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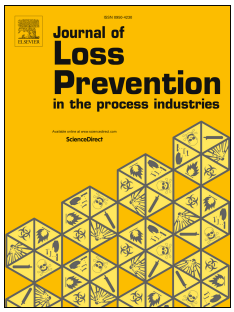

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Validation of Liquid Nitrogen Vaporisation Rate by Small Scale Experiments and Analysis of the Conductive Heat Flux from the Concrete

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The vaporisation of a liquid nitrogen pool spilled on concrete ground was investigated in small scale field experiments. The pool vaporisation rate and the heat transfer from the concrete ground were measured using a balance and a set of embedded heat flux sensors and thermocouples. The ability to predict the concrete's thermal properties based on these measurements was investigated. This work showed that a simple, one-dimensional theoretical model, assuming heat conduction through a semi-infinite ground with ideal contact between the cryogenic liquid and the ground, commonly used to describe the heat transfer from a ground to the LNG, can be used to match the observed vaporisation rate. Though estimated parameters, thermal conductivity and thermal diffusivity, do not necessary represent real values. Although the observed vaporization rate follows a linear trend, and thus can be well represented by the model, the overall model prediction seems to be overestimated. The temperature profile inside the concrete is slightly over-predicted at the beginning and under-predicted at later stage of the spill. This might be an effect of the dependence of the concrete's thermal properties on the temperature or may indicate an incorrect modelling and a varying temperature of the ground surface.

Keywords: liquid nitrogen; LNG; cryogenic liquid; vaporisation; conduction

1. Introduction

The vaporization of cryogenic liquids like liquefied natural gas (LNG) is governed by heat transfer phenomena including conduction, convection and thermal radiation mechanisms. The present work investigates the contribution of conductive heat transfer to the vaporization rate of cryogenic liquid through the series of small scale, well controlled and instrumented experiments performed with liquid nitrogen (LN_2) as safer analogue of LNG. The experiments were performed in a wind tunnel built at Ras Laffan Industrial City (RLIC) and in the field at Ras Laffan Emergency and Safety College (RLESC) in Qatar.

Natural gas (NG) has become one fast-growing source of energy, and Qatar is one of the largest producers and exporters of NG, and the largest exporter of Liquefied Natural Gas (LNG) in the world. Qatar exported 75 million metric tonne of LNG in 2011, of which 47% to Asia Pacific and 42% to Europe. The total LNG export from Qatar is about three times larger than the next largest exporters, Malaysia and Indonesia, and 4 times larger than Australia (BP, 2012).

The worldwide LNG industry has had a relatively good safety record so far. However this industry seems to continuously increase and thus brings new challenges and needs that require special attention. Therefore, it is crucial and strategic to conduct fundamental and applied research in areas related to LNG production, handling and transportation to increase their safety. Texas A&M University at Qatar in