is ash, heat, flue gases and other content present in ash which are not burned. This output released into atmosphere causing diseases, pollution, acid rain and heat loss also. This point highlights the usage of the heat energy, flue gases and ash content in an effective way for benefit to human being.

### 4.1 Ash

Ash is basic content comes after burning of material. The waste material fed to go incineration process and ash is forms at bottom ash chamber. The ash is effectively used for construction purposes. Ash contains some metal debris that could not burn totally. This metal collected for recycling.

### 4.2 Flue Gases

Flue gases are mixture of many gases that obtained by burning of different waste material during process of incineration. These gases are specially causes the many diseases such as lung cancer, asthma and other respiratory problems. The gases evolved during incineration mainly are Nitrogen dioxide, Carbon dioxide, Sulfur dioxide, water vapor and traces of oxygen. The sulfur is removed by desulfurization systems. Nitrogen dioxide, oxygen and water are forms nitric acid that used in the production of crops. This will improve the production and quality of crops.

### 4.3 Heat

Large and continuous heat is produced during combustion of waste material. This heat is utilized by converting it into electricity. Heat is depends on the calorific value of waste.

## 5. CALORIFIC VALUE (CV) OF WASTE

The different material has different calorific value. The CV of the waste is depends on the composition of the waste. Waste with a lot of PVC has a higher calorific value then waste with less PVC and more paper. Here given some approximate numbers about the calorific value of materials.

Type of material	CV (MJ / kg)	CV (kCal / kg)
Medical waste	19 – 24	4540 – 5735
Industrial & hazardous waste	22 – 40	5257 – 9558
Domestic waste (without recycling)	7 – 16	1673 – 3823
Domestic waste (after recycling)	10 – 14	2389 – 3345
PVC	41	9797
Dry wood	14.4	3441
Paper	13,5	3226

Braun carbon	7 – 12	1673 – 2867
Petrol (benzene)	45 – 47	10573 – 11231
Coal	15 – 27	3584 – 6452
Diesel	46	10992
Ethanol	30	7168

**Table-1: Calorific value (CV) of materials [12]**

A material can burn without supporting fuel when it has a calorific value of min. 14.4 MJ/kg, this is approximately dry wood. To know the overall calorific value of the waste, need to measure the calorific value or estimate by analyzing the composition. If there is no chemical reaction by mixing the different materials together, a weighted average of the different calorific values is a good approximate value for the calorific value of the waste mix. If the amount of waste is known, and the calorific value of the waste is known, it is possible to design the incinerator and flue gas treatment system. [12]

## 6. CALCULATION OF CALORIFIC VALUE AND NET POWER GENERATION POTENTIAL IN KOLHPUR CITY

The calorific value of waste is determined by help of Bomb Calorimeter. The Net Calorific value is finding out by taking various sample reading.

Assumptions:

Water Equivalent (W) = 2718.52 Cal/C

Calorific Value of Thread (CVT) = 2.1 Cal/Cm

Calorific Value of Nichrome Wire (CVW) = 2.33 Cal/Cm

Conversion Efficiency = 20 %

Calorific Value (CV) of Sample:

$$CVS = \{T \times W - (CVT + CVW)\} / M \quad \text{_____ [1]}$$

Where,

T=Rise In Temperature,

M=Mass of Sample,

Sample Used= MSW

Net Calorific value based on percentage of composition present in waste. The Net Calorific Value (NCV) of waste is 2276 Kcal/kg.

Potential of recovery of energy form MSW through thermo chemical treatment methods can be made from its calorific value.

Total waste quantity (W) = 1 Ton,

$$\begin{aligned} \text{Energy recovery potential (kWh)} &= NCV \times W \times 1000/860 \\ &= 1.16 \times NCV \times W \end{aligned} \quad \text{_____ [2]}$$

$$\begin{aligned} \text{Power generation potential (kW)} &= 1.16 \times NCV \times W / 24 \\ &= 0.048 \times NCV \times W \end{aligned}$$

$$\text{Net power generation potential (kW)} = 0.0096 \times NCV \times W \quad \text{_____ [3]}$$

If NCV = 2276 Kcal/kg, then

Net power generation potential = 21.85 kW

Net power generation potential (160 Ton) = 21.85 x 160

$$= 3496 \text{ KW}$$

Net power generation potential (160 Ton) = 3.496 MW

## 7. CONCLUSION

This study briefly describes the proper incineration for small city as Kolhapur and utilization of byproducts effectively for the welfare of human being. The power recovery depends on calorific value of waste and from that, it was found that the net power generation potential from incineration of municipal solid waste for Kolhapur city is about 3.496 MW.

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