Back to basics: Waste-to-liquid fuel

Pyrolysis, a process that converts hydrocarbon products like waste plastic and tyres back to their roots of liquid fuel, is a potential solution to reduce waste to landfill. *earthworks* looks at Japanese technology being tested locally and a homegrown company ready to enter the market.

A relatively new technology, pyrolysis is said to be the second best option for plastic waste after recycling, and infinitely preferable to landfilling. There are a number of different companies worldwide with patents on equipment and solutions using pyrolysis to convert waste plastic to oil, and a number of demonstration plants globally.

Since most plastics are made from crude oil by-products, the process essentially takes plastic back to its original form by using heat (but no oxygen) to reduce the plastic to a gas, which is then 'cracked' or condensed, forming oil.

Kraaifontein pilot

As part of its ambitions and obligations to divert waste from landfill, the City of Cape Town partnered with Japanese firm CFP to test the company's patented pyrolysis plant. The Kraaifontein waste management facility, north of Cape Town, is known as a 'clean MRF' (material recovery facility) dealing only with recyclable materials.

The pilot plant at Kraaifontein followed an agreement with the Japan International Co-operation Agency and was made possible through million grant funding from the organisation. The Japanese pyrolysis plant technology was developed and supplied by Kanyemiya and CFP Corporation. All equipment was manufactured in Japan and shipped to South Africa with the pilot phase starting in November 2015.

The waste plastic is processed through a washer, and is then sent through a shredder. The shredded material undergoes a heating process (no oxygen involved) and emerges as a thick sludge. This is then passed through a reactor, where extreme temperatures of up to 400°C result in a chemical reaction. Gasification occurs and then condensation, which leaves behind the oil.

Barry Coetzee, City of Cape Town manager technical strategic support: Utility Services, says in March the pilot plant was running at a conversion rate of between 50% and 70% – taking into consideration that the plant is designed to convert one kilogram of waste plastic into one litre of cracked oil. There are many impacts on the conversion rate and finding the right mixture, or blend of plastics is just one of those.

The plant at Kraaifontein is designed to process feedstock of three different types of plastic: polyethylene; polypropylene; and polystyrene. The different types of waste plastic must all be separated and cleaned.

Percival Swanepoel from the City of Cape Town's Kraaifontein facility was trained by CFP staff on how to operate the plant, which has a design capacity to process 500kg/day. About 75% of the fuel produced by the plant is fed back into generators that power the plant.

Research is being done on how the plant operates in South African conditions. Takuri Kokuba from CFP says usually 1kg of waste material would produce 1litre of fuel, but in South Africa, lesser efficiencies are being achieved. They found that in South Africa there are a lot of additives in the waste material, and this forms a residue, which lowers efficiencies as it means the tanks have to be cleaned out regularly.

Kokuba says environmental conditions such as strong winds at the Kraaifontein plant have played a role, and the plant has been adjusted for wind. As the pilot was running over the summer months, higher ambient temperatures also affected the equipment and process. On the labour front, language barriers made things difficult, as well as the South African work ethic, which is different to what CFP is used to in Japan.

The city's main concern is whether or not the pyrolysis plant is affordable, and if it ticks the boxes for alternatives to landfill. The Kraaifontein project is an opportunity to test this and the efficacy of the process as an alternative to landfilling. The cost of landfilling in South Africa, at about R350/ton, is relatively low compared to global costs in countries where space is a major issue. The six-month pilot ended late April 2016, and the city will assess whether or not this is a viable alternative.

"The feeling is that this technology is not a general waste alternative. There are other large-scale alternatives to landfilling in this resource economy and we need to look at all aspects. At every point in the value chain there is waste, and that is where we need to close the loops," says Coetzee.

Local innovators

Tucked away in Somerset West, GTEK Fuels, (part of GrahamTek Holdings) has been researching and developing a locally appropriate plastic and hydrocarbon waste-to-liquid fuel plant with global appeal.

The company's design is patented, and the technology has been developed and perfected over five years in South Africa, with a demonstration plant running for two years in Bot Rivier near Somerset West. The company is now ready to go to market. "We have researched how exactly to fit into the waste value chain, and how we can add value and best monetise the non-recyclable waste streams," says GTEK Fuels divisional director Tom Callaghan.

The GTEK Fuels plant is substantially different to the Japanese example. It is designed to process general and hazardous waste and can take multiple sources of hydrocarbon-based waste, including medical waste, e-waste, all plastic (except PVC) and waste tyres. This also means the equipment is much larger, and one production unit can process about 20 tonnes a day or 400t/month. It's best to keep plastics and tyres separate as plastics produce higher yields of fuel (about a 65% conversion rate), while tyres generally have a conversion rate of about 45%-50%.

"The general waste is inserted into a big, robust thermal chamber and is decomposed under heat (up to 400°C) and vacuum, creating a vapour in the absence of oxygen and any chemical catalysts. There is no combustion or incineration of waste," explains Callaghan.

Part of the vapour produced is diverted back to power the thermal chamber, reducing reliance on electricity. The rest of the vapour moves from the thermal chamber to gas-to-liquid units where it is condensed to form a synthetic gas that is converted into furnace or bunker oil (known as Marine Diesel Oil at about 700-800ppm) as it passes through condensers and atomisers. GTEK's patented process takes the thermal mechanical cracking process a step further, converting the furnace oils into clear 500ppm diesel that meets SANS 342 quality and could be used in heavy vehicles.

Ordinarily this would be where the process ends. Callaghan says the company is also registering a patent that deals with the emissions from the plant. The technology is designed to be a closed loop with zero emissions throughout the process.

In addition, GTEK has come up with solutions to deal with the residue left behind in the thermal chamber when processing waste tyres. Steel from the tyres can be sold to scrap dealers, but the other by-product, which does not convert to vapour in the chamber, is carbon char. "We have a patented process to convert waste carbon char residue into carbon black with a basic spec of N330, that can be further processed to achieve varying grades of carbon black. This is the stuff that tyre manufacturers use to make new tyres," says Callaghan.

The company is excited about this innovation, called the Pulveriser, which implodes the carbon char by using sub-sonic and super-sonic sound waves. The carbon char is reduced to a fine micron size powder, which is put though a chemical wash system to remove impurities. The end product is 'carbon black', which is sold back to tyre and rubber manufacturers.

Callaghan says the resulting impact of the process is a 95% reduction in volume of waste otherwise destined for landfill. There are markets for the products and when it comes to selling or using oil, one needs this to be done at large-scale to make it viable. GTEK is confident in the viability of this project, particularly since local manufacturing costs make it more affordable upfront.

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