CHARACTERISING THERMAL FATIGUE AT MIXING POINTS IN INDUSTRIAL PIPEWORK

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Introduction

Plants often consist of many interconnecting pipes transporting fluids that are combined or distributed for various purposes. Fig.1 shows a typical industrial plant. Thermal striping is thermal variation which occurs in locations where there is partial mixing of fluids at various temperatures[1]. This phenomenon is prominent especially at mixing points (Fig.2) where there is a combination of hot and cold fluids. This temperature fluctuation propagates to the pipe wall, leading to thermal stress [2].

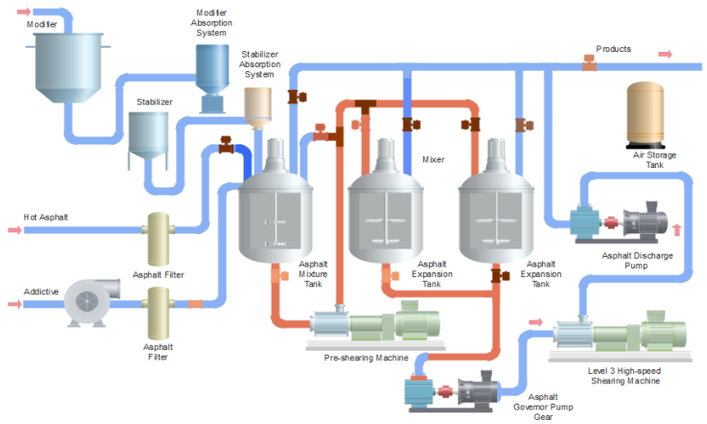

Fig. 1: A typical plant with interconnected pipes

If the thermal stresses are cyclic and higher than the fatigue limit or endurance limit of the structural material, then thermal fatigue may occur [2]. A number of accidents in the nuclear plants have been attributed to this. One of such is the Civaux I Pressure Water Reactor (PWR) accident in France in 1998[3].

Importance of Research

For structures exposed to thermal fluctuation, it is necessary to understand the pipe wall temperature that may lead to higher stress and failure after repetitive cycles. Some accidents have been recorded in the first few years of the system operation. Unfortunately, it is difficult to properly monitor and detect thermal fatigue using common thermocouples as a result of the limitation in time of response[4], because the stresses may be driving by short-term temperature transients during a mixing operation. Hence, a robust system of predicting and detecting thermal fluctuation, thermal stress and number of cycles to failure is important. Fig. 3 shows a CFD simulation at a pipe mixing point using a simulation software for modelling and detecting the temperature fluctuation at the pipe wall.

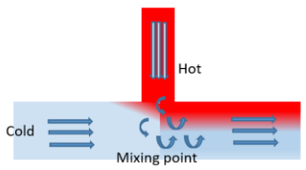

Fig. 2: Mixing point of hot and cold water

This research will develop a guideline for a modelling informed inspection that will lead to

- improvement in the safety of the plant
- safety of human lives
- decline in needless inspections

Project Aim & Objectives

- Understand and describe thermal fluctuation and stresses near the pipe mixing points by Computational Fluid Dynamics (CFD) & Finite Element Analysis (FEA).
- Identify quantifiable parameters to depict thermal stresses at the mixing points.
- Establish inspection criteria to identify critical points susceptible to failure near the mixing points, thereby reducing the resources spent on inspection and ensuring there is safety of lives and property.

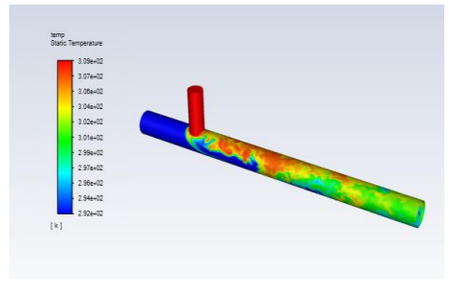

Fig. 3: CFD simulation at mixing point

Research Methods

Fluid Structure Interaction (FSI) approach will make use of CFD and FE analyses to determine the thermal fluctuation at the wall and the subsequent thermal stresses. Models will be developed to understand the phenomenon taking place at pipe mixing points. Experiments will be used to validate the simulation results.

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