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PREDICTING SOLID PARTICLE EROSION IN MULTIPHASE FLOW: CHALLENGES AND SUCCESS STORIES (KEYNOTE PAPER)

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ABSTRACT

Solid particle erosion is a major problem in many industrial applications where solids are entrained in gas and/or liquid flows. For example, erosion of production equipment, well tubing and fittings is a major operating problem that costs the petroleum industry millions of dollars each year. Entrained sand particles in the oil/gas production fluid impinge on the inner surfaces of the pipes, fittings, and valves that result in solid particle erosion. In certain production situations with corrosive fluids, erosion is compounded with corrosion causing severe erosion-corrosion. Even in situations when sand control means are utilized such as gravel packing and sand screens, small sand particles can plug sand screens promoting higher flow velocities through other portions of the screens causing failure and allowing sand production. Erosion can cause severe damage to the piping and equipment wall, resulting in loss of equipment and production downtime.

Solid particle erosion is a mechanical process by which material is removed gradually from a solid surface due to repeated impingement of small solid particles on the metal surface. The erosion phenomenon is highly complicated due to the number of parameters affecting the erosion severity, such as production flow rate, sand rate, fluid properties, flow regime, sand properties, sand shape and size, wall material of equipment, and geometry of the equipment. For ductile materials, erosion is caused by localized deformation and cutting action from repeated particle impacts.

It is well known that solid particle erosion rates are a strong function of the impacting velocity of particles and also the mass of impacting particles. Predicting solid particle erosion in multiphase flow is a complex task due to existence of different flow patterns. The existence of different flow patterns and sand and liquid holdup in vertical and horizontal pipes means that a unique erosion model has to be developed for each flow regime if the model is to account for the number and velocity of impacting particles. The particle impact velocity is affected by the pipe geometry, carrying fluid properties and velocity, flow pattern, particle size and distribution in the flow. Among different multiphase flow patterns in horizontal and vertical flows, severe erosion damage can occur in annular and slug flows with high gas velocities and low liquid velocities. Although there is a lack of accurate mechanistic models to predict solid particle erosion, there is a need to develop engineering prediction models for multiphase flows.

Earlier erosion calculation procedures in multiphase flow were primarily based on empirical data and the accuracy of those “empirical” models was limited to the flow conditions of the experiments. A framework for developing a model has been established for predicting erosion rates of elbows in multiphase flow. The model considers the effects of particle velocities in gas and liquid phases upstream of the elbow. Local fluid velocities in multiphase flow are used to determine representative particle impact velocities. Also based on data representing sand holdup for several flow regimes, the masses of impacting particles are estimated. Erosion experiments are also conducted on elbows in two-inch and three-inch large scale multiphase flow loops with gas, liquid and sand flowing in vertical and horizontal test sections. Based on the experimental data for different flow regimes including slug, wet gas and annular flow a method for improving a previous model is discussed and is being implemented to predict erosion rates in multiphase flow.