FABRICATION OF SMALL SCALE INCINERATOR FOR ENERGY RECOVERY AND WASTE VOLUME REDUCTION

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Abstract: *Disposal of waste is an immense issue the world over. With increasingly more urbanization the government is thinking that it is hard to appropriately arrange squanders, both industrial and household. While household wastes can be disposed as landfills in rustic zones that isn't choice for the metropolitan network. Most homes rely upon metropolitan/city workers, and every one of these wastes are arranged as landfills which is the most mainstream garbage removal technique in developing nations like India. Yet, these landfills cause water and air contamination. Another strategy for garbage removal is incineration/combustion. Here wastes are scorched in a controlled situation. This technique isn't without cones, yet contrasted with the drawn out risks presented via landfills this is a superior choice. Yet, incinerators are costly, and the vast majorities are not taught about the advantages of utilizing household incinerators. The project aim is to manufacture a home grown/family unit incinerator that can be effectively moved from one place to other and furthermore to use the waste burnt to be changed over to Thermal and Electrical Energy. It should be moderate too.*

Keywords: Solid Waste, Incinerator, Population, Thermo Electric Generator, Waste volume, Heat and Electricity.

1.0 INTRODUCTION:

Solid waste is described as non-liquid waste material bobbing up from home, trade, business, industrial and agricultural activities and so forth. Urban India (approximately 377 million humans) generates 63 million tonnes of municipal stable waste (MSW) every year. Of this about 43 million tonnes (70%) is gathered and 11.9 million tonnes (20%) is dealt with. About 31 million tonnes (50%) is dumped as landfills. With the change in consumption patterns and economic growth, the estimation of urban MSW generation may increase to 165 million tonnes in 2030 and 430 million tonnes by 2050. On a median, 20 to 30 % of the total waste generated remains uncollected, developing Environmental risks in city settlements. Solid waste is often cited as a key issue causing environmental degradation. Due to the unplanned urbanization and fast industrialization, Asian countries were main victims of unmanageable solid waste. The waste incineration process reduces the natural and combustible waste to non-flammable matters like ash and results in weight loss that may correctly be disposed of on land, or in underground pits and also helpful for Energy recovery.

1.1 AIM OF THE PROJECT

Municipal Solid Waste is turning into a large hassle in India. In this take a look at, lowering of solid waste through introducing of incineration generation become mainly targeted and very last target changed into to recover the waste energy generating on the combustion technique and convey power. The Input regards the available MSW and fuel and outputs regard the waste thermal energy, power through Thermo Electric Generator and clean surroundings. The Final aim of the project is to recover the maximum energy from burning waste and to produce the thermal and electrical energy and reduce the volume of the waste collected and utilize the residue of waste.

1.3 NEED OF THE WASTE TREATEMENT

Waste treatment is crucial for controlling environmental pollution. All countries have extraordinary laws and guidelines to deal with these wastes. Waste remedy techniques have to be completely tested with non-stop in-cycle manage to make certain minimum performance requirements are reproducibly achieved. The waste generation is the never ending process and it is growing more with the rapid urbanization. Management of waste highly needed for the effective handling of the waste produced. Open dumping is the traditional technique followed to collect the waste and dumped in the open place which eventually contaminates the soil, water, air around us.

2.0 THEORETICAL FRAME WORK

2.1 CLASSIFICATION OF SOLID WASTES

Waste may be classified based on supply, substance, risky houses, management or blend of these standards. Two major waste classes can be established based at the distinct rules and coverage contraptions commonly in vicinity: non-hazardous or solid waste and unsafe waste. Based upon the type of wastes there are different forms of waste are generated.

2.2 INCINERATION

Incineration is a waste remedy system that entails the combustion of natural materials contained in waste materials. Incineration of waste materials converts the waste into ash, flue fuel and heat. Incineration seeks to minimize the volume of waste and toxicity of it and is a widely used method for managing the municipal solid waste which cannot be recycled.

2.3 THERMO ELECTRIC GENERATION

The thermo electric generator is a device that converts the difference in the temperature (heat flux) into the electrical energy through the phenomenon known as Seeback effect. The difference in the input and output of heat generates voltage. Thermoelectric Modules function like heat engines, however are less cumbersome and haven't any moving elements.

2.4 HOW INCINERATION SUITS INDIA

India is known as the second most populous country with faster growth rate. The population of the country is increasing in speedy manner year by year is itself the regarding issue and waste produced with the aid of people is increasing quicker with speedy urbanization and diverse other elements.

3. DESIGN METHODOLOGY

3.1DESIGN

Design is the key element for the construction of the incinerator to mitigate the effective incineration process to limit emissions, avoid clinker formation and slagging of the ash (inside the primary chamber), avoid refractory harm destruction. The temperature, residence time and other hints are rarely achieved with the aid of small scale incinerators. But the small incinerators are to be designed to attain efficient burning of waste and proper handling of the residue for the managing waste effectively.

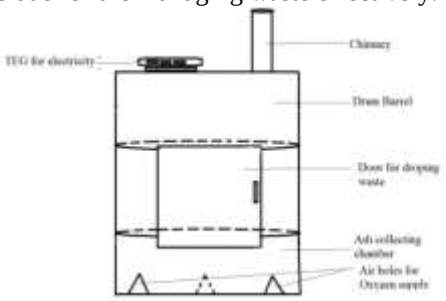


Figure 1: Design of Small Scale Incinerator

3.2 CONSTRUCTION

Construction of Incinerators involves adequate design, drawings and quality control. Dimensional drawings, tolerances, material lists are needed for effective construction. There are different types of Incinerators based upon their size, usage and design. The auxiliary equipments are connected according to the usage, temperature required, reduce emissions etc. Construction of the incinerators is the main element which helps in proper waste management.

3.3 OPERATION AND MAINTENANCE

Proper operation is vital to reaching design parameters. In trendy, the manufacturer or designer of the equipment should offer a guide that discusses operating practices consisting of startup strategies, shutdown processes, regular operation, troubleshooting, renovation strategies, endorsed spare components, and so forth. Combustion and emission tracking is used mechanically for numerous purposes, inclusive of figuring out whether or not incinerators are nicely operated.

4. PLANNING AREA AND WASTE GENERATION

4.1 PROFILE OF THE CITY

Nandyal is spread in an extent of 19.08 Sq.Kms in scenic serene surroundings and is an essential town in Kurnool District, Andhra Pradesh, India. The populace of the town is 2,11,400 as in line with 2011 Census. The town is located at 15.480N and 78.480E and has a mean elevation of 203.000 meters (666 feet). It is placed at a distance of 72.00 Kms from the District Kurnool and 286.00 Kms from the Hyderabad. The legit language is Telugu.

Table 1: Profile of the Nandyal city

Category	2011	2020
Area	19.08 sq.km	19.08 sq.km
Population	2,11,400	2,76,175
Population Density	11,192	12,010
No. of Households	45,046	47,144
Floating population	50,000	65,000

Source: Nandyal city sanitation plan

4.2 PROJECTION OF POPULATION AND GROWTH RATE

Population is one of the major factors in figuring out destiny sample of progress and improvement of the city. As in line with 2001 census document, the population of the town is 1,52,676 and its miles improved to 2,00,516 inside the year 2011 census, thus recording 38.72% decadal growth. The density of populace involves be about 11,147 individuals per Sq.Km. Demographic Studies found out a population of 4,20,000 for Ultimate Year i.e. 2047.

4.3 WASTE GENERATION ESTIMATION

The amount of MSW generated depends on several of things along with populace, meals habits, widespread of living, industrial activities and seasons. Major sources of solid waste generation in the town are domestic waste, commercial establishments, markets and restaurants.

4.4 EXISTING SOLID WASTE DISPOSAL SYSTEM

The Solid Waste collected from the Urban Local Bodies is transported to a chosen disposal site close to PV Nagar, approximately 3 Kms from Nandyal. This area is used for disposal of waste since 1995 and it has an area of about 20 acres. The amassed blended waste is transported to PV Nagar (Nandyal) dumping location via truck and dumped on open land without any processing.

Table 2: Estimation of Waste Generation

No.	Parameter	Calculation	
		2011	2020
1	Population	200516	2691520
2	Total Waste generated	63 TPD	82TPD
3	Per Capita of waste generation	314gms	308gms

Source: IL&FS Environmental Infrastructure & Services Limited (2016): Detailed Project Report for Implementation of MSWM in Zone V of Andhra Pradesh. Nandyal Municipality.

5. FABRICATION OF THE SMALL SCALE INCINERATOR

5.1 FLOW OF FABRICATION PROCESS

Drafting the Model → Selection of Drum/Barrel → Selection of appropriate materials → Estimation of amount of materials → Procuring the materials → Marking → Cutting → Bending → Welding → Painting → Bonding/Joining → TEG Connection

5.2 FABRICATION PROCESS

Having long past through many journals and theories, collective efforts were inflicted on this fabrication method of this small scale incinerator. Various published papers had been taken as reference and non-stop have a look at of each theoretical and sensible design is executed to come up with the satisfactory viable outcome. The first step in the fabrication procedure is material selection. Incinerator fabrication is almost done with the selection of barrel drum as the incinerator and the drum selected is of 55 gallon open head (open on one end) steel drum which usually carries 220 liters of oil. The thermo mechanically treated (TMT) square bars are considered for making the mesh to carry the weight of waste inside the drum and act as layer between burnt and to be burnt waste. A hollow iron pipe of certain height is selected as the chimney. Air holes for the oxygen supply has been cut to make the supply of oxygen naturally for burning and also to remove the water at times of rains. Gate for the incinerator is fixed with the hinges to make the operation in free manner to dump the waste. The connection of Thermo electric generator modules are adjusted according to the need. The fabrication process of the small scale incinerator is completed and is ready for testing.

a) Cutting of door b) Welding the chimney c) Joining the mesh and hinges d) Incinerator ready for testing

Figure2: Fabrication of Incinerator

5.3 COMPONENTS AND MATERIALS

The Main Components of the small scale incinerator:

i. Barrel Drum
ii. Chimney
iii. Thermo Electric Generators
iv. Ash and Residue collector

5.3.1 Barrel drum: Barrel drum is the main component and acts as readily made incinerator for burning the waste. These drums are made from plastic, laminated paper board and steel. The drum made from steel can be used as the incinerator after it is modified according to the requirement. The selected steel drum is of 55 gallons and is an absolute suit as the small incinerator.

5.3.2 Chimney: The role of the chimney in the boilers and incinerators is to let the burnt gases in to the atmosphere through it. Different metals are used for chimney manufacturing, for the small scale incinerator a hollow iron pipe has been used as chimney.

5.3.3 Thermo Electric Generator: TEGs are the components which are responsible for converting the thermal energy into electrical energy in the small scale incinerator and can be used in many numbers by series connection to generate power.

5.3.4 Ash and Residue collector: The Ash/Residue collector is considered as the bottom part of the incinerator which was separated by a mesh type iron rods welded at the position leaving gap for residue.

Table 3: Specifications of small scale Incinerator

Item	Dimensions	Value	Tolerance level
Inner diameter	D1	566 mm	± 2
Outer diameter	D2	585	Maximum
Chime inner diameter	D3	585	Maximum
Drum height	H1	890	± 5
Clearance between base and floor	H2	4	Minimum
Distance between beads	H3	300	± 3
Gate height	H4	250	
Total capacity		212	Minimum
Chimney height	H5	150	
Stove		19x19 cm	
TEGs(4)		40x40 cm	

6. EXPERIMENTAL SETUP AND ARRANGEMENT

The test arrangement comprises of the fabricated small scale incinerator loaded with the waste and the connection of the thermo electric generator modules. The waste is burnt with some fuel for initial burning and the burnt waste produces the Thermal energy which has different temperature with the time and is calculated accordingly. Thermo electric generator modules are connected in the series and parallel connection at any location of the incinerator. The TEG modules convert the thermal energy of the waste into the power and voltage is generated. The energy generated can be calculated by using a multimeter.

Figure 3: Connection of TEG Module

Figure 4: Burning of waste in the incinerator

7. RESULTS AND DISCUSSIONS

7.1 WASTE VOLUME REDUCTION

The waste burnt in the small scale incinerator includes the paper, wood, cardboards, dry twigs and leaves etc. The tables below indicate the amount of waste collected and burnt in the particular time. The waste in burnt in the burning chamber of the incinerator to reduce the volume and weight of the waste.

Table 4: Quantity of different wastes burnt against time

	30 min	60	120	180	240	300
Paper	32 kg	63	125	183	246	310
Wood	12	23	47	62	75	86
Card board	25	52	98	153	206	253
Dry leaves, twigs	21	38	78	108	152	195
Average	20	40	80	120	160	200

By running about 5 hours a day the amount of waste burnt can be calculated as follows
Average solid waste burnt per hour = 36 to 46 kg
Time utilized for burning = 5 to 6 hrs
Daily burning of waste = 36 x 5 = 180 kg
Waste burnt per week = 180 x 7 = 1260kg
Burning per month = 1260 x 30 = 37,800 kg

The waste burnt per month can be around 37 tones and may differ based on moisture content, season, weather, etc. The waste burnt can reduce the waste by 80 % of volume and 70 % of the weight of the collected waste.

7.2 GENERATION OF THERMAL/HEAT ENERGY

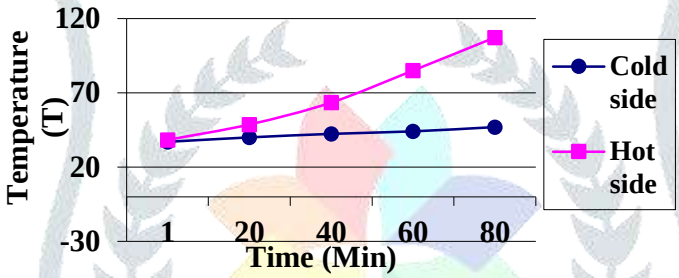
The generation of heat energy in the small scale incinerator depends upon the waste burnt and the calorific value and the moisture content and type of the waste burnt. The capacity of the small scale incinerator can be maximum 200 kg but the construction made that it can burn only 80 kg, of which it can vary from 40 to 70 kg of waste is burnt for effective burning. The temperature achieved after burning the kg of waste is about 80 to 160 ^{o} C. The waste is supplied through the gate of the incinerator and is placed on the mesh and is burnt and the heat energy i.e. temperature can be known by measuring instruments of heat and waste burnt produces the heat energy which can be used for cooking, heating water, drying, etc as shown in the figure.

Table 5: Calorific values of wastes

Type of Material	CV (MJ/Kg)	CV (kCal/kg)
Paper & Card boards	13	3223
Coal	15-27	3583 - 6451
Dry wood	14	3441
Twigs	17	4044
Domestic waste	7-16	1671 - 3822
Dry leaves	17-19	4046 - 4521

Table 6: Thermal energy obtained from burning waste with time factor

Temp / Time	Cold side temp, T_C	Hot side temp, T_H	Temp Diff in ^{0}C
1 min	37	38.2	1.2
20	40	48.6	8.6
40	42.4	63.4	21
60	44.1	85	40.9
80	47	107.3	60.3



Graph 1: Graph showing Temperature and Time

7.3 GENERATION OF ELECTRICAL ENERGY

The Electric energy generated from this incinerator is dependent upon the temperature difference of hot and cold side of the Thermo Electric Generator Modules and also no. of TEGs used. The power generated from TEG Module depends upon the temperature difference and the maximum voltage that can be generated is 4.8 volts. The different voltage is generated at different temperature differences.

The current (in Amps) in parallel, produced from Thermo electric generator modules

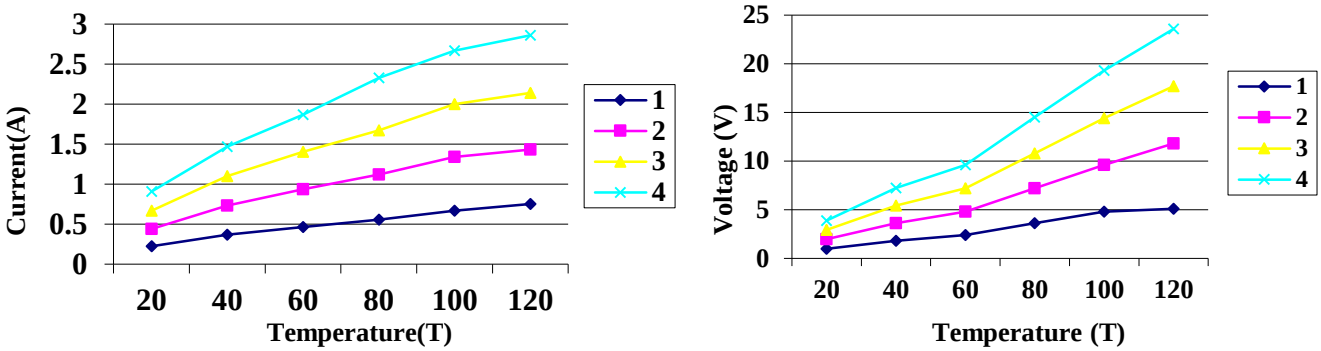
Table 7: Current produced from the TEG Connection

Series	Temp	No. of Modules			
		1	2	3	4
1	20	0.225	0.44	0.670	0.91
2	40	0.368	0.733	1.102	1.47
3	60	0.464	0.939	1.406	1.87
4	80	0.558	1.120	1.675	2.33
5	100	0.669	1.34	2.00	2.67
6	120	0.752	1.43	2.14	2.86

The voltage (in volts) in series, produced from Thermo electric generator modules

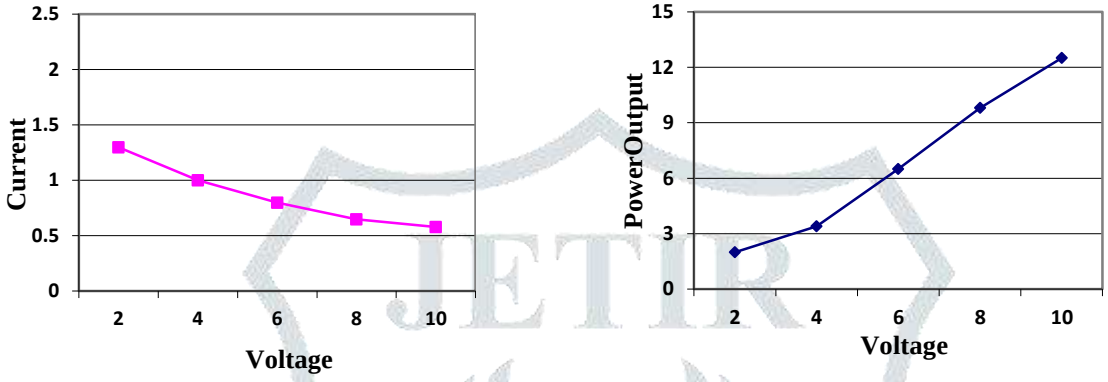
Table 8: Voltage produced from the TEG Connection

Series	Temp	No. of Modules			
		1	2	3	4
1	20	0.97	1.95	2.92	3.86
2	40	1.8	3.62	5.41	7.72
3	60	2.4	4.8	7.2	9.6
4	80	3.6	7.2	10.8	14.5
5	100	4.8	9.6	14.4	19.3
6	120	5.1	11.8	17.7	23.6



Graph 2: Graphs showing the Relation between voltage, current to the Temperature

The Power output can be calculated by using the voltage and current produced and generally the power generated is calculated as the product of current (I) and Voltage (V). The simple formula for power generated can be as below



Graph 3: Graphs showing relation between V-I and P-V

The fluctuations in the power output will be occurred due to the effect of seasons, moisture content and the atmosphere, etc. The 4 TEG modules are connected two in series and two in parallel connection. Therefore the power output can be calculated as

- Voltage = 2x4.8 = 9.6 Volts
- Current = 2x0.669 = 1.33 Amps

P = V x I
= 9.6 x 1.33
= 12.76 Watts

On the average the Power output ranges from 12 to 15 watts of power at different temperature when 4 TEG modules are utilized.

8. CONCLUSION

All varieties of waste substances are generated in the Indian cities as in different countries. However, inside the absence of a properly-deliberate, scientific method of waste control and of any powerful regulation of waste burning and recycling, the left-over waste at the dumping yards typically consists of high percent of inert and of putrescible natural relies. A simple solid waste incinerator was designed, built and efficiently carried out for thermal and electrical power generation by burning waste.

Solid waste incineration reduces weight, extent, and odour which also results in emissions of flue gases and other residues like the bottom ash and fly ash. However, with the growing issues of waste control within the city areas and the unwell outcomes of the prevailing waste management practices on the public heath, the pressing want to improve the waste management system and to adopt the advanced, scientific methods of disposal of waste, which makes incineration a good notable option.

Test results indicated that the system can be used for waste disposal and energy recovery despite the fact that the flue gases aren't safe for the environment since the concentrations of certain harmful gases had been above the recommended standards, a demonstration that similarly work is needed each in the combustion chamber and the device before it is able to be endorsed for large scale applications.

9. REFERENCES

- **A.W. Culp**, "Principles of energy conversion", 1996.
- **Christine Junior, Oliver Dingel**, "Energy and Thermal Management, Air conditioning, Waste Heat Recovery", 2018, Germany.
- **G.D. Rai**, "Non Conventional Energy Sources", Delhi 1997.
- **H.A Sorenson, John wiley**, "Energy conversion systems", Toronto 1983.
- http://www.wtert.org.
- http://en.wikipedia.org/wiki/Seebeck_effect#Seebeck_effect
- https://robu.in/product/sp1848-27145-thermoelectric-powergenerator
- http://nandyal.cdma.ap.gov.in/