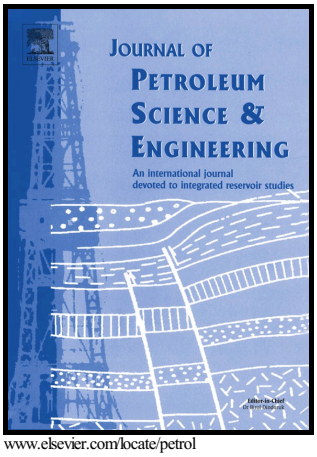

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Influence of intermittent flow sub-patterns on erosion-corrosion in horizontal pipe[1]

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Abstract

Thinning of pipe wall due to erosion and corrosion has resulted in many catastrophic failures and huge economic losses in petroleum refineries (Wood et al., 2013) and nuclear power stations (Ahmed, 2012). The intermittent structure of two-phase flow through pipe (intermittent flow regime) is an important factor responsible for such erosion and corrosion. The present research is an effort to develop a regime map showing possible erosion and corrosion phenomena due to intermittent flows in pipe. In this direction, flow visualization experiments are carried out for three distinct sub-regimes of intermittent flow namely, plug flow with or without bubble rim, less aerated slug flow and highly aerated slug flow. Images captured at a rate of 1600 frames per second at 288 diameter downstream of inlet are utilised for analysing the dynamics of intermittent flow structure in terms of expansion, contraction, breaking, coalescence, collapse, and collision of bubbles. Quantitative measurements of intermittent flow characteristics (including plug/slug frequency, plug/slug velocity and length of liquid plug/slug) and their influence on erosion-corrosion phenomena in the pipe are reported in detail. Based on these qualitative and quantitative analysis, a regime map for prediction of erosion-corrosion phenomena in pipes is established as a function of inlet flow conditions for both the phases. Transition boundaries for four distinct erosion-corrosion phenomena: shear stress induced erosion, cavitation erosion, liquid impact induced erosion and flow accelerated corrosion are represented in the map and eight distinct regimes of erosion-corrosion are illustrated. The regime map is represented in terms of non-dimensional superficial Reynolds numbers of both the phases to account for pipe diameter, flow rate and fluid viscosity. This erosion-corrosion regime map developed in this research will immensely aid to the effective design of piping systems and optimization of operating conditions for safer operation of petroleum refineries and nuclear power stations.

Keywords

Intermittent flow; flow visualization; flow characteristics; erosion-corrosion regime map.

1. Introduction

Material degradation or wall thinning due to erosion-corrosion in piping system represents one of the major problems in petroleum industries, nuclear power plants, chemical industries, geothermal industries and desalination plants. Such erosion-corrosion normally occurs on various piping components including tees, elbows, downstream of control valves, flow elements, reducers or orifices. Catastrophic failures with serious fatalities in past due to erosion-corrosion in piping systems have been reported by Wood et al. (2013) and Ahmed (2012). Preliminary evaluation of these failures indicated that flow accelerated corrosion (FAC) and liquid impact induced erosion (LIIE) were the likely failure mechanisms. Such mechanisms have been related in literature to the intermittent structure of two-phase pipe

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