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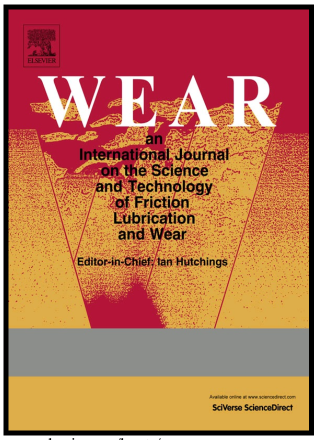


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# Predicting fine particle erosion utilizing computational fluid dynamics

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**ABSTRACT**

Sand flowing with produced fluids cause severe problems for the oil and gas industry, amid them material removal from pipelines has always been crucial. Solid particle erosion prediction in gases and liquids is challenging as many different parameters significantly affect erosion. Particle size is one of the parameters that has been investigated. Previous studies show that small, sharp particles cause severe erosion in both gas and liquid systems. This is particularly an important topic for oil and gas production conditions as small particles can pass through sand screens existing in sand exclusion and management systems. The current work utilizes Computational Fluid Dynamics (CFD) to calculate erosion caused by these particles in different geometries. The geometries include submerged jet impingement and elbows. The CFD utilizes an Eulerian-Lagrangian approach for erosion calculation. The aim of this study is to investigate the effect of CFD mesh and different turbulence models on predicting the behavior of small particles. A low-Reynolds number k-ε turbulence model is employed to account for the turbulence effects. A very fine grid spacing is used near the walls to resolve the viscous sublayer and boundary layer and to aid in the examination of the effects of particle-fluid interaction in the near-wall region. Moreover, simulation results are compared with experimental data available in the literature for elbows and conducted during this investigation for fine particles submerged in an impinging slurry jet in order to validate the presented modeling approach.

**Keywords:** Solid particle erosion, Fine sand particles, CFD, Direct impingement, Elbow



## 1. INTRODUCTION

Solid particles in oil and gas wells travel with the produced fluids through the system and impact the inner walls of piping components and equipment multiple times and cause erosion. This results in material removal of the exposed surfaces and inevitably equipment failure, which is called solid particle erosion. This issue has grown in importance in various applications especially in the oil and gas production industry, since large quantities of sand may enter the piping systems as oil and gas fields become more mature and sand particles detach from reservoirs. The piping system erosion requires maintenance that can be rigorously time and cost consuming. In recent years, this subject has concerned many researchers and encouraged them to study and understand this obstacle in order to improve designs and control flow rates to extend the operation life of production equipment. To achieve this goal, a prediction tool is needed to define and predict the erosion behavior of solid particles. However, developing such a model is very demanding, considering quite a few parameters playing roles in causing erosion. Until now, several factors have been identified that affect solid particle erosion, among them particle impact speed, particle impact angle, particle properties such as material, shape, size, sharpness, and target surface properties such as material, hardness, ductility and flow conditions are recognized to significantly influence solid particle erosion and its mechanisms [1–3].

Therefore, various erosion equations have been developed attempting to account for different conditions and as many factors as possible. Although, none are found to be applicable to all cases [4]. These erosion equations are obtained either based on pure theory, which are called mechanistic, based on pure experimental data, which are called empirical, or a combination of both, semi-empirical/semi-mechanistic. Grant and Tabakoff [5] , Oka et al. [6] , Zhang et al. [7], Huang et al. [8] are commonly used equations in erosion studies and literature. Recently, many studies have investigated the erosion phenomenon by means of Computational Fluid Dynamics (CFD).

Several geometries have been studied in the literature. Shirazi et al. [9] developed a semi-empirical model to predict erosion in pipe geometries and simulated erosion in elbows and tees. Chen et al. [10,11] and Vieira et al. [12] also investigated erosion in plugged tees and elbows. Zhang [13] studied erosion in sudden contraction/expansion geometries. These geometries have high turbulent kinetic energy and contain areas of recirculation; therefore, small particle impacts can be more prevalent than large particle impacts. He found that CFD tends to overpredict erosion caused by 25 micron sand particles in water by a factor of 20 compared to experiments. Moreover, the erosion