International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Role of Plasma Gasification in Waste Management

Kalpana Singh

Department of Chemistry, JNPG College, Lucknow

Abstract: ***Solid Waste management (SWM) is an acute and complex problem in developing economies like India. Progressing states have inadequate budget for waste management, out of which major portion of which goes to collection and transportation rather than its treatment. Various techniques like land filling, incineration and composting have been used for waste management, but none of them fully assure the growing need of waste management in major cities. In this work we have compared various methods of waste management and suggested a better method of plasma gasification, in which pyrolysis of solid waste takes place at very high temperature thus ensuring syngases as the output of gasifier. The method not only treats all types of waste, but also produces many useful byproducts and electricity.***

Keywords: waste management, incineration, land filling, composting, plasma gasification

1. Introduction

Higher standards of living of ever increasing population has resulted in an increase in the extent and variety of waste generated. This is a great and scorching problem in contemporary, fast growing society. The waste management approach in India is extremely inefficient, using old and obsolete technology for storage, treatment and disposal. Because of lack of storage and high processing costs, great amounts of wastes that are generated daily cause threats to our health and destroy the natural balance. It is now realized that if this waste generation continues indiscriminately, then very soon it will be beyond rectification. Management of waste has, therefore, become very important in order to minimize its adverse effects. Conventional waste utilisation methods certainly do not solve the current problems, because the harmful residues such as ash, dust, gases left behind cannot be filtered off even with the usage of innovative technologies. Municipal waste problem is undoubtedly waiting for proper solutions.

2. Literature Study

The traditional waste management techniques include landfilling, incineration and composting. A detailed study of these techniques along with their limitations is done.

(i) Land filling: It is the most common and economic method of waste disposal. Landfills are carefully designed structure built into or on top of the ground in which trash is isolated from the surrounding environment (groundwater, air, rain). This isolation is accomplished with a bottom liner and daily covering of soil. Complex organic wastes are slowly degraded or decomposed by the soil micro-organisms, primarily by aerobic or facultative bacteria and fungi. Since air cannot enter through a compacted land-fill, the aerobic bacteria decompose the organic solid waste by utilizing whatever oxygen is present inside the landfill. Then, decomposition by the anaerobic micro-organisms begins and this accounts for the degradation of most of the solid waste present in landfill. The water –soluble organic acids generated in this process enter the water media and diffuse through the landfill soils. Anaerobic methane bacteria accumulate in landfill systems and generate appreciable quantities of methane gas. The limitations of landfilling include: (i)A highly contaminated liquid called leachate is produced. It has high organic content, soluble salts and other constituents which contaminate ground water. (ii) Most of the methane generated during anaerobic decomposition escapes into atmosphere and poses a potential fire hazard. (iii) Carbon dioxide combines with water to produce carbonic acid which dissolves minerals and salts of Ca, Mg, Fe, Cd, Pb and Zn. These dissolved salts move into ground water causing increased hardness and heavy metal toxicity. (iv)Problems are caused due to bad odours, insects, vermin apart from noise and dust caused from waste transportation vehicles and compacting operations. (v) The land used as a landfill cannot be used in future as a productive farm land.

(ii) Incineration: In this technique, the solid organic wastes undergo controlled combustion so as to convert them into incombustible residue and gaseous products. Incineration is usually done when suitable site for landfilling is not available within economic haul distances from the source of solid waste. The volume of the waste is reduced to more manageable levels thereby reducing the transportation costs to the ultimate disposal site. Incineration reduces the land required to one-third of that required if the refuse is to be landfilled. The limitations of incineration include: (i) High capital and operation costs. (ii) The possibility of air pollution if controlled combustion is not carried out properly (iii) Ordinary incinerators cannot be used for radioactive wastes.

(iii) Composting: Composting is the aerobic and thermophilic decomposition of organic matter present in the refuse by micro-organisms, primarily bacteria and fungi. The organic matter is transformed into a stable humus like substance during the process. The reactions taking place during composting generate heat and hence the compost temperature rises. Depending upon the composition and nature of the waste, the waste volume is reduced by about 30 to 60%. Composting , however, affects surface and ground water resources, soils and air quality from the process residuals including solid residues and /or leachate to be disposed of and gases emitted from the process(such as green house gases and odours)

Licensed Under Creative Commons Attribution CC BY

3. Plasma Gasification

Plasma Gasification is one of the most efficient method for solid waste management. It gasifies matter in an oxygen-starved environment so as to cause decomposition of waste material into its basic molecular structure. It uses high electrical energy and high temperature created by an electrical arc gasifier. The wastes are not incinerated. This arc breaks down waste mainly into elemental gas and solid waste (slag), in a device called a plasma converter. The reactor operates at a slightly negative pressure. This means that the feed system is complemented first by a gaseous removal system, and then a solid removal system. The essential parts of a plasma gasification system include:

1) **Trituration and conveyor section**: This section consists of a grinder for breaking the trash into manageable size so that it can be handled by the conveyor, which pushes it to the plasma furnace.
2) **Pyrolysis chamber with plasma torch:** It is an air-locked chamber having one or more plasma torches. It allows the garbage in but prevents hot gases from escaping into the atmosphere. The chamber is lined with heat-resistant refractory material. There is a drainage system towards the bottom side of the chamber for slag removal. It also consists of a water-cooling system. There is an exit vent towards the top of the chamber for the escape of gases.
3) **Gas reformer and heat exchanger:** The reformer reforms hydrocarbon fuel into hydrogen rich syn gas. The hot gases heat water to produce steam in the heat exchanger. It is then used for running a steam turbine which is coupled to a generator to produce electricity.
4) **Gas cleanup filter:** The gases produced by pyrolysis comprise mostly of carbon monoxide (25 per cent), hydrogen and hydrocarbons (15 per cent), and carbon dioxide and nitrogen (60 per cent). The syngas or producer gas thus produced is then cleaned. Thereafter, the gas is burned in internal combustion (IC) engine generator sets to produce electricity

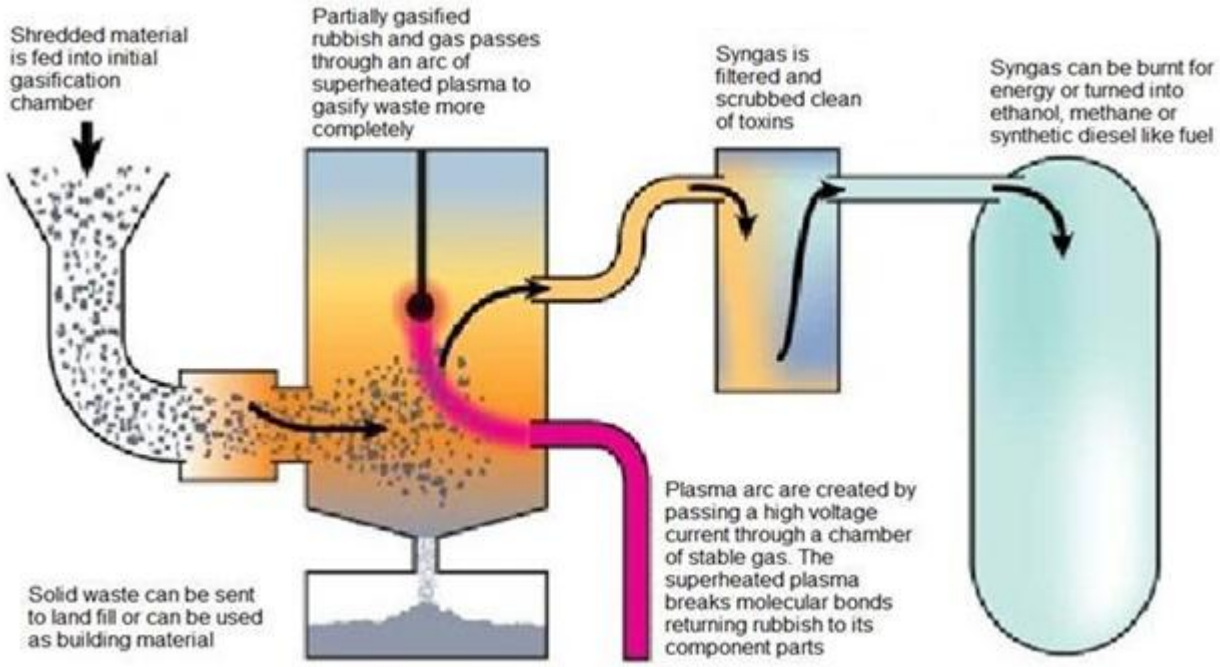


Figure 1: Process of Plasma Gasification (Source: juanjogabina.com)

4. Advantages of Plasma Gasification

1) Plasma method utilizes efficiently all types of hazardous, toxic or lethal waste because of high temperature which is capable of disassociating molecular bonds.
2) Plasma gasification takes place in a closed system, without releasing ashes, waste remnants, dusts and toxic gases into environment. Regained metals return to metallurgic industry and created slag is used as an additive to road construction materials. Non-toxic gases, which are created, are stored in special containers (gas cylinders) and used as fuel and energy creators.
3) The volumetric waste reduction for most solid wastes is approximately 300 to 1.
4) Plasma technology allows converting large quantities of municipal waste in the range of 10 to 500 tons a day.
5) This method of waste reduction is the only method available to reduce electronic waste, which does not undergo biodegradation.
6) The costs of using plasma technology are significantly reduced as a result of creation of ecologic by-products.
7) Contaminates in slag and gases created during plasma utilization with elements such as mercury, cadmium, sulphur, SO_2, HCL, dioxins, selenium, chromium, lead, barium, arsenic, radioactive elements are strictly controlled by usage of special water or dry scrubbers and filters. Using this method elements are considerably minimized below environmental standards. The remainder of the pollutants sink into glassy slag and can

Licensed Under Creative Commons Attribution CC BY

be treated further in close system, which is a major distinction to conventional incineration.

8) The ashes that are formed as a result of conventional incineration can be burned down to further using plasma technology to make them harmless.
9) Contemporary plasma converters are computer controlled, safe, quiet and can be stationary or mobile.
10) Plasma waste utilization will improve public health and safely achieve "total and irreversible destruction of hazardous and toxic compounds", "lethal viruses, bacteria and prions that are dangerous to our health.

5. Conclusion and Discussion

In this work, a review of the various waste management techniques was done. It was found that traditional methods like composting, landfill and incineration are not very helpful to completely eradicate the problem of solid waste management. Plasma Gasification has the limitation of large initial investment costs relative to landfill and the need of occasional maintenance. These limitations are insignificant compared to the numerous advantages plasma gasification provides. Hence it can be concluded that Plasma Gasification is a breakthrough technique in waste management.

References

[1] "Plasma pyrolysis and gasification of plastic waste-a review", Journal of scientific and industrial research, ISSN: 0975-1084 (Online)
[2] "Thermal Plasma Fundamentals and Applications",Boulos, M.I.; Fauchais, P., Pfender, E. 1994,Plenum Press, New York-London.
[3] "Problems of Solid Waste Management in Indian Cities", Vijay Kumar, Dr R.K.Pandit,
[4] International Journal of Scientific and Research Publications, Volume 3, Issue 3, March 2013,
[5] "Portable application of thermal plasma and arc discharge for waste treatment, thermal spraying and surface treatment", T. Iwao, M. Yumoto (2006). IEEJ T. Electr. Electr. 1: 163- 170
[6] "From waste to electricity through integrated plasma gasification/fuel cell (IPGFC) system", G. Galeno, M. Minutillo, A. Perna (2011), Int. J. Hydrogen Energy 36: 1692-1701.
[7] "Thermal plasma waste treatment", J. Heberlein, A.B. Murphy (2008). J. Phys. D: Appl. Phys. 41: 053001.
[8] "Application of thermal technologies for processing of radioactive waste", International Atomic Energy Agency (IAEA) (2006).
[9] "Solid waste plasma gasification: Equilibrium model development and exergy analysis",
[10] Mountouris, E. Voutsas, D. Tassios (2006), Energy Convers. Manage. 47: 1723-1737.
[11] The alter NRG/Westinghouse plasma gasification process: Independent waste technology report, in, Juniper.com, Bisley, England", Juniper.com (2008).
[12] "Thermal Plasma Gasification of Municipal Solid Waste (MSW)", Youngchul Byun, Moohyun Cho, Soon-Mo Hwang and Jaewoo Chung,
[13] "PlasmaGasification of Waste", Ed Dodge, Cornell University – Johnson Graduate School of Management, Queens University School of Business
[14] "Waste Gasification Impacts On The Environment And Public Health", A Technical report published by The Blue Ridge Environmental Defense League
[15] "Thermal Plasma Gasification of Biomass", Milan Hrabovsky, Institute of Plasma Physics
[16] ASCR, www.intechopen.com
[17] "The Environmental Performance Of Plasma Gasification Within The Framework Of Enhanced Landfill Mining: A Life Cycle Assessment Study", M. Danthurebandara, I. Vanderreydt, K. Van Acker, Fifth International Symposium on Energy from Biomass and Waste, Venice 2014
[18] "Efficiency Evaluation of RDF Plasma Gasification Process", Spyridon Achinas & Evangelos
[19] Kapetanios, Energy and Environment Research, ISSN 1927-0569

Licensed Under Creative Commons Attribution CC BY