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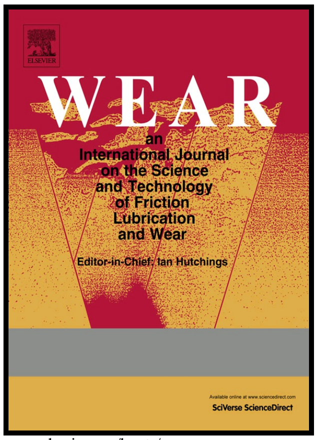

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A numerical investigation of wear caused by dilute slurry injected into an annulus through rectangular apertures

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Keywords: Solid particle erosion, Slurry erosion, Vortex-induced wear, Flow through aperture, Impact statistics.

Abstract

Slurries conveyed in conduits generate erosion caused by particle impacts on the walls. Those impacts result from the average velocity and the turbulence of the carrying liquid. We investigate the erosion and relevant flow features, when the dilute slurry passes from the inner to the outer annulus through four equally spaced rectangular apertures on the periphery of the tube dividing these two conduits. The flow of dilute slurry was solved numerically. A consideration was given to the effects of particle size on erosion rate and statistical distribution of impact velocity, angle, and total erodent mass inducing wear. In addition, the numerical solution of the continuous phase velocity was validated with measurements. A confined trailing vortex forms at the longitudinal edge of the aperture, amplifying the erosive wear on the outer wall of the annulus. A large amount of particles passes near the aperture's horizontal downstream edge and intensifies the erosion rate above it. The effect of these flow features becomes more pronounced for larger particles. The statistical analysis of impact velocity, angle, and mass showed that the mean velocity in the channel dominates erosion caused by impacts of large particles. On the other hand, the near-wall turbulence mainly affects the erosion resulting from impacts by small particles.

1. Introduction

Erosion caused by slurries is frequently encountered in various industries, where the solid particles are transported in channels by liquids. This phenomenon is often attributed to elevated velocity of the slurry approaching the walls at certain adverse incidence angles (Pereira Abbade and João Crnkovic [1], Clark et al. [2,3], Desale et al. [4–6], Elkholy [7], Gupta and Singh [8], Hojo et al. [9], Levy et al. [10–13], Lhymn and Wapner [14], Lin and Shao [15], and Shetty et al. [16,17]) and turbulence (McLaury [18], Jafari et al. [19], Humphrey [20]). Many slurry supply networks involve various flow control devices used for pumping, redirection, redistribution, and separation of the conveyed substances. Those devices experience erosion due to unique features of the flows developing inside. The high erosive wear caused by slurry vortices was observed by Wu et al. [21,22] in impeller blades and Wong et al. [23] behind imperfections (such as cavities and welds) in pipes. The particles might migrate within the slurry and concentrate in certain regions of the conduits, thus elevating rates of material removal (Shah and Jain [24]). Erosion was also observed in valves (Wallace et al. [25]) and chokes (Forder et al. [26]) due to adverse slurry velocity and turbulence (McLaury [18]). An important feature in slurry erosion is the effect of conveyed particle size and weight. The velocity lag increases for the heavier and larger particles, affecting the erosion rate. The smaller the particle is, the faster it will respond to abrupt changes in the drag force caused by velocity fluctuations in turbulent flow. Despite the sharp drop in mean velocity