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Development of a new type high-efficient inner-cone hydrocyclone

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ABSTRACT

Performance of a hydrocyclone can be influenced by many factors, such as structural type, geometric parameters and operation parameters, among which the structural type plays a very important role. The separation principle of a typical hydrocyclone was introduced. Focused on a gas–liquid separation, numerical simulation of the typical hydrocyclone was carried out. The gas phase fraction distribution was analysed. It is shown that the separation effect was not satisfactory. A revising idea was thus proposed and developed step by step, so a new inner-cone hydrocyclone (ICH) was designed. The inner-cone structure was thought to provide a more stable flow field for phase separation. It functions like a gas carrier that is beneficial for radially separated gas congregating on and growing into larger gas bubbles. It also produces an upward pushing force to gas bubbles, so as to enhance the gas–liquid separation performance, although the ICH has lower inner tangential velocities than the typical hydrocyclone. Numerical simulation and experimental study verified the analysis. Pressure drop of the ICH is much lower than that of the typical hydrocyclone; and the ICH has a wider scope for the change of liquid split ratio or inlet gas–liquid ratio. Development of the ICH would provide a new thought for the design of other separators.

Keywords: Hydrocyclone separator; Gas–liquid separation; Numerical simulation; Experimental study; Inner-cone hydrocyclone

1. Introduction

Hydrocyclone is a kind of multi-phase separator widely used in petrochemical, mining and many other industries (Bradley, 1965). It performs a separation function by utilising the density difference among different immiscible phases (Svarovsky, 1984; Zhao et al., 2010). Hydrocyclone has many advantages such as higher separation efficiency, smaller separator body, no moving parts inside, faster separation process, and so on.

The hydrocyclones can be classified into several categories according to the types of separating media. For two phase separation, there are gas–liquid, gas–solid, liquid–solid, oil–water, solid–solid hydrocyclones, etc.; and for three-phase separation, there are gas–liquid–solid, gas–oil–water, oil–water–solid, gas–solid–solid hydrocyclones, etc. (Zhao and Li, 2006).

The separation performance of hydrocyclones can be influenced by many factors (Jiang et al., 2002), and the hydrocyclonic separation mechanism is not yet understood thoroughly. The research work is quite complicated although its structure is relatively simple (Slack et al., 2004; Dyakowski and Williams, 1993; Nowakowski et al., 2004). Many researchers studied on the effects of geometric and operating parameters on the pressure characteristics and separation performance of hydrocyclones (Chu et al., 2000; Pasquier and Cilliers, 2000; Ni, 2003; Belaidi and Thew, 2000; Zhao et al., 2008).

This paper mainly introduces the design idea and process of a new type high-efficient hydrocyclone, inner-cone hydrocyclone (ICH), based on a gas–liquid separation analysis. Experiments were performed to investigate the separation

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