Part 2 of 2

Plasma Arc Gasification For Waste Management

A plasma pyrolysis system developed in Gujarat can treat 15-20 kg of hospital waste per hour. It can be set up at a cost of Rs 1-1.2 million. The method can be used efficiently for municipal solid waste and plastic waste also.

GP CAPT (RETD) K.C. BHASIN

Part 1 of this article dealt with plasma gasification, treatment of wastes in plasma gasifiers and components of plasma gasification systems. In continuation, I describe here some of the plasma gasification systems used worldwide and in India.

Plasma gasification systems used worldwide

Some of the well-known global firms are Westinghouse Plasma Corporation (WPC), Integrated Environmental Technologies (IET), The Solena Group and Startech. Their proprietary plasma gasification systems are described below.

Westinghouse Plasma Corporation (WPC). WPC’s proprietary plasma gasification vitrification reactor design (Fig. 5) combines a moving-bed gasifier with its industrial plasma torch technology. WPC, in conjunction with Alter Nrg (an engineering firm), is able to provide full gasification equipment, complete with feed handling, slag removal and gas cooling systems, for various applications. The system engineering drawing is shown in Fig. 6.

WPC has commercially operating/under-installation facilities in Japan, USA and India.

Japan. Hitachi Metals’s waste-to-energy facility, located in Utashinai, Japan, was constructed in 2002 and has been operational since 2003. The facility processes 200-280 tonnes/day of a mixture of auto shredder residue and municipal solid waste to produce electricity.

A second facility, built near the neighbouring cities of Mihama and Mikata, Japan, was commissioned in 2002 to treat 20 tonnes per day of municipal solid waste and four tonnes per day of sewage sludge for production of heat utilised in a municipal waste-water treatment plant.

India. Two hazardous waste disposal plants with a capacity of 72 tonnes/day and using WPC gasification technology and plasma torches to produce electricity are under construction in Pune and Nagpur, by SMS Infrastructures, India. When operational, these are expected to produce 5 megawatts of electricity.

USA. One WTE facility is at approval stage in the US. When completed, Geoplasma’s WTE plant in Florida will be the largest plasma gasification facility in the world processing up to 3000 tonnes per day of municipal solid waste and producing 120 MW of electricity. The first phase will process 1500 tonnes per day and produce 60 MW of electricity, which is enough to power 60,000 homes. The facility is expected to become operational by mid-2010.

Integrated Environmental Technologies (IET). It uses a plasma-enhanced melter (PEM) to transform waste into highly stable glass-like residues, recoverable metals and hydrogen-enriched gas (Fig. 7). The technology is unique in that it combines three processes: plasma arc
using multiple graphite electrodes, joule (resistance) heating using glass melter technology and superheated steam. This combination results in a stable and highly controllable treatment system.

The plasma operates at temperatures from 3000°C to 10,000°C in an oxygen-free environment with the presence of superheated steam ensuring that pyrolysis and steam reforming reactions dominate. A high-efficiency scrubber is used to remove volatile metals and other pollutants from the hydrogen-rich product gas (100 BTU/scf or more), a portion of which may be recycled to provide power to the PEM and the other portion used to generate electricity.

Metals in the waste are recovered. The glassy aggregate is also recovered and may be recycled as road building, blasting grit or construction material. Volume reductions are up to 98 per cent depending on how the process is run and the composition of the waste.

IET is more interested in treating radioactive, hazardous, industrial, municipal, tire, incinerator ash and medical waste streams. It has sold several commercial PEM units throughout the world to process a wide range of waste materials. For details, visit ‘www.inen-tec.com/commercial.html.’

**The Solena Group.** The Solena Group, a strategic partner of Westinghouse, uses the integrated plasma gasification combined cycle (IPGCC). It is a unique process that uses a patented plasma gasification vitrification (PGV) technology for conversion of low-value fuels/feed stocks (such as coal waste, petroleum coke, bio-mass and different waste forms including municipal solid waste) into a low-heating-value synthesis or syngas containing carbon monoxide and hydrogen gases. This gas is then employed as a primary fuel for a gas turbine.

The IPGCC can also be viewed as a two-stage processor of an opportunity feedstock. The feedstock is first gasified (partially oxidised) in a gasifier using high-temperature plasma heating systems at atmospheric pressure. The gas is then cleaned and combusted (completely oxidised) in the gas turbine to produce electricity.

The PGV reactor, in essence, cleans the solid/liquid and/or dirty fuels/feed stocks by converting them into a valuable byproduct fuel gas or syngas to power a gas turbine.

The IPGCC system generally consists of four separate processes: feedstock handling, plasma gasification and vitrification, gas cooling and clean-up, and gas turbine combined cycle.

The IPGCC system offers significant advantages over standard IGCC. By applying the PGV technology for gasifying the feedstock, the plasma heating system provides an independent and extremely powerful heating...
source at atmospheric pressure, allowing the gasifier system to be fuel-flexible, have high availability for base load power, achieve higher efficiency, and provide lower operation and maintenance costs.

The PGV reactor employs plasma torches to heat the reactor to 4000–5000°C at atmospheric pressure. At this operating temperature, the PGV process uses a carbon-based catalyst and oxygen-enriched air to cause the hydrocarbon or organic material to undergo partial oxidation, i.e., the hydrocarbon material is depolymerised into carbon and hydrogen molecules by the plasma-generated heat and undergoes partial oxidation to be released as a mixture of H₂ and CO. The syngas has a heating value of about one-third to one-sixth of natural gas. All inorganic or non-hydrocarbon-based materials in the feedstock are simultaneously vitrified into an inert glassy slag, suitable for use as construction materials including aggregates, tiles or bricks.

The IPGCC system uses General Electric’s LCV gas turbines. The process is shown in Fig. 8.

Utilising biomass as a fuel source, Solena’s technology can be used anywhere in the world. Presently, plants based on Solena’s IPGCC technology are operational in North America, the Caribbean, Europe and South America.

Solena Group’s ongoing projects include:

1. Five 40MW renewable energy plants in California
2. A renewable energy plant for a hazardous waste management group in Europe to turn solid and liquid waste into clean energy
3. Two 90MW renewable energy plants for two major European cities
**Startech.** Startech’s plasma gasification uses extremely high-energy plasma (at a temperature of 16,649°C, which is three times as hot as the surface of the Sun). The plasma torch inside the containment vessel is directed by an operator to break down whatever material is fed into it. It acts much like contained, continuous lightning, and everything that is fed into the system is broken down into its constituent atoms. Because the plasma torch so thoroughly annihilates anything that is fed into it, it is also an excellent means of dealing with dangerous and hazardous waste. The system is called a closed-loop elemental recycling system.

Startech’s plasma converter system is shown in Fig. 9. First, the trash is fed into an auger that shreds it into small pieces. Then the mulch is delivered into the plasma chamber, where the superheated plasma converts it into two byproducts. One is a plasma-converted gas (PCG). Also called syngas, it is composed mostly of hydrogen and carbon monoxide, and is fed into the adjacent Starcell patented system for conversion into fuel. The other byproduct is molten glass, which can be sold for use in household tiles or road asphalt.

Joseph Longo, CEO of Startech Environmental Corporation, USA, claimed that his plasma converter could turn the most vile and toxic trash into clean energy—and promised to make a relic of the landfill. An article on the same appeared in March 2007 issue of *Popular Science* magazine under the title ‘The Prophet of Garbage.’ The same can be viewed at ‘www.popsci.com/scitech/article/2007-03/prophet-garbage’

Startech’s current and future installations include those in Japan and South Carolina, USA. The plasma converter system installed in Japan can process five tonnes per day of hazardous incinerator ash. A joint project with ViTech Enterprises to manufacture and install a 10-tonne-per-day plasma converter facility to destroy out-of-date pharmaceutical products is in progress in South Carolina, USA.

The company’s negotiations with various bodies throughout the world are at various stages of progress.

**Indian scenario**

In India, about 30 million tonnes of municipal solid waste and about 4400 million cubic metres of liquid waste are generated annually. The municipal solid waste generation ranges from 0.25 to 0.75 kg/day per capita with an average of 0.45 kg/day per capita. In addition, large quantities of solid and liquid wastes are generated by the industry.

Most of the generated wastes find their way into land and water bodies without proper treatment, causing severe water pollution. These also emit greenhouse gases like methane and carbon dioxide, adding to air pollution.

There exists a potential for generating an estimated 1700 MW of power from the urban and municipal wastes, and about 1000 MW from industrial wastes in the country. The
Indian domestic wastes contain 60-80 per cent moisture and 70-80 per cent biodegradables and 7-10 per cent combustibles by wet weight. In comparison, in the West, with relatively dry wastes, the reverse is true: They contain 16-24 per cent biodegradables and the rest are mostly combustibles. Hence, burn technologies are unviable in India.

**Plasma gasification plants.** Presently, there are two 68 tonnes-per-day hazardous waste disposal plants utilizing the WPC’s PGVR technology. As mentioned earlier, these are being constructed at Pune and Nagpur by SMS Infrastructures Limited to produce 5 MW of electricity.

**Plasma pyrolysis system designed by FCIPT.** The Gujarat-based Facilitation Centre for Industrial Plasma Technologies (FCIPT), which is a part of the Institute of Plasma Research, in collaboration with TIFAC of the Department of Science and Technology, has designed a plasma pyrolysis system.

The torch (consisting of two electrode devices that convert electrical energy into heat energy) has also been developed by FCIPT. In the primary chamber, waste is fed and treated with plasma emitted by the torch. Thereafter, gases and slag are formed in the chamber. The gases include carbon monoxide, nitrogen and hydrocarbons. These are decontaminated (scrubbed) in the secondary chamber (with the help of a chemical/water shower). The temperature of the gases is also reduced from 600°C to less than 80°C during the quenching process. The entire process takes place in the absence of oxygen.

The system can treat 15-20 kg of hospital waste per hour. It can be set up at a cost of Rs 1-1.2 million. The plasma pyrolysis method can be used efficiently for municipal solid waste and plastic waste also. The gas product has a heating value of approximately one-third the heating value of natural gas. Therefore it can be used as an efficient fuel source for industrial processes, including electricity generation and production of methanol and ethanol. The slag can be used in the construction industry or for road paving. Plasma discharge treatment has no byproducts which must be disposed of as waste. Therefore it can be viewed as a totally closed treatment system. The plasma pyrolysis system is shown in Fig. 10.

Four systems have been supported by the Department of Science and Technology for field installations for plastic/municipal waste disposal, focusing on the demonstration in ecologically sensitive regions.

Meanwhile, Bhabha Atomic Research Centre (BARC) has provided technology for conversion of kitchen wastes, stale food, split milk, leftovers from hotels and vegetable refuge into organic manure, offering excellent topsoil material to the farmers. A few such plants have already been installed in Maharashtra, Orissa and Gujarat.

Similarly, Mumbai-based Asian Electronics Ltd and Singapore’s Enviro-Hub Holdings have teamed up to build four power plants of 8 MW each using a commercially viable technology for producing electricity from plastic waste.

Here are the excerpts of an e-mail posted by Hareesh Iddya of Indian Institute of Science (IISc), Bangalore, on May 4, 2007 on ‘Down to Earth’ website, which show some emissions from the exhaust of FCIPT’s plasma pyrolysis system.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>CPCB Standard*</th>
<th>Plasma System</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>100 mg/Nm³</td>
<td>40-85 mg/Nm³</td>
</tr>
<tr>
<td>NOx</td>
<td>400 mg/Nm³</td>
<td>7.25 mg/Nm³</td>
</tr>
<tr>
<td>PM</td>
<td>150 mg/Nm³</td>
<td>31-105 mg/Nm³</td>
</tr>
<tr>
<td>Dioxin &amp; Furan</td>
<td>0.1 ng/Nm³ TEQ</td>
<td>0.1 ng/Nm³ TEQ</td>
</tr>
</tbody>
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*Central Pollution Control Board’s emission standards

Source: www.plasmaindia.com
demoralising effect on the efforts being put in by the Institute:

“Scientists at the IISc, Bangalore, have been working on biomass gasification for more than 20 years. They have developed fully commercial technology for producing heat or power from wastes. Though the technology is being implemented in several industries, certain upstream R&D is still required to modify the technology for proper utilisation of refuse-derived fuel.

“We were planning to try this technology through a pilot plant at a small town called Chitradurga where the estimated daily municipal solid waste production is 44 tonnes (15 tonnes of combustible material). The plant involves processes like segregation, drying and pelletisation of municipal waste before gasification with about 220 kW of power production. Of this, about 50 kW was estimated for in-house consumption. Under the plan, the plant was to be set up on a landfill site spread over an area of 14 hectares on the outskirts of the town. The project had also received approval from Chitradurga municipality.

“However, following a hullabaloo by well-intentioned environmentalists, the whole matter is now in a limbo.”

Import of foreign technologies for waste management. We should wisely evaluate all pros and cons before adopting any imported technology. We must draw lesson from the costly blunder that was made in 1980’s while installing a Danish-supplied incinerator at Timarpur in Delhi at a cost of Rs 410 million that ran for only six days because of high inerts and ash in the waste supplied. India lost the case at Hague because ‘suitable waste’ to be provided was not defined in the agreement. Current interest and caretaking costs have totaled a staggering Rs 2 billion or more. Even worse, this valuable waste-disposal site has been lost for decades to the city as the plant is neither being sold as scrap, nor are there any takers to take it over for operation.

Assessing viability of the imported plasma gasification technology. For assessing the financial viability of the projects, especially those involving foreign firms like Startech, the operating cost, net cost of operation and capital cost should be taken into account.

Operating cost. The electrical power requirement for conversion of one tonne of municipal solid waste into vitrified solids and metals, hydrogen and carbon monoxide gas averages around 670 units (kWh). At Rs 3 per unit, the cost of conversion works out to be Rs 2000 per tonne. Although one may be able to reduce the running cost by, say, 75 per cent, after selling the byproducts, the net cost of the plant would still be Rs 750 per tonne.

Net cost of operation. As an example, let us consider Delhi (not entire NCR) with its current population of over 15 million. The average garbage generation may be assumed to be 0.7 kg per person per day (against Americans’ average of about 2 kg per person per day). Accordingly, Delhi would be generating around 10,500 metric tonnes of garbage per day. The net operational cost would thus be Rs 7.875 million per day (at Rs 750 per tonne) or Rs 2870 million per annum. This is in addition to garbage collection and transportation and other infrastructure costs.

Capital cost. A Startech plasma converter that could handle 2000 tonnes of waste daily costs roughly $250 million. Delhi would require eight such huge plants at a whopping cost of $1000 million (roughly Rs 40 billion).

India, being a labour-intensive country, should employ matching technologies by segregating the various types of wastes and treating each one using indigenously-developed appropriate technologies.

Concluded