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Study on the separators for plastic wastes processing

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Abstract

The separating principle of the cyclone separator has been analyzed by analyzing the tangential speed, the axial speed, and the pressure distribution of the flow field inside the cyclone separator. The dimensional parameters of the separator with larger effects on the separation efficiency of plastics have been identified such as the length of the overflow pipe, the length of the separator, and the diameter of the discharge opening. Based on Taguchi method, orthogonal experiments have been designed for separating process parameters according to the identified dimensional parameters. Furthermore, the separating process has been simulated for different dimensional parameters and different operating conditions. The separating efficiency of waste plastics has been obtained. According the analyses, the optimization of the separator has been conducted. The optimal dimensional parameters and operating parameters of the cyclone separator have been identified for high efficient separation of waste plastics.

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Keywords: Cyclone separator; Waste plastic sorting; Taguchi method; Orthogonal experiment

1. Introduction

Pollutions introduced by widely used plastic products become more and more serious [1, 2]. Conventionally, waste plastics are buried or burned [3]. These methods have progressed a lot, but still there are secondary pollutions to generate harmful gas [4]. Therefore, the best way to handle waste plastics is to recycle them. But in the recycling process, it becomes more and more important to sort these waste plastics with various densities [5, 6]. Drum screens have been used to sort municipal wastes [6, 7]. But drum screens are not suitable for the sorting of waste plastics with various densities. In previous pneumatic sorting experiments, the wind directions are always fixed resulting in the limited contacting time between the plastic particles and the blowing air. Consequently, the sorting efficiency is

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very low. The cyclone separating method has been applied and introduced in this paper. The dimensions of the sorting equipment have been reduced largely. The contacting time between the plastic particles and the blowing air and the sorting efficiency have been increased.

2. Cyclone sorting principle

There are balanced guide model and residence time model for cyclone sorting. Previous experiments show that the Barth model of the balanced guide models is relatively better than other models. As shown in Fig. 1., the Barth model forms a hypothesis plane CS inside the separator by extending the overflow pipe to the discharge opening of the separator.

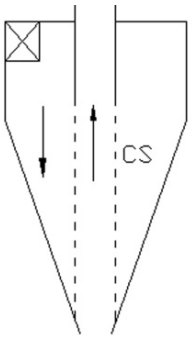

Fig. 1. The hypothesis plane CS.

In the plane CS, the centrifugal force bearing by the plastic particles and the air-flow resistance come to a balance.

$$\rho_t \frac{\pi d_t^3}{6} \frac{v_{\theta CS}^2}{0.5D} = 3\pi\mu d_t v_{rCS} \tag{1}$$

Where, ρ_t is the density of plastic particles, d_t is the diameter of plastic particles, $v_{\theta CS}$ is the tangential speed in the plane CS of plastic particles, v_{rCS} is the axial speed in the plane CS of plastic particles, D is the diameter of the cyclone separator.

The centrifugal force bearing by the plastic particles is in direct proportion to the mass of the plastic particles. Assume diameters of plastic particles are the same, the centrifugal force bearing by the plastic particles is in direct proportion to the density of the plastic particles. The mixed waste plastic particles enter the entrance of the separator under the air forces. With the constraints of the side wall, motions of waste plastic particles change from linear to revolving by the centrifugal actions. Most of the airflows move in a spiral way and enter into the cone portion of the separator. The formed vortex is known as the outside vortex. Meantime, mixed waste plastics in the airflow with larger densities will contact and collide with the side wall of the separator by centrifugal forces. Then, these plastic particles will fall into the discharge opening following the outside vortex and leave the separator. Under the motions of the outside vortex, high pressure area and low pressure area will be formed near the outside wall and in the central area of the separator, respectively. Therefore, air flows up at the center of the separator and plastic particles with lower densities will fly up and escape from the overflow pipe. Based on this principle as shown in Fig. 2., waste plastic particle with various densities are sorted.