Tyre and Plastics Pyrolysis

Introduction

Pyrolysis is a technique often confused with incineration. Both techniques work with high temperatures but the main difference is that pyrolysis works without oxygen being present. The lack of oxygen causes the base material to decompose and not combust (burn). Using the link below, more extensive information on pyrolysis can be found:

https://en.wikipedia.org/wiki/Pyrolysis

When browsing the internet (you-tube), numerous examples of (tyre) pyrolysis units can be found. What virtually all of them have in common are:

1) Batch-type processing and/or
2) Continuous Rotary kiln process. However not possible to seal this unit properly resulting in undesirable atmospheric emissions or – even worse – ingress of oxygen in the retort which may cause fire and/or explosion.

In the past 7 years, Mr. Jan Becker (retired professor after lecturing 26 years at the University of Pretoria) has worked on improving the pyrolysis process with emphasis on a designing a zero-emission, sealed Pyrolysis Unit. This resulted in November, 2015 in commissioning a production unit in Springs / South Africa capable of processing 30 tonnes of shredded tyres/day in a continuous process and free of emissions. The design is modular; multiple units can be installed and interconnected. In August of this year, the first Plastic Pyrolysis Unit will be commissioned near Johannesburg / South Africa. Shortly after commissioning, a full report will be placed onto www.dutchinspect.net

DutchInspect BV has acquired the rights for this technique for all territories except South Africa to market this concept world-wide. All units have been designed to fit into 20’ or 40’ containers to facilitate transport. An ordered unit will be operation within 6 months after placing the order.

The Pyrolysis technique can be applied to numerous commodities as long as the commodity entered into the process holds energy. Examples:

- Tyres
- Plastics
- Sewage waste
- Medical waste
- Wood
Tyre Pyrolysis

Feedstock and products + properties:

A single unit can process 30,000 kg shredded tyres per 24 hours. The shredded tyres are to be up to 50 mm in size. The steel can either be removed or remain inside the shreds. With 330 operational days per year, the total annual processing capacity for a single unit is 10,000 mt. During the balance 30 days per year the unit will be overhauled.

The daily input of 30,000 kg shredded tyres is equivalent with appr. 4000 car tyres or 650 truck tyres. Tyres from agricultural equipment and/or earthmoving equipment is also suitable.

The feedstock can be acquired by:

1) Collecting tyres and process the tyres on-site for storage and use
2) Collecting processed tyres
3) Collecting the tyres from abroad (*)

(*): Economically least interesting as subsidies given in the UK to waste tyre collectors.

In order to avoid down-time on the TPU, it is recommended to keep a feedstock of at least 10-15 days processing (300-450 mt). With a bulk-density of abt. 300-350 kg/cbm, the size of the feedstock will be around 1000-1500 cbm.

Input

Aside from the 30,000 kg shredded tyres per day, the following input is required:

1) Gas

The TPU is started with LPG or LNG. After 4 hours, the TPU reaches its operating temperature of 475 C. Then, the unit will run "dry" for 1 hour to ensure that all moisture has been removed. After appr. 8 hours running on feedstock, the syngas production will have stabilized and can be used to replace the LPG or LNG.

The TPU uses 2 gas burners:

LPG / LNG:  20 kg/hour (10 kg/hour per burner)
Syngas:      60 kg/hour (30 kg/hour per burner)

Note: The lower calorific value of the syngas causes the increased gas consumption of the two burners. The produced syngas is put through a scrubber which takes out Sulphur and Mercaptanes from the syngas. Burning the syngas will only result in CO2 and H2O as exhaust gases. The excess syngas can be used to dry the feedstock immediately prior to entering into the TPU.
2) Electricity

The total power required to run electrical motors and pumps is 25 kW. The intended warehouse has power connection.

3) Water

The water storage capacity for the heat-exchangers is 30 cbm. The circulating water will be cooled in the air outside the warehouse (similar to the set-up in Springs / South Africa). Daily expected water consumption: < 1 cbm/day.

4) Noise

The noise-output mainly comes from the 2 burners: 60-65 dBA (Springs / South Africa). In the new set-up, the burners will be positioned under the retort where in Springs / South Africa, the burners are positioned on the side of the retort. With the burners positioned under the retort, extra noise dampening measures can be taken to bring the noise-output to below 60 dBA.

**Output**

The output ratio for the various components is depending on the presence of steel wire in the shredded tyre. Figures based on 30.000 kg shredded tyres as daily input:

A: Shredded tyres without steel  
B: Shredded tyres with steel

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<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
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<tbody>
<tr>
<td>Oil:</td>
<td>48 % = 14.400 kg</td>
<td>40 % = 12.000 kg</td>
</tr>
<tr>
<td>Char:</td>
<td>45 % = 13.500 kg</td>
<td>38 % = 11.400 kg</td>
</tr>
<tr>
<td>Syngas:</td>
<td>6 % = 1.800 kg</td>
<td>4 % = 1.200 kg</td>
</tr>
<tr>
<td>Steel:</td>
<td>1 % = 300 kg (*)</td>
<td>18 % = 5.400 kg</td>
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(*): Based on experience, even shredded tyres from which the steel has been removed still contains abt. 1 % steel wire

**Oil:**

The oil produced by the TPU has a low viscosity; comparable to regular diesel oil. The analysis results of the oil (as for the char) will be added to this report

The Calorific Value (CV): 42 MJ/kg

For comparison: the CV of Diesel Oil is 36 MJ/kg

This oil is from renewable source and therefore has added value for its end-users
Char:

The char can be further processed to make an activated carbon. It is done in a fluidized system using steam and nitrogen as a carrier gas. The yield for the activated carbon using this process is abt. 40% of the original char mass. The balance of the char is converted into a syngas. The total quantity of syngas produced during the activation process can be used to generate electricity. The energy generated this way is equivalent to between 14-18 MW/day.

The char can also be sold to manufacturers of activated carbon products. One company on our list of potential buyers is Cabot Corporation in Rotterdam (http://www.cabotcorp.com).

The char can also be pelletized to serve as fuel in power plants. With this fuel being from renewable source, both producer and user can benefit from extensive subsidy programmes in the Netherlands, the UK and other countries in the EU.

Steel:

The steel will be collected and pressed into bales or in pellets for marketing

Syngas:

CV of the Syngas: 40 MJ/cbm = 830kW/h

For comparison: the CV of Natural Gas (LNG) is 32 MJ/cbm and that of LPG is 46MJ/cbm

When the TPU is processing shredded tyre, about 75% of the produced syngas will be used to maintain the process temperature of 475°C. The balance of the syngas can be used for:

- Drying the shredded tyre prior entering into the TPU
- Power generation
- Flare
The unit in Springs / South Africa consist of the following components (from left to right):

1) The Feeding Hopper

This hopper will be filled with shredded tyres. The feeder to the retort is sealed with a double flap-valve and purged with Nitrogen to prevent Oxygen from entering into the retort. The feeding is fully automated and controlled with a PLC system. The system processes 30 mt shredded tyre per day. The hopper holds 10-15 mt. This ensures that only 2-3 times/day, the hopper requires additional filling.

2) Retort + Condenser + Scrubber

Here, under temperature of 475 C, the shredded tyre will decompose into vapour, gas and solids. The vapour and gas are extracted through an opening at the top of the retort and entered into a condenser where the vapour will condensate into oil. The gas (syngas) will go to the next stage to be treated. The oil is pumped into holding tanks. The syngas will be scrubbed to remove the hydrogen sulphide and mercaptans to less than 2ppm. The syngas pressure is then increased to about 1 bar(g) and stored in a gas receiver under enough pressure to suit the burner requirements.

The (dry) solids (the char and steel wire) are extracted at the rear end of the retort and cooled. A magnetic drum separator then separates the char and the steel. Char and steel are collected separately in big bags.

During start up, the heat for the pyrolysis process is generated with a dual gas train burner system starting with LPG gas. After 8 hours when a steady state is reached the system will then run of the syngas from the syngas receiver. The volume of the syngas is more than sufficient to fuel the burners and sustain the process without the use LPG gas source.

The entire unit is electronically operated with exception of filling the Feeding Hopper. A series of sensors throughout the system will continuously monitor the pyrolysis process and steer the flow of gaseous, liquid and solid components. Throught the system, Oxygen sensors are positioned. Once
oxygen is detected, the TPU will automatically come to a full shut down.

**Storage of output components**

Oil

With a daily production of abt. 15,000 liters of oil per day, sufficient storage space is needed.

Syngas

The produced syngas will be stored into a tank under 800 mBar pressure. From this tank, the two burners for the TPU will be served. The excess gas can either be flared off or be utilized for drying purposes and/or generation of electricity.

Char

The char will be collected and stored into big bags. The storage will have to be done in a dry space.

Steel:

The steel will be collected. Storage is possible in big bags (as the steel will mostly consist of thin pieces of wire). Alternatively, the steel wire can be compressed into pellets or small bales. This material can be stored outside.
**Space requirements / operations**

The footprint of a Tyre Pyrolysis Unit measures 30 x 12 meters and a minimum ceiling height of 9 meters. This area does not cover the storage space for the resulting products: Oil, Char, Steel and Syngas.

The personnel requirements for operating a TPU:

- 1 supervisor
- 1 mechanic for maintenance
- 3 operators (material-logistics / operating/monitoring the PLC etc)
Requirements for delivery

Tyre Processing Unit – 30,000kg/day processing capacity

Basis: Turn-key delivery on site in 40’ and 40’Open Top containers)

Conditions:

- Excluding all fees, taxes, levies etc. for delivery from South Africa to the United Kingdom
- Excluding labour for assembly; assembly under supervision from the manufacturer
- Excluding operational personnel

The buyer shall provide with”

- Space to house the equipment
- Licences, permits etc. to operate the equipment
- Storage space for feedstock (shredded tyres) and products (Oil / Gas / Char / Steel)

Delivery time: appr. 6 months

Price: Upon request
**Plastics Pyrolysis**

**Plastic Pyrolysis Unit**

*Key features of the Plastics Pyrolysis Technology:*

- The oil produced can be blended with diesel for use in commercial transport or other industrial applications as a renewable fuel source.
- The oil produced can be utilized to generate electricity.
- A proportion of the Syngas produced within the process is used to power and heat the process itself.
- The remaining balance of Syngas can also be used to generate electricity.
- The waste solids (mostly sand) can easily be disposed of without any environmental impact or hazard.
- The pyrolysis technology is modular and a single unit can process up to 50 mt/day of plastics.
- The raw plastic feedstock can be any type or mix of plastic except PVC.

These mentioned plastics cover the vast majority of waste plastics. Plastic recycling comes with the problem that – aside from collected PET drinking bottles – plastics are often mixed. Mixed plastics have very limited use and often ends up in a waste disposal plant for incineration with inevitable emissions into the atmosphere.

Collected waste plastic cannot be entered into the Plastics Pyrolysis Unit (PPU) without pre-processing. Plastic film is too light and reacts too quickly in the retort. The collected plastics will be granulated, heated and dried and pressed through an extrusion machine to form the ideal feed for the PPU.

Currently, three types of Plastic Pyrolysis Units have been designed:

a) 4.8 mt/day capacity with a 600 mm diameter retort
b) 10 mt/day capacity with a 750 mm diameter retort
c) 50 mt/day capacity with a 1750 mm diameter retort
Plastic pyrolysis (at 500 C) results in the following products:

- **Oil (\(^*\))**: 90 %
- **Syngas**: 9+ %
- **Dirt / sand (\(**\))**: < 1 %

\(^*\): The Oil / Gas ratio may vary slightly depending on the plastics composition
\(**\): The collected plastics will pick up dirt and sand during collection / transport and this will be the solids remaining after the pyrolysis process.

**Oil:**

The oil produced by this unit has a low viscosity, same as te oil obtained from tyre pyrolysis but with two advantages:

- a) The oil from plastics pyrolysis is virtually Sulphur free
- b) The Calorific Value (CV): 46 MJ/kg

The Calorific Value (CV): 42 MJ/kg

For comparison: the CV of Diesel Oil is 36 MJ/kg and the CV of Tyre Pyrolysis Oil is 42 MJ/kg.

**Syngas:**

CV of the Syngas: 40 MJ/cbm = 830kW/h

For comparison: the CV of Natural Gas (LNG) is 32 MJ/cbm and that of LPG is 46MJ/cbm

The gas generated by the Plastics Pyrolysis Unit will mostly (75-85 %) be used to maintain the operating temperature of 500 C.

The balance of the syngas can be used for:

- Drying the plastics prior pelletizing
- Power generation
- Flare
**Space requirements / operations:**

The footprint of a Plastics Pyrolysis Unit measures 30 x 8 meters and a minimum ceiling height of 7 meters. This area does not cover the storage space for the resulting products: Oil, Char, Steel and Syngas.

For the plastics pre-processing (granulating / pelletizing), another 12 x 10 meters surface space is required.

The personnel requirements for operating a TPU:

- 1 supervisor
- 1 mechanic for maintenance
- 4 operators (material-logistics for both units / operating/monitoring the PLC etc)

Note: When both a Tyre Processing Unit and a Plastics Processing Unit are used within the same perimeter, less personnel is required; the supervisor and the mechanic can cover both units. The operational staff for the 2 units combined will be 5 in total: 2 PLC operators and 3 people for material logistics.
Requirements for delivery:

Plastics Processing Unit – 4.800kg/day processing capacity including (plastics granulator / pelletizer)

Basis: Turn-key delivery on site (in 40’ and 40’Open Top containers)

Conditions:

- Excluding all fees, taxes, levies etc. for delivery from South Africa to the United Kingdom
- Excluding labour for assembly; assembly under supervision from the manufacturer
- Excluding operational personnel

The buyer shall provide with:

- Space to house the equipment
- Licences, permits etc. to operate the equipment
- Storage space for feedstock (collected plastics / plastic pellets) and products (Oil / Gas / Sand and Dirt)

Delivery time: appr. 6 months