RESEARCH ARTICLE OPEN ACCESS

Development of plasma technology for waste Management in India

Shaown bhowmik[1], R.K Jain[2]
1Department of mechanical engineering, ITM University Gwalior, India
2 Professor of mechanical engineering, ITM University Gwalior, India

Abstract:

An enormous amount of municipal solid waste is produced by per person daily in India. Due to the rapid growth of human population these wastes are also increasing day by day and creating pollution in the environment. These wastes may vary from organic, inorganic or both in nature and releases toxic gases like dioxins, furans, mercury, polychlorinated biphenyls etc. The thermal plasma technology is one of the efforts which can be used for the treatment of municipal solid waste and helps in the production of syngas in an ecofriendly manner. In this way the plasma technology can also help in lowering down the emission of greenhouse gases from the environment and make it a safe place for living.

***Keywords* — Municipal solid waste, dioxins, thermal plasma**

I. INTRODUCTION

Disposal and treatment of large quantity of solid waste is one of the major issues in India. The total waste generated in India is estimated to be more than 100000 metric tons per day. More than 90% of waste collected formally is landfilled on open lands and dumps. 2% is openly burnt on streets and only 10% of waste is formally treated which is lower than any substantial standard of developing countries. The Central pollution control board (CPCB) has made many plans and programs relating to the abatement of pollution in India. Almost 47 cement plants are implemented for the co-processing of hazardous wastes in cement kiln. But out of 79 composting plant in India only less than 15% are actually functioning and rest are not in proper working condition [1]. So incineration has become the major treatment process of solid wastes. Different types of incinerators, kilns are also built in different parts of the country for the proper treatment of these municipal solid wastes. The total waste generation is estimated to be 165 million tons by 2031 and 436 million tones by year 2050 [2]. Some incinerator plants are built and some are planned to be made [3].

Location	Company	Size
Narela, Delhi	Ramky	24MW
Ghazipur, Delhi	IL & FS	10MW
Jabalpur, MP	Essel	11MW
Pallavapuram, Tamil nadu	Essel	5MW
Surat, Gujrat	Rochem	12MW
Jawaharnagar, Hyderabad	Ramky	20MW

Table 1. Incineration plants built in India

But this incineration ultimately encourages more waste production as it requires large volume of waste to keep the fire burning. Smoke and ash emitted by the chimneys include acid gases, nitride oxides, heavy metals, dioxins etc. In this case plasma treatment of municipal solid waste is a far

more ecofriendly option. Plasma is the fourth state of matter and these plasma arcs mainly have high temperature which can totally remove any potential for undesirable byproduct to be generated.

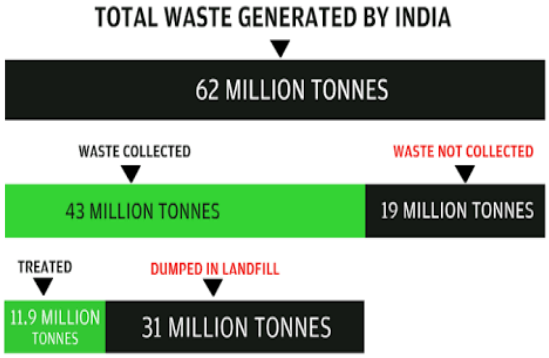

Fig. 1 India's municipal waste scenario

Fig. 2 Total waste generated by India

II.WASTE TREATMENT BY PLASMA GASIFICATION

Plasma gasification is an extreme thermal process which breaks down the chemical bonds of the feedstock such as municipal solid wastes, plastic etc. in a plasma converter. The smaller plasma torches uses argon and the bigger plasma torches uses nitrogen as its inert gases. An electric arc is mainly generated between two electrodes by passing strong electric current under high voltage. The heat generated inside is equivalent to the surface temperature of the sun and the torch's temperature ranges from 4000 to 25000°F (2200 to 13900°C).The inorganic wastes turn into glass like substances which can be used by industries as aggregates like blocks, bricks, gravel and paper. Similarly the organic wastes are turned into syngas which can be turned into electricity and liquid fuels.

In China, Zhao et al. studied about the volume reduction of the fly ash without any additive by thermal plasma. It was observed that fly ash treated in plasma furnace with power input 100KW the slag was obtained and crystallization was improved as the slag was water cooled. The heavy metals originated in the incinerated ash were confined in the treated silicate framework yielding low leach ability result [4].

Peng et al. demonstrated that the major advantages of using thermal plasma are fast heating rates, high temperature allowing the formation of vitrified slag and low off gas flow rates. The operation was done in 100KW plasma melting furnace. The result showed the consumed energy for ash melting takes the highest portion (48.44%) of the total heat output. The high temperature flue gas was released through the same outlet with slag which keeps it from solidifying at the outlet. In this way the energy efficiency of the furnace was also increased. If use of other output energies are considered then 9.82% of energy within flue gas can be recovered theoretically [5].

Morrin et al. reviewed the gasification and plasma fundamentals in relation to the specific process along with insight on MSW based feedstock properties and sulphur pollutant there in . The study focuses on the two stage fluid bed gasifier with overall process including fuel preparation, fuel bed gasifier, plasma converter, gas cleaning and power generation. The bed operates at 850 degree Celsius. The syngas emitted out is cooled at 1200 to 200 C. Here the thermodynamic equilibrium calculation models can be used to predict the equilibrium composition of multicomponent reacting system across a wide range of temperature and pressure [6].

Rutberg et al. learned about high temperature plasma gasification of wood for the creation of a fuel gas (syngas) for consolidated heat and power generation. Plasma has advantage over existing thermochemical forms which are in the high heating worth gases, process control and the lower vitality utilization per unit of yield. From one kilogram of 20% dampness wood it is conceivable to get 4.6e4.8 MJ of power (net of power input) and

9.1e9.3 MJ of warm vitality when utilizing wood with normal basic arrangement and with a LHV vitality substance of 13.9 MJ, when utilizing a consolidated Brayton and Steam cycle producing plant it was discovered that gasification by the air plasma is the most basic and promising strategy for building up the innovation of creating the syngas from wood and wood residuals [7].

Barcza et al. stated that plasma technology was first applied in Africa and it was realised that advantages could be attained from processing of metal fines and for the production of Ferro-alloys. The operations were performed in 40 MVA DC transferred arc furnace. The large scale operations uses graphite electrode instead of water cooled torches. The technology has been used in large scale purpose in different sectors for waste management to processing of ilmenite etc. [8].

Barcza et al. demonstrated a experiment in plasma furnace operated at 120KW showed that the efficiency of utilization of electrical energy increased from 44.4 to 61.3 percent when the feed was preheated at 700degree Celsius in a fluidised bed reactor. It is also demonstrated that the rate of energy loss from plasma furnace is independent of both power and feed flux. The magnitude of the energy losses from a plasma furnace are not strongly influenced by the local conditions around the arc of the feed stream [9].

Hlina et al. demonstrated a plasma gasification process with torch power 100-110KW and the mass flow rate of the gasification materials of tens/kg was set up during experiments. The synthetic gas produced had very high content of hydrogen and carbon monoxide (approx. 90%) which is in a good agreement with theory. The highest efficiency was in the case of gasification of wood sawdust and slightly higher than for pellets and waste plastics [10].

Katou et al. had demonstrated a incineration plant with 1710 KW output and maximum throughput of 25ton/day. It successfully concluded a 40-day continuous operation and all the heavy metals evaporate readily when the ash is melted by the plasma furnace and their concentration found in the slag is low. More than 99% of PCDDs and PCDFs in the incineration residue are destroyed by the melting processes [11].

Janajreh et al. studied the gasification model based on non-stoichiometric chemical equilibrium. The average efficiency of plasma gasification is calculated to be around 42% with air gasification gives around 72% of gasification efficiency. The result of plasma gasification showed that using high calorific value feedstock can accommodate high amounts of steam as plasma gas, resulting in a hydrogen rich high heating value syngas [12].

Mountouris et al. had shown the treatment of sewage sludge in best and naturally well-disposed strategy for strong waste treatment and vitality use. The process shows the vitality use capability of sewage slime treatment utilizing an incorporated procedure including plasma gasification, pre-drying and electric vitality generation. The study says that the muck from the Psittalia sewage treatment plant shows that the procedure isn't just independent from a vitality perspective, however it prompts net creation of 2.85 MW electrical vitality [13].

Byun et al. had exhibited the thermal plasma gasification/vitrification for municipal solid waste treatment. The gasification unit, has a limit of 10 tons/day. Two non-exchanged thermal plasma torches were used in this process. The power limit of each plasma torch was 200 kW, with operational voltage and current of 571±30Vand 293±10 A, respectively. The measures of electricity and LPG devoured were 1.14 MWh/MSW-tons and 7.37 Nm3/MSW-tons, respectively [14].

Fig. 3 Plasma gasification process

III.INCINERATION VS GASIFICATION

Incinerators utilize a lot of air to consume strong waste and creates polluntants that must be dealt with after ignition. Temperatures up to 850C. Lime and carbon are added to evacuate the corrosive gases and ingest substantial metals, dioxins, furans and Volitile Organic Compounds (VOCs). Gases are separated in substantial stacks to expel tidy and response particles (otherwise called fly ash remains). The remaining fly ash should likewise be painstakingly discarded or can be reused. The temparature created by the incinerator is utilized to make steam and produce power. Hot water and steam created in this procedure can likewise be utilized for district heating sysyem. Clean gas, steam and CO2 are discharge by means of the chimney.

Gasification on the other hand does not really burn the municipal strong waste. It separates the atoms utilizing heat and a little measure of air or oxygen. It is then recombined to frame syngas, like petroleum gas however more touchy to burning. Syngas can be utilized to make chemicals, composts, buyer items and produce power.

Comparison of Plasma and Incineration

Feature	Incineration	Plasma Torch
Volume Reduction	5:1	250:1
Weight Reduction	3:1	9:1
Integral Smoke Stack	Require 100-300 ft	N/A
Increase in Moisture Content	Increases Harmful emissions	No effect
Temperature Control	Requires secondary fuel, may have cold spots	Easily Maintained
Air Emissions	Can exceed standards	Clean by-product gas
Landfill Requirements	Bottom Ash-Leachable/Fly Ash- Toxic	None
Commercial by-products	Heat for electricity	Gas for electricity, Slag for resale

Fig. 4 Comparison of plasma and incineration

IV. ADVANTAGES OF PLASMA TECHNOLOGY FOR WASTE TREATMENT

- Clean obliteration of dangerous waste.
- Keeping hazardous waste from reaching landfills
- A few procedures are intended to recuperate fly fiery remains, base powder, and most different particulates, for 95% or better preoccupation from landfills, and no destructive emanations of harmful waste
- Potential creation of vitrified slag which could be utilized as development material
- Preparing of natural waste into flammable syngas for electric power and thermal energy
- Creation of significant worth included items (metals) from slag
- Safe intends to decimate both medical and numerous risky wastes.
- Gasification with starved ignition and quick extinguishing of syngas from hoisted temperatures can keep away from the creation of dioxins and furans that are regular to incinerators.

V. ANALYSIS AND DISCUSSION

The treatment of municipal solid waste is a growing problem not only in India but in most of the developed and developing countries across the globe. Plasma technology is an economically feasible and proven technology which can be used in advances of other waste to energy plants and incinerators. As per the present records these solid wastes will tend to increase more and more and to get a beneficial result the plasma gasification process is one of the best way to overcome it. Almost all types of municipal solid wastes can be treated in plasma furnace. The residuals like slag which are generated after the treatment lose their harmful effect and can be used as aggregates by different industries and have a definite market value. Overall it is a cost effective process and many incentives are taken and are already available in India for future development. So proper financial support from the government or any private sector, adequate lands for building of infrastructure and technical employees and labours are required for the development of this type of advance technology.

VI. CONCLUSIONS

In the present day the plasma technology is a wide scale approach in many different field. Initiatives are being taken by the government of India for the implementation of this new technology for the treatment of municipal solid waste and other hazardous wastes which are emitted by the industries. The use of plasma technology in India can bring a new change in the environment and many possibilities will come up in the recent years. The use of syngas can further utilized in the generation of electricity and liquid fuels which will reduce the growing demand of power and energy. Many different places are there where these kind of plants can be implemented with minimum set up cost. Though the initial set up cost is high but in comparison to other waste to energy plants these have high efficiency and high power generation which will initially recover the cost of production. The maintenance and operating cost does not exceed the minimum requirement in comparison to other waste to energy plants.

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