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PLASMA TECHNOLOGY: A SOLUTION TO WASTE MANAGEMENT AND POWER GENERATION

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Abstract: Plasma gasification is thermal process using plasma which converts organic matter into a syngas. A torch powered by an electric arc, is used to ionize gas and catalyze organic matter into syngas with slag remaining as a byproduct. It is used commercially as a form of waste treatment and tested for the gasification of municipal solid waste, biomass, industrial waste, hazardous waste, and solid hydrocarbons. The double benefits of waste treatment and energy production can be achieved. The process is environmental friendly with very low quantity of NOx, SOx. Thermal plasma process for waste management and power generation is viable and sustainable.

Keywords: Plasma gasification, Environmental waste, Power generation, Syngas.

Introduction: There are necessities of nature's working which seems to intervene in greater forms of human activity. Every form tend towards a harmonized complexity and totality which again breaks apart into various channels of special efforts and tendency to unite once more in a larger and more puissant synthesis. Waste management is one form and also a solution to complexity. Municipal solid waste management is one of the major environmental problems of Indian cities [1]. It causes hazards to inhabitants. Hazardous materials may be solid or liquid found in hospital wastes, military waste, nuclear waste and asbestos posed danger to health and environment. High tech plasma gasification process is an efficient technological tool for hazardous waste destruction which occurs in oxygen starved environment so that waste is gasified [3].

Principle: Plasma is an electrically conducting medium in which there are equal numbers of positive and negative charged particles. Plasmas are generated when electromagnetic forces cause's electrons to be pulled apart from nuclei result in ionized gas. A high voltage current is passed between two electrodes to create a high intensity arc, which rips electrons from air and converts gas into plasma [5]. In plasma arc technology, torch is used to generate plasma temperatures from 1000^0 C to 10000^0 C. It is referred to fourth state of matter. Plasma technology include high thermal efficiency, waste volume reduction, high energy density, pretreatment is not required, and absence of fossil fuels [6].

Materials and Methods: Plasma furnace is a vertical refractory vessel in which contaminated waste material is introduced near top with coke and limestone. Plasma torches are located near bottom of furnace and gas is directed into bed of coke located at bottom of vessel. Air enters through tubes placed above the torch. Torch raises the temperature of coke bed to very high level, the gas generated moves upwards through furnace to vitrify the waste [3]

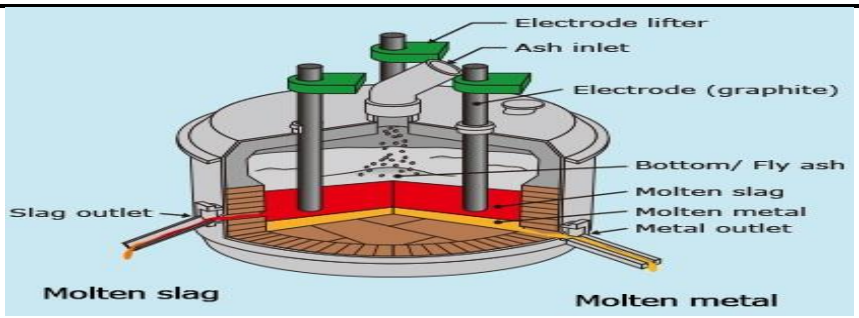

Fig.1 Plasma Furnace.

A furnace with multiple plasma torches to continuously pyrolyze household and industrial waste. In plasma gasification process the matter gasified in an oxygen starved environment to decompose waste material. A constant flow of electricity through plasma maintains a field of extremely intense energy to disintegrate garbage into components. Vitrified rock like byproduct can be used as aggregate for construction and syngas. Syngas is mixture of hydrogen and carbon monoxide and can be converted into fuel. Syngas can be fed to cooling system to generate steam to drive turbine for electricity generation. Municipal solid waste can be considered as source of renewable energy with plasma gasification technology can be leading edge technology to harness this energy [1].

Plasma gasification Process: Gasification takes place in a closed sealed reactor made of stainless steel vessel filled with air. A 650 ampere current is passed between two electrodes. This rips electrons from air to create plasma. Sorting of municipal waste is not required [4]. The gas is suitable for power generation unit. Gas is contaminated with NOx, SOx, hydrogen chloride and particulate matter which causes damage to chimney and environment. These components gets removed through processes and cleaned gas similar to natural gas fed to compressor, stored and ready to use.it can be used as feedstock for chemical processes, production of methanol [2].

Plasma Furnace: Plasma furnace have been successfully applied to the production of a variety of materials, particularly ferro-alloys. They have the advantage of allowing the direct use of fine feed materials. The power input is not limited by the electrical conductivity of the materials being processed, feed rate and power can be controlled independently. High power-fluxes lead to the use of smaller reaction vessels. Pilot-scale DC open-bath transferred-arc plasma furnaces of upto 1 MW in power, using single hollow graphite electrodes. These furnaces have been used to achieve power fluxes of over 2 MW/m^2 of hearth area. When coupled with a fluidized-bed preheating unit, the consumption of electrical energy per ton of product decrease, allowing an increase in throughput of almost 40 percent at constant electrical power input. Ferrochromium is produced on an industrial scale in a 40 MVA plasma furnace with an increase of about 20 percent in chromium recovery relative to conventional submerged-arc furnace production. High-temperature treatment of this hazardous waste material allows the recovery of zinc and recyclable alloys, and the production of an innocuous slag.

Plasma Torch: The features that make thermal plasmas attractive are a high energy density (106-107J/m^3) that comes with high heat flux density (107-109W/m^2), high quenching rate (106-108K/s), and high processing rates.Direct current (DC) arc plasma torches are, generally, the primary component of these processes that include plasma spraying, ultra-fine particle synthesis, metal welding and cutting but also, extractive metallurgy, waste treatment and biogas production. These torches operate as thermal, chemical, and electrical devices in processes that achieve material modifications which often cannot be achieved, or are not economically feasible, with other devices. For instance, plasma-sprayed coatings make possible turbine blades to withstand temperatures up to 1200 °C and provide unparalleled wear-resistance to prosthetic implants.

Fig. 2 Plasma Torch

Syngas cleaning: The purpose of syngas cleaning is to remove pollutants as sulfur dioxide, particulate matter, hydrochloric acid, and hydrogen sulphide. The basic operations are acid gas neutralization, gas cooling and particulate removal. Firstly the syngas is sufficiently cooled by quenching. The gas leaves the chamber at about 350^0 C. The gas then passed through fabric filter bag house to remove particulates, send to saturation tank which lowers temperature to 50^0 C, then it passes through a bed of aqueous scrubber for acid remover. Sodium hydroxide solution is used to neutralize acid. Then gas undergoes first stage compression to use in gas turbine. Other than being used as a fuel, syngas can be further converted to become a broad range of products including Methanol, Gasoline, Ethanol, Dimethyl Ether, Hydrogen, Mixed Alcohols, Diesel, Aromatic compounds [1].

Vitrified slag: The system of plasma vitrification of ash produces a chemically stable and mechanically resistant product. After vitrification the mineral product looks like a glassy, basalt structured lava (even of higher than basalt mechanical strength), and its main components are silicon, aluminum and calcium oxides in the form of chemically inactive compounds, resistant to flushing.Vitrified material in the form of lumps were tested with the Vickers's method to measure their hardness.Determination of oxides concentration in ashes was done using the method of X-ray fluorescence spectrometry.Vitrified product obtained after the plasma treatment is environmentally acceptable. It can return to the environment as an aggregate in the construction industry.

Power Generation: The gasis cooled prior to clean up by passing through a heat recovery steam generator and recovered heat is used to generate steam is sent to steam turbine to generate electric power. The cooled gas is compressed and used as fuel in combustion gas turbine which drives electric generator. The hot gas passed through second cycle of heat recovery steam generator to produce additional steam and hence electricity [2].

Environmental Sustainability: One technology which can use various types of waste, produce electricity and hydrogen without emitting dioxin, furan and mercury is plasma technology. Thermal plasma process seems to be realistic solution for waste treatment and power generation. It is a disposal process that can get rid of almost any kind of waste by laminating existing landfills, open dumps and produce clean power for national grid [4].

Fig..3 Vitrified Slag

Case study: A sustainable solution for Municipal solid waste management in Indian cities Bhopal, Hyderabad, Vijayawada, Vishakhapatnam India.

Madhya Pradesh's first biomethanation plant that can generate biogas for electricity generation, was constructed in 2015 at Bhopal, Madhya Pradesh. Built for around rupees two crore, Municipal corporation survey estimates that daily, about two tonnes of waste will be collected from residential colonies and three tonnes from vendors. A total of 800 MT of waste is generated in the city every day, with 60% being organic or disposable [4]. This makes it an enriched resource for alternate energy generation.This is part of the Bhopal Smart City project and the scheme is also being linked to the Swachh Bharat initiative.The launch marks a forward leap in Bhopal Municipal Corporation moves for sustainable development and reduction of the city's carbon footprint. The plant will be able to process four to five tonnes of segregated organic municipal solid waste daily and produce biogas. The estimated power generation is about 23 MW.

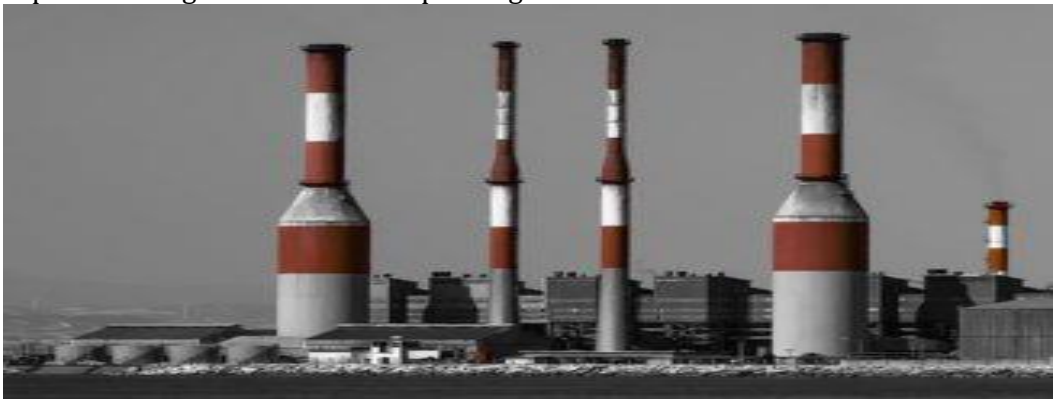

Fig. 4 Bhopal solid waste management Project.

Waste to energy plant established at Vijayawada in December 2003 by Shriram energy systems Ltd. Hyderabad with capacity of about 500 tonnes per day of municipal solid waste and power generation of 6 MW. A plant established at Gandhamguda near Hyderabad in November 2003 by M/s Selco International Ltd. of 700 tonnes per day of municipal solid waste and power generation of 6.6 MW. At Vishakhapatnam, in the year 2009 M/s Shriram Energy systems Ltd. established plant of 600 tonnes per day capacity of 6 MW power generation.

Conclusion: Municipal solid waste management is a challenge for town planners. Application of plasma gasification process in waste to energy relieves the pressure on distressed landfills and offers an environmental friendly solution. Environmental waste management problems and power shortages can be solved by thermal plasma soluton for solid waste management. It is a leading edge technology for waste to energy production. Plasma arc technology safely converts large variety of environmental hazards. Environmental performance is ine of the greatest strength of gasification process.The process is viable, sustainable, environmental friendly and is future of green power generation.

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