Bulletin of Electrical Engineering and Informatics
Vol. 12, No. 4, August 2023, pp. 2105~2116
ISSN: 2302-9285, DOI: 10.11591/eei.v12i4.4790

Modeling and simulation of a pipeline leak detection using smart inspection ball

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Article Info

Article history:

Received Sep 14, 2022
Revised Oct 16, 2022
Accepted Dec 5, 2022

Keywords:

Computational fluid dynamics
Fluid flow
Heat transfer
Leakage
Pipeline

ABSTRACT

Recently, pipelines have replaced more carbon-intensive transportation methods making them more environmentally friendly for transporting energy and water supplies. However, pipelines can pollute the air, water, soil, and climate when they leak, causing economic, and environmental damage. Pipeline online monitoring provides data analysis and suitable controlling strategies to contain the risk. This paper proposes a three-dimensional numerical model simulation taking advantage of the fluids moving through pipelines at specific speeds. The transport speeds depend on many conditions, such as pipe diameter, the pressure through which the fluid is being transported, and other factors, such as terrain's topography and viscosity of the fluid. Under these conditions, the inspection approach uses a self-charging movable ball. The sensors inside the ball capture data as it travels through the pipe. The simulation focuses on spherical flow and pipe noise with and without leakage based on the COMSOL software platform. The paper shows the effect of several parameters, including leak location, sensor placement, ball diameter, sound pressure level propagation along a pipe and around the sphere, velocity, and temperature distribution that give the background for future smart ball design in a promising practical pipeline test project.

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1. INTRODUCTION

The World Energy Report 2020 indicates that using natural fluids and fossil fuels for energy production accounts for thirty percent of the world's demand [1]. The rapid growth of the world's population as well as the acceleration of industrialization, have led to a rise in the use of fossil fuels such as petroleum and natural gas [2]. Transporting fuels, such as the delivery of fuels via fluid pipelines, is an example of an essential component of the energy supply that must be considered. The pipes are exposed to many factors, including flow stress, neighborhood circumstances, and sound pressure [3]. In addition to this, the difficult conditions of real-time operations, such as those that take place in the marine environment while it is under the pressure of the seas, in remote regions of deserts, and underground, where they are exposed to the soil stress force, lead to an enormous amount of environmental pollution [4]. Another factor that contributes to the ease with which pipelines might be damaged is the unstable operation of the flow of fluid [5]. The major challenge is discovering leaks due to physical deterioration and the advanced age of pipelines [6]. The issue has been going unnoticed while steadily deteriorating for a considerable time. The alteration in the fluid flow pattern is the tried-and-true approach for detecting leaks [7]. Because of the leakage, there may be an abrupt shift in pressure across the free stream, which will skew the flow [8]. The varying flow may be employed in