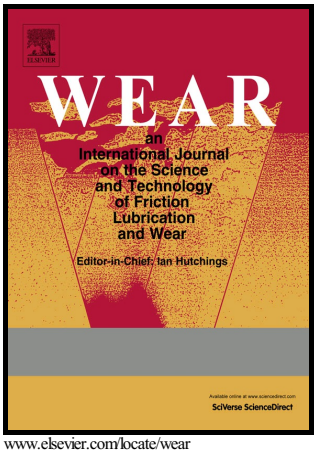

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Effects of particle shape and swirling intensity on elbow erosion in dilute-phase pneumatic conveying

Jia-wei ZHOU[a], Yu LIU[b], Song-yong LIU[a*1], Chang-long DU[a], Jian-ping LI[a]

[a]School of Mechatronic Engineering, China University of Mining and Technology, Xuzhou, Jiangsu, China, 221116

[b] School of Mechanical and Power Engineering, Henan Polytechnic University, Jiaozuo, Henan, China, 454000

Abstract

Elbow erosion, which is mainly caused by collisions between particles and wall, is a prominent problem encountered in dilute-phase pneumatic conveying systems. The particle shape and air-flow regime markedly influence the particle-wall collision characteristics through the ambiguous impacts of both the geometric boundary and relative velocity. This paper numerically investigates the effects of particle shape and swirling intensity on elbow erosion in dilute-phase pneumatic conveying using the CFD-DEM method. Initially, the non-spherical particles are modelled based on polyhedrons and scanned real coal particles, and their morphologies are characterized according to sphericity. Subsequently, the calculation compatibility of attrition models based on CFD-DEM simulation is calibrated by comparing the erosion rates calculated on the basis of different classical models. In addition, the compatibility of the selected model for the coarse particle pneumatic conveying is verified via experimental measurements. Based on the two-way coupled Eulerian-Lagrangian method, simulations of the gas-solid flow that consider the elbow direction, particle shape, and swirling intensity are performed, and the correlation models with sphericity and swirling number for different elbow directions are assessed. In general, it is found that the elbow direction affects the magnitude, distribution, and position of the maximum of the erosion rate. The mean erosion rate generally varies with the particle sphericity in a nearly inclined "S" pattern in all elbow directions. The mean erosion rate evidently decreases with swirling number first quickly and then slowly. To develop a modified predictive model based on the classical erosion model, the polynomial and the Exp3p2 exponential function are adopted to fit the influences of particle shape and swirling intensity, respectively. The fitting deviations agree reasonably well with the calculation results.

Key words: elbow erosion; particle shape; swirling intensity; elbow direction; CFD-DEM; dilute phase pneumatic conveying

1. Introduction

Pipe erosion, particularly that occurring in the elbow, is a significant defect in the dilute-phase pneumatic conveying systems. The fundamental cause of erosion is the removal of material from the wall surface due to the interaction between particle and surface and this surface damage is classified as erosive wear because of the high relative velocity. The velocity and impact angle of the particle play major roles in pipe surface damage. However, in a dilute-phase pneumatic conveying system, appropriate conveying velocity is necessary to keep particles moving and prevent pipe blocking. Due to this inherent erosion characteristic of pneumatic conveying, a better understanding of the effects of the particle characteristics and flow regime on erosive progress is needed to reveal the interaction mechanism and develop a predictive model for pipe erosion. At the same time, the technique used for mitigating of pipe erosion is badly in need of pneumatic conveying operation.

To increase the overall understanding of the complex phenomenon of material removal from the wall surface, which is attributed to the interaction between the particle and the wall, many efforts have been made to reveal and predict the laws of the erosion process. Finnie [1, 2] first discussed the mechanism of material removal for brittle

*corresponding author, E-mail addresses: coalminer@cumt.edu.cn (Song-yong LIU)