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Air-carton packaging waste flow dynamics in a conical spouted bed

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Abstract

Currently, the generation of modern solid waste has caused large environmental impact. Because of the high added-value components, the carton packaging highlights among the wastes generated in large urban areas. The manufacture of tiles (or plates) and the pyrolysis are the main routes for the recycling of these wastes. In literature, the conical spouted bed has been pointed out as a promising air-solid contact system for processing the pyrolysis. Thus, this research aims to analyze the air-carton packaging waste flow dynamics in a conical spouted bed. The flow behavior of air-waste was experimentally investigated by analyzing data of bed pressure drop, air velocity and fountain height. Moreover, the simulation of operating conditions in the conical spouted bed was conducted using the computational fluid dynamics (CFD). It was found that particles of carton packaging in a shaped of disks do not achieve the spouting regime. However, for beds with mixtures composed of polyethylene and carton disks(5 and 10% carton weight), the spouting regimes wereattained.Furthermore, the simulations in ANSYS FLUENT software using the Eulerian Granular Multiphase model showed good agreement with experimental data.

*Keywords:*Pyrolysis; carton packaging waste; fluid dynamics; spouted bed; CFD

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1. Introduction

Originally conceived in 1954 as an alternative to fluidized bed for the drying of grains of wheat, the spouted bed has been employed in various unit operations beyond the drying [1-2], such as in coating and granulation of particulates [3-4] and pneumatic transport [5]. Recently, the conical spouted bed (CSB) has been applied successfully as a chemical reactor in processes involving systems with eithermonosized particles or particle size distribution. Among these processes, the coal gasification [8], catalytic polymerization [9] and pyrolysis [10-11]can be cited.

Concerning the waste recovering, the pyrolysis technique in conical spouted bed has played a promising role in the utilization of biomass and solid wastefor a small scale production.In this context, many efforts have been concentrating to show the application of the conical spouted bed in the pyrolysis of materials such as sawdust [12], plastics [13] and tires [14].

In relation to the post-consumer carton packaging waste, i.e., a modern waste commonly seen in large urban areas, recovering was found to be the most feasible alternative for carrying out packaging Industry to reach the required environmental achievements.In addition, due to the value-added carton components, their reuse represents a highly profitable activity.

Because of post-consumer carton packaging waste characteristics,i.e., the multilayered structure,composed of different materials (paper, paper, polyethylene and aluminum),makes difficult wastes degradation in nature.Consequently, this becomes post-consumer carton packaging wastea potential polluter agentto the environment.

As reported in the literature, pyrolysis of carton packaging is an innovative and clean technology permitting that not only aluminum and polyethylene can be separated between each other but also coal high heating value andlow ash content can be produced [15-16-17].

In general, with respect to the simulation of air-particle flow in spouted beds, many efforts have been concentrated,but only few have done using CFD techniquefor describingconical spouted beds fluid dynamics [3-6-7].This tool can significantly contribute to the applications of CSBsfor different types of processes.The CFD technique usage, supported by experimental results, has aided practitioners to understand phenomena involved and operate the equipment efficiently.

Thus, in order to contribute to the CSB application as a pyrolysis reactor, this paper aims to conduct a theoretical and experimental investigation onair-waste fluid dynamics in a conical spouted bed.This research is focus on the following steps: 1) to obtain experimental data of bed pressure drop as a function of air velocity in the bed and analyze the minimum spouting operation conditions achieved; 2) to simulate the operating conditions of conical spouted bed using CDF technique and state comparisons to those obtained experimentally.

Nomenclature

CD Carton Disks

EGMMEulerian Granular Multiphase Model

PE Polyethylene

D_pDiameter

H_fFountain Height