Advanced Particle Separation with the Concept of Uniflow Cyclone

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ABSTRACT

The design of a particle separator was studied with the concept of uniflow cyclone, which would be used in a plant for coal gasification. To predict an internal flow field and pressure drop, numerical calculation was performed with a commercial CFD program of ANSYS Fluent ver. 12.01. The numerical results were confirmed with experimental measurements in a lab-scale uniflow cyclone separator (see Fig. 1). Both results show that a uniflow cyclone separator has an advantage in collection of small particles and reduction of pressure drop.

KEY WORDS: Separator design, Cyclone separator, Uniflow cyclone, Coal gasification, Syngas, Particle size distribution, Pressure drop

NOMENCLATURE

C_p Coefficient of pressure drop between an inlet and outlet
D_p Particle diameter (μm)
E_c Efficiency of particle collection
m'A Mass flow rate of carrier gas (air) supplying through a separator inlet (kg/hr)
m'P Mass flow rate of particle (coal) injecting into a separator inlet (kg/hr)
P_in Total pressure at a separator inlet (atm)
ΔP Pressure drop between a separator inlet and gas outlet (Pa)
T_in Total temperature at a separator inlet (°C)
u_A Flow velocity of air in a uniflow cyclone separator (m/s)
ρ_A Density of air at 8.11 atm and 250 °C

INTRODUCTION

A cyclone separator is the device for dust removal from gases by using centrifugal force in a vortex finder. The design for the cyclone separator has been studied well. And the characteristic design parameter has been suggested by previous researchers (Bohnet et al., 1997). The cyclone separator is featured by strong swirl flow due to a tangential entry.

A uniflow cyclone is the particle separator which has swirl vanes (curved blades) and a single channel in only one direction. The uniflow cyclone has an advantage in compact size and easy installation into particle feeding lines (Muschelknautz et al., 2011). The compact size means smaller volume and lower residence time of solid particles or gases in a separator. And one-directional particle separation is available to reduce pressure loss between an inlet and outlet.

In the current study, we would like to suggest the uniflow cyclone separator which has both advantages in the cyclone separator and the uniflow cyclone, as shown in Fig. 1. The particle separator with the concept of uniflow cyclone is characterized by a tangential entry inducing strong swirl flow and one-directional flow channel for lower pressure drop. The uniflow cyclone separator would be useful for higher efficiency of solid separation from gases and freely from space retrain in the determination of facility setup. The objective of the present study is to predict numerically the characteristics of the suggested uniflow cyclone separator.