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Pyrolysis of tyres: A comparison of the results from a fixed-bed laboratory reactor and a pilot plant (rotatory reactor)

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Abstract

A comparison is made of two similar processes run on different scales. On one hand, tyre pyrolysis experiments were run in a fixed-bed laboratory reactor, designed to allow for the separation of the solid, liquid and gas fractions. On the other hand, experiments were run in a tyre pyrolysis pilot plant with a rotatory reactor, where solid and gaseous fractions were obtained. The solid fractions from both processes were subjected to chemical analyses (proximate, elemental and of calorific value) and thermal analyses, with no significant differences found in the analyses of the two solid fractions. The gas fractions from both processes were analysed by gas chromatography, the results showing small differences in composition and calorific value, because of the different operating conditions of each facility, mainly the heating ramp and residence time.

Keywords: Pyrolysis; Tyres; Thermogravimetry; Gas chromatography

1. Introduction

Increasing numbers of discarded tyres have become a problem. The most common way of dealing with them is dumping, which entails great economic losses and environmental pollution. Recent data show that in the European Union, 2.5 million tonnes of scrap tyres appear each year, equivalent to 80% of new tyre sales. Tyres are made up of different materials: organic ones of a polymeric type, such as natural or synthetic rubber, inorganic ones and metals. This complex structure makes recycling difficult [1]. A possible solution to the problem is to treat tyres not as waste, but as an energy resource [2].

The company Recuperación Materiales Diversos, S.A. (RMD) is carrying out recovery of electrical and communication cables and scrap tyres, based on the recuperation and separation of the polymeric and metal contents. In the case of discarded tyres, the company has set up a pilot pyrolysis plant where tyres are subjected to thermal decomposition into two fractions, solid and gas, both of which can be used as fuel for generating energy.

A comparison is offered here of results of tyre pyrolysis experiments run in a rotatory reactor at the company's pilot plant and in a fixed-bed laboratory reactor, with a view to the former being improved.

2. Material and methods

2.1. Experiments

For the laboratory experiments, 50 g batches of ground tyre shreds with a particle size of 0.42 mm were used, while for those run at the pilot plant, batches were of about 20 kg with a particle size of between 1 and 5 cm. Both samples were obtained by the mechanical shredding of average-sized tyres.

Two experiments run in the rotary bed reactor of the pilot plant (PP1 and PP2), are compared with one experiment on the laboratory fixed bed (LR). A similar temperature was

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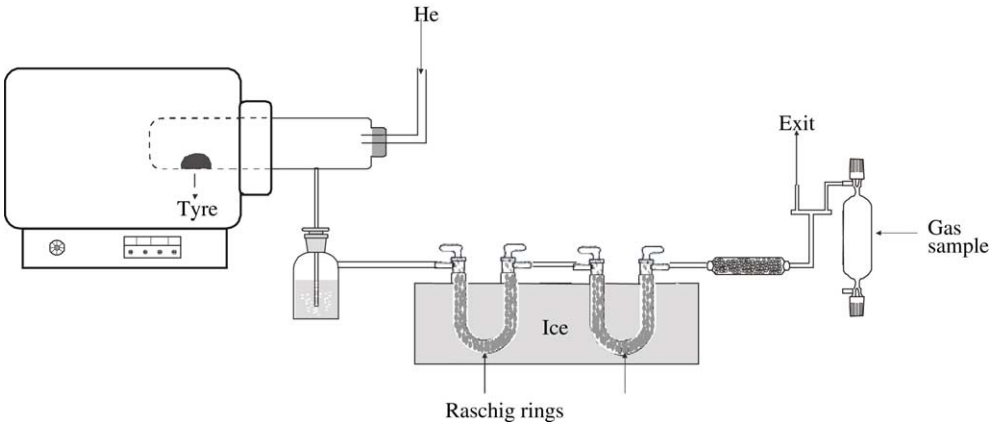

Fig. 1. Scheme of the laboratory experiment.

used in both cases, about 550 °C, at which temperature devolatization is complete [3].

2.2. Laboratory

The scheme of the laboratory-scale experiment is shown in Fig. 1. A reactor was placed in a horizontal oven, consisting of a quartz tube 40 cm long and 7 cm in diameter, which was loaded with the sample. The oven was heated electrically with a heating rate that was not constant but which increased with temperature, from 5 to 60 °C/min. In the forward part of the reactor there was a gas intake, the carrying gas used being helium with a flow rate of 200 mL/min. The gas products of the process came out through the lower part of the reactor. To clean the gas and separate it from the condensable fraction, three stages of traps were set up. Firstly, the gases leaving the reactor made direct contact with ice, and then passed through two columns placed in ice and packed with ranching rings, to be finally filtered through a tube packed with cotton and silica gel. The process lasted about 15 min, the time taken for the reactor to reach 550 °C.

2.3. Pilot plant

The pilot plant reactor is shown in Fig. 2. The shredded tyre was fed in discontinuously, in batches, through a hopper and two valves, thus ensuring conditions of oxygen-free atmosphere. The pyrolysis reactor consisted basically of an electrically heated chamber containing a wormscrew that pushed the shredded tyre material through the reactor. In the reactor, the atmosphere was totally oxygen-free (inert), and the temperature was kept constant at 500–600 °C, which brought about the thermal decomposition of the tyre material [4]. Inside the reactor, a slight depression was kept up with a suction pump, which moved the gaseous products from the furnace to the combustion chamber. In this case, the process lasted about 30 min, the time taken for the shreds to leave the reactor.

2.4. Sampling and analysis

The horizontal-oven laboratory tests produced three fractions: solid, liquid and gas, while the pilot plant only gave two: solid and gas, principally because of the operating

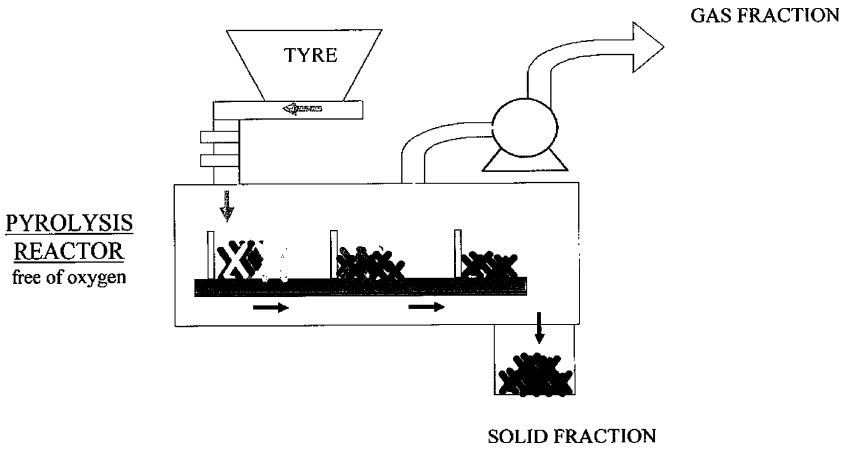

Fig. 2. Scheme of the pilot plant reactor.