'BeauTifueL' Plasma gasification for conversion of garbage to fuel

By I.J. van der Walt, Necsa

Organic waste like bio-, municipal- and agricultural waste can be converted into fuel by a 'laptop' waste conversion plant. A thermal plasma process is used for gasification of the waste into a syngas that is scrubbed, compressed, cleaned further and converted into the desired product spread via a small-scale Fischer Tropsch process using a standard catalyst bed. This product is a liquid fuel and can be used to generate electricity. 'BeauTifuel' was showcased at the COP 17 conference in November/ December 2011 in Durban.

After plasma gasification was developed by the South African Nuclear Energy Corporation (NECSA), and the small-scale Fisher Tropsch process by the Centre Of Materials and Process Synthesis (COMPS), independent from one another, these two entities joined forces to develop a system that would be able to convert waste into fuel or electricity.

Plasma technology is widely used in the world for various applications including lighting, welding, metal melting, chemical analysis, surface modification and many more. Using a high temperature or thermal plasma, one can generate a high temperature zone superior to other conventional gasification techniques. Where the conventional techniques can only reach 800 to 1 100°C, the plasma gasifier is operated at 1 300 to 1 500°C. This increases the waste conversion efficiency from solid into syngas. The higher temperature also enables one to treat non-homogeneous types of waste that may contain some metal, glass or ceramics. All of the organic waste will be converted to syngas while the non-burnable components will melt and accumulate in the bottom of the reactor.

The Fischer Tropsch process was developed almost a hundred years ago in Germany and made famous by companies like SASOL, to produce hydrocarbon compounds like synthetic crude oil, waxes or gases. These products can be refined in order to produce products like diesel, paraffin, petrol, methane, propane, etc. COMPS mastered the Fischer Tropsch process to such an extent that they miniaturised the process in order to produce the synthetic crude oil on a few barrels per day scale.

Process

Different types of waste are generated in different forms. For instance plant material can be grass, leaves, wood chips or logs. Municipal waste can be food rests, plastics, paper, rubber, etc and medical waste will be supplied in a sealed box. For this reason waste should be homogenised with regards to the size in order to enable effective feeding of the waste into the plasma system. As indicated in *Figure 1*, the waste preparation step is the first step of this waste conversion system.

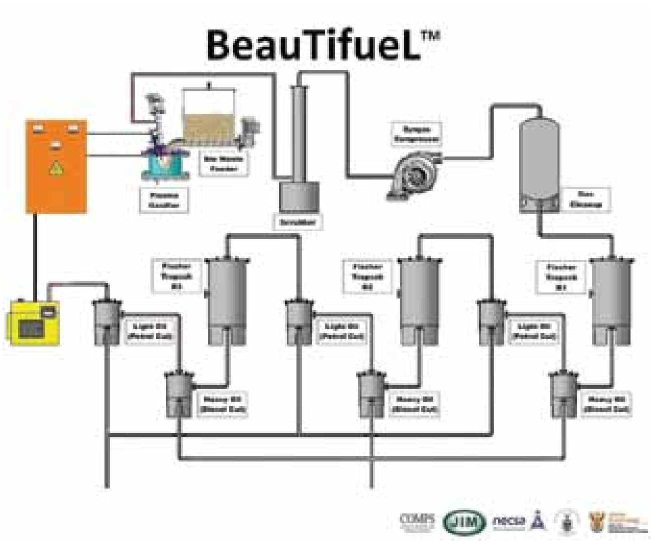

Figure 1: Plasma waste conversion system.

After waste preparation the waste is fed into the reactor at a rate of one to three tons per day. In the high temperature reactor the waste is converted by a thermal plasma, using air as plasma gas, into syngas. Depending on the waste, some reagents might be needed in order to optimise the efficiency of the conversion. In some instances the waste contains more carbon than can be converted on a continuous basis. In such a case CO_2 coming from the process is used as a reagent to convert all of the carbon.

After gasification, the gas is cooled down quickly to room temperature before it is stripped of any particulate matter and some inorganic components in a water scrubber.

After scrubbing the moist gas is compressed to a pressure of 4 to 10 bar, and dried before it is passed through a gas cleanup trap where activated carbon strips out any traces of sulphur. To increase conversion efficiency, three catalyst bed reactors were installed in series. Each reactor is fitted with two condensers/separators where a specific product range is extracted. The clean and sulphur-free syngas is now passed through the catalyst bed where the long-chain hydrocarbon generation starts.

After the last Fischer Tropsch reactor some unconverted gas along with gaseous hydrocarbon products will be used in a gas generator, generating electricity to run the system. This makes the running cost considerably cheaper.

The current system can convert one to three tons of waste and generate electricity and/or oil. The cost for such a unit will be R3 000 000.

Conclusion

This small system will be successful for a small community using one to three tons of waste on a continuous basis. The BeauTifueL system can convert a variety of waste into hydrocarbon liquid fuel. This fuel can then be used for running a generator or diesel engine transport vehicles. The hidden benefits are the fact that you spend less for fuel, you spend less for electricity, you reduce the volume of waste more that 95% and you create jobs.

The BeauTifuel system produces ~1 barrel of liquid fuel per 1 ton of waste and has a maximum capacity for 3 tons of waste on a daily basis. The unconverted gas as well as the gaseous fraction of hydrocarbon is used to generate electricity to run the plasma system. This reduces the running cost to a very small amount.

Acknowledgements

I would like to thank the Centre Of Materials and Process Synthesis (COMPS), the South African Nuclear Energy Corporation (NECSA) and the Technology Innovation Agency (TIA and DST) for collaborating to make this project a reality.

Dr IJ van der Walt received his Ph.D in 2008 and has extensive experience in high temperature chemistry and waste treatment. He has experience in plasma technology and applied this technology for experimental purposes for many applications, including mineral beneficiation, fluorocarbon production, waste treatment, etc.

Enquiries: Tel: 012 305 3216 or email jaco.vanderwalt@necsa.co.za.

About the author