Segregation of domestic wastes of fruit and nut shells in a conical spouted bed reactor

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Abstract

☑ The energy recovery from waste is increasing at an annual rate of 4% since 2000, with 55% of all the waste to energy conversion happening in Europe [1]. Biomass is the largest contributor to the renewable energy consumption of EU [2].

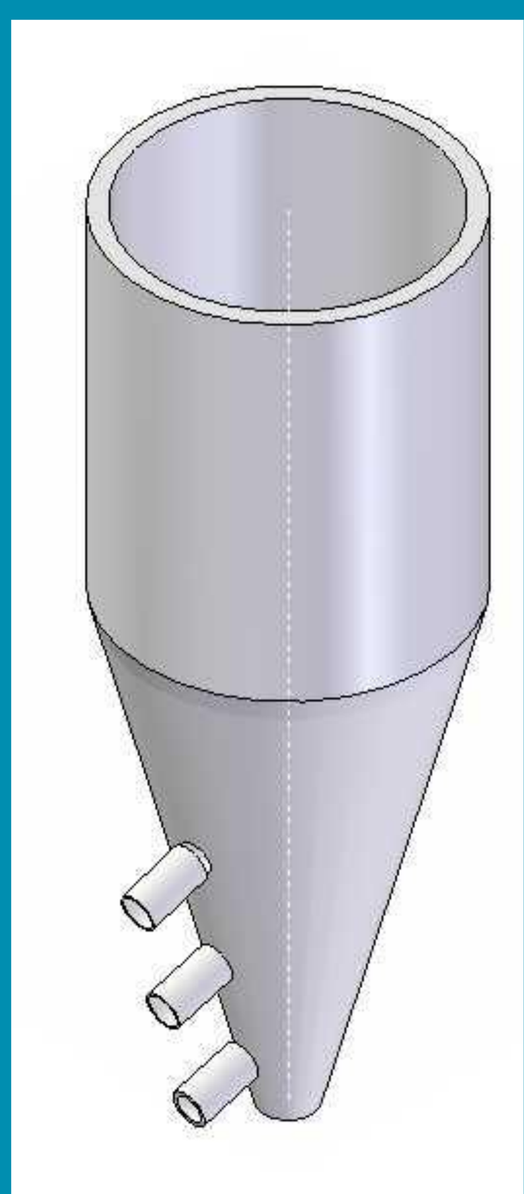
☑ Spouted beds technology can be a sustainable alternative for energy exploitation of renewable biomass wastes. Most of the applications of spouted beds involve mixtures of solids of different particle sizes and/or densities likely to segregate which may cause moisture and temperature profiles.

☑ First qualitative studies of segregation date from 1977 [3] in a half-column of spouted beds. Subsequent studies of segregation in spouted beds have been summarized by Rovero and Piccinini [4]. Recently segregation has been analyzed in spouted beds by Marques and Bacelos [5], by Santos et al. [6], and by Du et al. [7]. Segregation in conical spouted beds has been studied with binary and ternary mixtures [8-10]. Nevertheless research about segregation of biomass wastes mixtures in conical spouted beds is scarce, Xabier et al. [11].

☑ In this paper, the segregation performance of beds consisting of domestic wastes of pine nut and halzenut shells of different particle size and/or density has been experimentally analyzed in conical spouted beds with different mass fractions and the degree of segregation has been quantified by a mixing index.

Materials and Methods

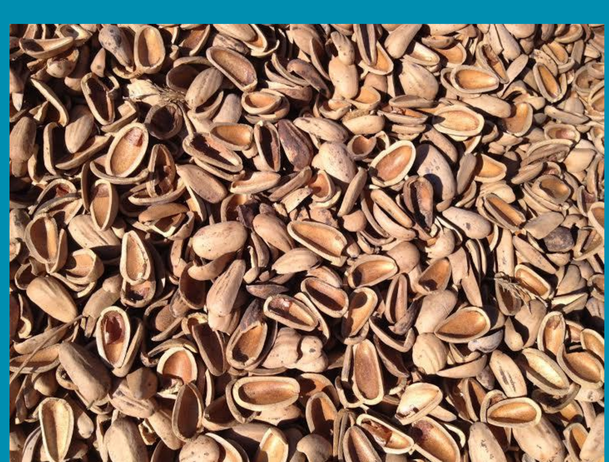
Experimental equipment with the conical spouted bed reactor



Spouted bed reactor

☑ **Pine nut shells wastes**

Density, ρ_s= 1212 kg/m^3
Mean Sauter diameter, d_s = 3-5 mm
Solids moisture content 6.5 wt% (dry basis) measured by Mettler Toledo HB43-S Halogen



Pine nut shell wastes

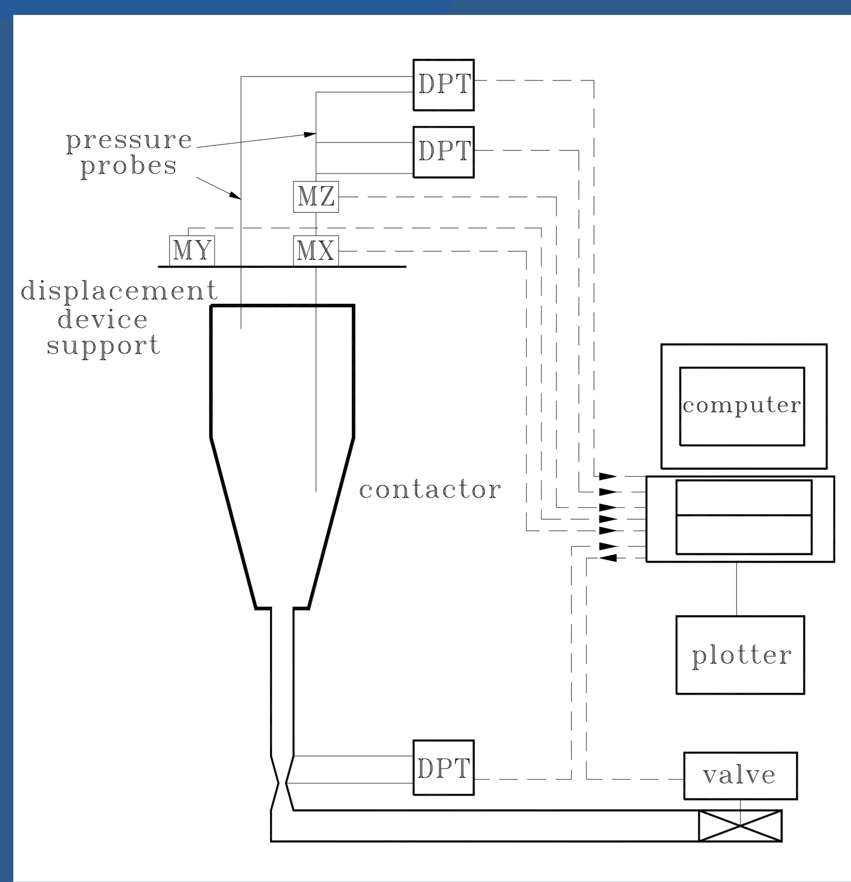
☑ **Biomass wastes**

Density, 910 kg/m^3
Particle diameter, d_s = 4-7 mm
Solid content range 9 wt% (dry basis) measured by Mettler Toledo HB43-S Halogen

Hazelnut shell wastes

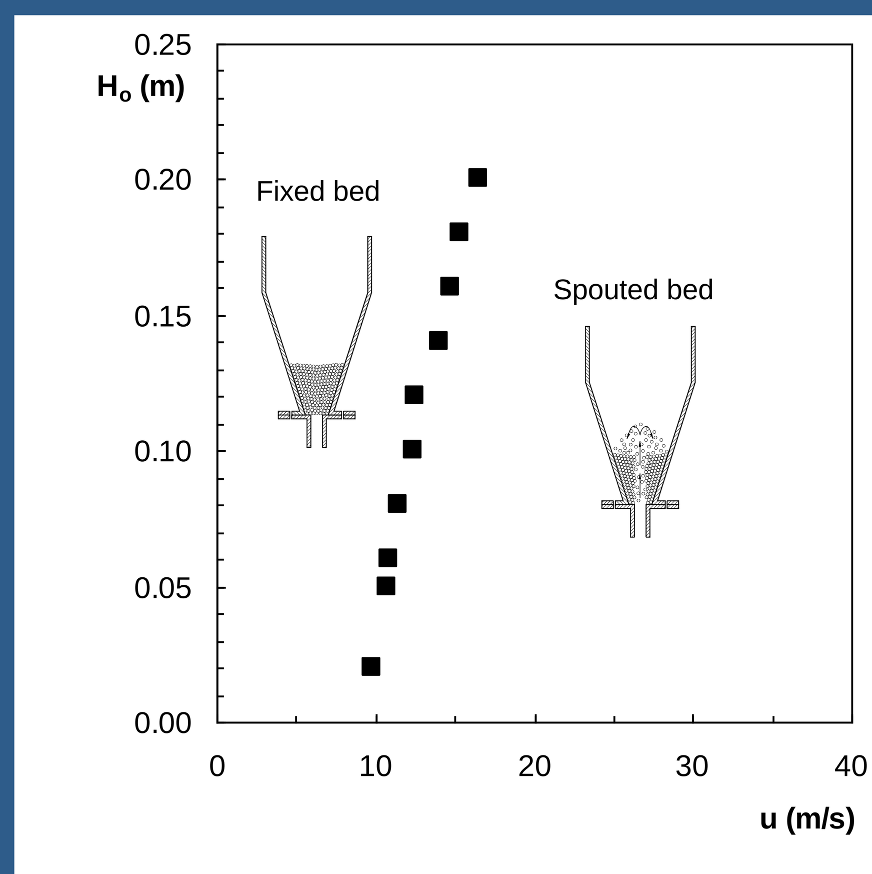
Sampling Device

☑ Probe connected to a suction pump
☑ Vertical tube of 14 mm i.d
☑ Radial and longitudinal position established by means of a computer-coordinates displacement device
☑ Sampling distance of 20 mm
☑ Optimum sampling duration was estimated between 3 and 5 s
☑ Each sampling repeated three times at each position
☑ Solids returned to the contactor after each sampling



Results

☑ Operating conditions for beds consisting of wastes of binary mixtures of pine nut and hazelnut shells have been determined in the spouted bed regime.
☑ By increasing air velocity from zero, the bed passes from the fixed bed to the spouted bed regime and the corresponding velocity is the minimum spouting velocity.
☑ The minimum air flow rate was determined when the standard deviation pressure drop fluctuations was lower than 10 Pa [12].
☑ Minimum spouting velocity increases with the stagnant bed height.



Operating map of stagnant bed height against gas velocity. γ= 36º, D_o= 0.04 m, binary mixtures of pine nut and hazelnut shells of 50 wt% of d_s= 4.12 m.

☑ The mixing index index, M_b, has been calculated from the experimental values of weight fraction of particles of greater effective diameter and or density in the upper volume half of the bed and the weight fraction on the whole bed [10].

$$M_b = (\overline{X_B})_u / \overline{X_B}$$

☑ The high mixing index obtained, around 1.1, proves the uniformity of the beds consisting of binary mixtures of pine nut and hazelnut shells.

References

[1] Kummamur, B. WBA Global Bioenergy Statistics, 2017.
[2] European Commission. Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Renewable Energy Progress Report. COM(2017) 57 final. European Commission, Brussels.
[3] Piccinini, N., Bernhard, A., Campagna, P. & Vallana, F. Power Technol., 1977, 18, 171
[4] Rovero, G. & Piccinini, N. In: Spouted Spout-Fluid Beds, Cambridge, 2011141.
[5] Marques, I.I.D.R. & Bacelos M.S. Chem. Eng. Process., 2013, 70, 37-47.
[6] Santos, K.G., Campos, A.V.P., Ferreira, L.V., Santana, R.C. & Barrozo, M.A.S. Chem. Eng. Technol., 2013, 36(12), 2148.
[7] Du, W., Zhang, J., Bao, S., Xu, J. & Zhang, L. Powder Technol., 2016, 301, 1159.
[8] Bacelos, M.S. & Freire, J.T. Ind. Eng. Chem. Res., 2006, 45(2), 808.
[9] Olazar, M., San José, M.J., Peñas, F.J., Aguayo, A.T. and Bilbao, J. Ind. Eng. Chem. Res., 1993, 32, 2826.
[10] San José, M.J., Olazar, M., Peñas, F.J. & Bilbao, J. Ind. Eng. Chem. Res., 1994, 33, 1838.
[11] Xavier, T.P., Libardi, B.P., Lira, T.S. & Barrozo, M.A.S. Powder Technol., 2016, 299, 210.
[12] San José, M.J., Alvarez, S. Chem. Eng. Technol. 38(4) (2015), 709-714.

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