CONICAL SPOUTED BEDS TECHNOLOGY FOR RECYCLING OF POLYETHYLENE WASTES

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Abstract

Conical spouted beds for recycling of polyethylene wastes have been used in order to tune up and determine the operating conditions for the thermal treatment. Hydrodynamic study has been carried with beds consisting of polyethylene wastes, of polyethylene pellets and of their mixtures at different operating conditions. Operation maps to operate in transition regime have been determined, as well as, the evolution of bed expansion with gas velocity to design conical contactor height.

Keywords: *Spouted Beds, conical spouted beds, polyethylene wastes, polyethylene recycling, thermal recycling*

1. Introduction

The increasing in consumption of plastic materials in developed countries has become in an environmental, therefore recycling is the viable option at the moment, thermal decomposition or pyrolysis is one of the procedures for recycling plastic with best perspectives for obtaining feedstock and fuel.

Spouted beds technology has been used in the design and in the pyrolysis of virgin plastics [1-4], which great advantages over other gas-solid contact techniques, particularly over the bubbling fluidized-bed reactor, which is the more developed technology for this process. However, bubbling fluidized-bed reactor has the great inconvenience of defluidization caused by the stickiness of sand particles coated with fused plastic [4]. The conical spouted bed has a vigorous movement of the solid which avoids the agglomeration of particles, so, the conical spouted bed requires a lower sand/plastic ratio, and so it has a greater production capacity by volume unit.

In a previous paper, the contactor has been designed and operating conditions has been determined with beds consisting of virgin raw polyethylene. In this paper, operating conditions to operate in transition regime and the evolution of bed expansion with gas velocity have been determined for thermal treatment of polyethylene wastes in conical spouted beds.

2. Materials and Methods

The experimental unit used has been described in detail in previous papers [5] and allows for operating with contactors of different geometry. The blower supplies a maximum air flow-rate of 300 $Nm^3 h^{-1}$ at a pressure of 15 kPa. The flow rate is measured by means of two mass flowmeters controlled by a computer and by two rotameters up to 300 $Nm^3 h^{-1}$ The accuracy of this control is $\pm$0.5% of the measured flow rate [6].

A differential pressure transducer (Siemens Teleperm) registers bed pressure drop signal. AMR-Control software registers and processes the air velocity data, which allows the acquisition of continuous curves of pressure drop vs. air velocity.

A conical contactor, Figure 1, made of polymethyl methacrylate has been used, whose dimensions are: column diameter, D_c, 0.36 m; bed bottom diameter, D_b, 0.06 m; contactor angle, γ, 36º; gas inlet diameter, D_o, 0.03, 0,04, and 0.05 m.

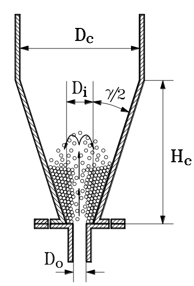

Fig. 1. Geometric factors of the conical contactor and outline of the particles.

The solids used are pellets of high density polyethylene (HDPE) and low density polyethylene (LDPE) and plastic wastes supplied by company Tuboplast Hispania S.A. Material properties and recycling symbols of plastic wastes are shown in Table 1. Melting point of HDPE and LDPE are 137 and 115ºC respectively and glass transition temperature -90ºC and of LDPE -110ºC. Both plastic materials are chemically resistant against acids, basics and alcohols. Mixtures, Table 2, have been obtained mixing polyethylene pellets and wastes of the same material with 25, 50 and 75 wt%. The stagnant bed heights studied are in the range 0.05 - 0.35 m.

Table 1. Properties of the materials.

Material	ρ_s (kg/m^3)	size range (mm)	$\bar{d}_S$ (mm)	ϕ	ε_o
LDPE pellets	923	2.7-5	3.5	0.95	0.34
HDPE pellets	940	2.7-5	3.5	0.92	0.36
LDPE wastes (4 LDPE)	923	10x12x0.5-14x18x0.5	5.3	0.24	0.35
LDPE wastes (2 HDPE)	940	10x12x0.5-14x18x0.5	5.3	0.24	0.35

Table 2. Properties of the mixtures.

Material	ρ_s (kg/m^3)	weight percent (wt%)	$\bar{d}_{S\ mixture}$ (mm)
LDPE mixtures	923	25, 50, 75	3.8 4.2 4.7
HDPE mixtures	940	25, 50, 75	3.8 4.2 4.7

3. Results and Discussion

The stable operating conditions of beds of polyethylene wastes in spouted beds have been delimited in diagrams of stagnant bed height, H_o, against gas velocity, u.

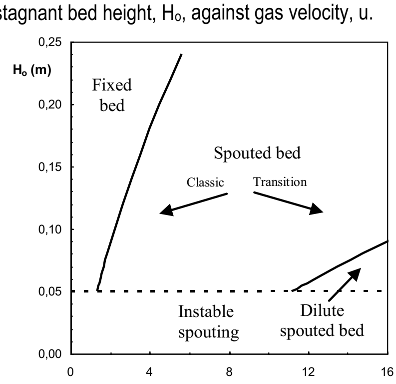

Fig. 2. Operating regimes in conical contactors. Experimental conditions: γ = 36°; D_o = 0.04 m and HDPE of $\bar{d}_S$ = 5.3 mm.

In Figure 2, the results plotted as an example correspond to a spouted bed contactor geometry (γ= 36º; D_o= 0.04 m) and for a bed consisting of HDPE of 3.5 mm of particle diameter and for different values of the stagnant bed height. The borders between the regimes, drawn with solid lines, have been obtained experimentally for each stagnant bed height. As it is observed, as gas velocity is increased bed passes from fixed bed to spouted bed regime. It is noteworthy that the HDPE has an instability region for low stagnant bed heights.

The experimental value of minimum spouting velocity is determined from the values of pressure drop by decreasing slowly gas flow as the point when the pressure drop levels off and it increases as stagnant bed height is increased and.

4. Conclusions

Gas inlet diameter and height of conical spouted bed reactor have been obtained for thermal treatment of polyethylene pellets, wastes and their mixtures, in a wide range of gas flow rate. Furthermore, it is determined that mixtures improve bed performance in the transition regime between conventional spouted bed and dilute spouted bed regimes.

These results predict good perspectives for polyethylene wastes recycling by this technology.

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