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The Impact of a ceramic wear liner on the separation efficiency of a particular cyclone dust collector

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Abstract

Cyclone separators are widely used in the gas solid separation processes. Their dimensions and configurations have a great influence on their performance and they have been widely studied in literature. In this research, the impacts of using a ceramic wear liner inside the wall of a special dust collector cyclone, installed in the Golgohar mining and industrial company in Iran, is investigated. In this research some numerical calculations and software analysis, based on the CFD, have been carried out and the results have been compared with the results of the practical tests and recorded data. This comparison shows the conformity of the results of the practical tests and the calculated results. In this research, the flow is a two-phase, gas-solid, type and the collision of the solid materials, which are mainly iron material with 200~700 micron dimensions, with the cyclone wall will increase the erosion. Therefore, to reduce the erosion a special ceramic wear liner is used as a protective layer for cyclone wall. Adding this protective layer has changed the geometry of the cyclone wall from different aspects; so the impacts of this type of liner on the performance and the separation efficiency of the dust collector cyclone should be investigated. The dilute two phase flow inside a cyclone is simulated using an Euler-Lagrange hybrid method. The gas phase is governed by the Navier-Stokes equations. This investigation can be a starting point for more research that can be result in producing more appropriate and efficient cyclones. For more accuracy, the comparison have been done for different speed of flow and the results show that this liner has a negative impact on the dust separation efficiency in this cyclone.

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Keywords: Cyclone; Ceramic; Dust separation; Separator; Wear Liner

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1. Introduction

Cyclone separators are widely used in the gas solid separation processes. Their dimensions and configurations have a great influence on their performance and they have been widely studied in literature. In this research, the impacts of using a ceramic wear liner inside the wall of a special dust collector cyclone, installed in the Golgohar mining and industrial company in Iran, is investigated. A strong rotation of gas is induced in the cyclone and the centrifugal forces are exerted on the particles, separating them from the gas flow toward the cyclone wall [1], [2]. In general, the flow field inside a cyclone is characterized with strong swirling vortex, and it is critical to the performance of cyclone separator. It's obvious that, there are many factors that have a big influence on the flow field, such as the geometry of cyclone and the operating condition [3], [4]. Fortunately, these two factors has been investigated by many researchers using both experiment and simulation [5].

2. Analysis and Modeling

The dilute two phase flow inside a cyclone is simulated using an Euler-Lagrange hybrid method. The gas phase is governed by the Navier-Stokes equations:

$$\frac{\partial \rho}{\partial t} + div\left(\rho u\right) = 0 \tag{1}$$

$$\frac{\partial (\rho u)}{\partial t} + div\left(\rho uu\right) = -\nabla P - div\left(\tau\right) + \rho g \tag{2}$$

Where ρ is gas density, u is gas velocity vector, p is pressure and τ is the stress. The particles are tracked by Newton's law of motion:

$$\frac{dV_P}{dt} = F_D\left(u - V_P\right) + g\left(\frac{\rho_P - \rho}{\rho_P}\right) + F \tag{3}$$

Where V_P is particle velocity, ρ is particle density, F is an additional acceleration force. F_D is drag coefficient and is calculated by:

$$F_D = \frac{18\mu}{\rho_P d_P^2}\frac{C_D Re_P}{24} \tag{4}$$

Where C_D is calculated by an empirical equation [6]. μ is the gas viscosity, dp is particle diameter and Re_P is particle Reynolds number given by:

$$Re_P = \frac{\rho\left|u - V_P\right| d_P}{\mu} \tag{5}$$

In this study, we investigate the effect of using a particular type of anti-wear ceramic coating liners on efficiency of a particular type of cyclone separating solid steel particles from air, as it is shown in figure 1. These liners are in form of rectangular cube of dimensions 0.02×0.3×0.4m, the simulation of this particular type of cyclone is carried out by Ansys Fluent software. There is a comparison between the two models in software analysis based on CFD method as shown in figure 2, the model entitled (A) has no ceramic liner and the other model entitled (B) has a particular anti-wear ceramic liner. To validate the numerical results, measurements and experimental calculations of dust separation efficiency in the cyclone equipped by ceramic liner (model (B)) are done in place. This equipment is used in iron ore industry and is emplaced in refining factory of Golgohar-e-Sirjan mining and industrial company in Iran. Numerical and experimental results comparison accomplished in this study, shows good agreement between numerical and experimental results. Inner net volume of this cyclone is about 80 m^3 and about 2200000 mesh cells are used in its tetrahedral meshing and to survey the analysis results from this point of view that numerical results are independent of mesh cell dimensions, this analysis results is also compared with the results from about 1700000 and 3400000 cells analysis which showed good agreement. The separation efficiency analysis and comparison in