C. Gisèle Jung*, André Fontana*

Scrap tyres pyrolysis: technology and equipment update, by-products valorisation

Scrap tyres, classified as priority waste stream by EU Commission, present disposal problems. According to recently prepared the EU Landfill Directive dumping will not more be allowed. There is a need for optimisation of the choice between material and energy valorisation in relation to the existing secondary raw material market. The quantity and quality of the end-products depends mainly on the process parameters. Qualifying the end products (char and oils) is necessary in order to fit with the market and to reach the best adequation with the demand.

The study shows the evaluation of different combinations of unit processes to achieve marketable secondary raw material.

Key words: scrap tyres, pyrolysis

Piroliza zużytych opon: najnowsza technologia i urządzenia, waloryzacja otrzymanych produktów


Na podstawie badań oceniono różne układy procesów jednostkowych służących do otrzymywania produktów o wartości handlowej.

Słowa kluczowe: zużyte opony, piroliza

Scrap tyres, classified as priority waste stream by EU Commission, present disposal problems. According to recently prepared the EU Landfill Directive dumping will not more be allowed. There is a need for optimisation of the choice between material and energy valorisation in relation to the existing secondary raw material market. The quantity and quality of the end-products depends mainly on the process parameters. Qualifying the end products (char and oils) is necessary in order to fit with the market and to reach the best adequation with the demand. In order to optimise the choice of a process, this work is presenting the different ways of by-products valorisation (material and/or energy).

The study shows the evaluation of different combinations of unit processes to achieve marketable secondary raw material. The objective is to define the best choice in:
• Low cost *stand alone* pyrolysis producing substitution fuels for energy valorisation;
• *Integrated pyrolysis* with post-treatment producing high added value end-products or energy.

A better managed industrial process, matching the market requirements, leads to a safe, sustainable and economic valorisation of used tyres. Innovative development of pyrolysis and gasification systems of scrap tyres at small-medium size could be useful as decentralised treatment. The products that are produced after pyrolysis are classified according to their quality and value.

In the present paper, an updated overview of the industrial and pilot plants using pyrolysis with different technologies including or not a post-treatment are presented.

**Process description [1]**

**Introduction**

Pyrolysis is a pre-treatment of waste at moderate temperature (450-750°C) in the absence of oxygen. The decomposition of the contained organic matter leads to the formation of gaseous and solid phases.

These phases are rather homogeneous so that their thermal valorisation can be performed easily in better environmental conditions than the direct incineration. The pyrolysis technique valorises their heat content by producing a stable storable solid fuel and an excess of gas to be burned. Pyrolysis furnaces can be sized for various tonnage. Current trend seems to fit scale from 2 to 6 t/h per unit corresponding to capacity between 15,000 and 50,000 t/y. On the other hand, small pyrolysis furnaces from 1 to 2 t/h (8,000 to 15,000 t/y) can be decentralised to reach local waste elimination.

**Technical aspects**

After pyrolysis, both solid and gaseous fuels have to be valorised.

*Pyrolysis (pre-treatment):*

There are several furnace types directly or indirectly heated, under vacuum or controlled atmosphere. Furnace technologies differ from the different constructors such as:

- vertical reactor
- horizontal reactor
- fixed or moving bed
- fluidised bed

![Pyrolysis Process Diagram](image-url)
Tyres are introduced in the furnace by an airtight mechanism. Organic compounds are progressively thermally decomposed. The furnace temperature is fixed typically between 450° and 750°C. The process generates a solid char (that is evacuated out by an airlock system) and a gaseous phase. The residence time lies generally between 30 and 60 minutes (rotating kiln) or up to 8 hours for a fixed bed.

**Pyrolytic coke:**
For tyres pyrolysis, the solid carbon residue is like a low volatile bituminous coal (28MJ/kg), 3-5% sulphur with 15% ashes. After magnetic separation of the steel (150 – 200 kg/tyre), the solid fuel can be directly sent to a combustion or a gasification unit in an integrated process.

**Pyrolytic gases:**
The proportions and composition of gases from tyre pyrolysis depends mainly on the process temperature and pressure, and on the residence time in the furnace [2].

Gases issued of pyrolysis are composed by a light non condensable phase (35MJ/kg) and an oil (40MJ/kg). The oil (eventually after cracking) is generally burned with the light phase. Combustion in a well-adapted boiler could generate the energy necessary for heating the pyrolysis furnace and auxiliary devices. The energy excess can be valorised in a heating system or in an electricity power production system.

**Classification of pyrolysis furnaces**
- with indirect heating by fuel, electricity or fumes. These furnaces lead to a possible valorisation of both pyrolytic solid and gases by post-treatment
- with direct heating by the gases produced by total or partial combustion of the pyrolytic gases and/or solid. These furnaces lead to a possible valorisation of the solid by post-treatment

**Furnace technologies**

**Pyrolytic furnaces with indirect heating:**
- **Rotary kiln:**
  - Constructors: THIDE-PKA (+ pilot available), Svedala, Carbon Products International (batch), RAT, Comerio
- **Moving bed reactors**
  - Moving chains
    - Constructors: Traidec (+ pilot available), Pyrocycling (pilot),
  - Rotating blades
    - Constructors: Alcyon, Okada

**Pyrolytic – gasification furnaces with direct heating**
- **Rotary kiln:**
  - Constructors: Basse-Sambre-ERI
- **Fixed bed reactors**
  - Batch cells
    - Constructors: Nexus (+ pilot available)
  - Vertical furnace
    - Constructors: Terra
- **Moving bed reactors**
  - Multiple-hearth furnace
    - Constructors: NESA (+ pilot available)

**The choice of a technology**
There is a need to choose the best technology, well adapted to the local situation (waste dispersion and end-products market). Taking into account:
- the revenues from the tipping fee for the tyres elimination and the sale of the energy and/or the end-products,
- the global costs (transport, financial, operating and ultimate residue elimination), the solution lies between a stand-alone pyrolysis plant with energy valorisation, and a process with a post-treatment (and the production of high added value products).

**References**