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Efficient water deluge nozzles arrangement on offshore installations for the suppression of pool fires

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ABSTRACT

Offshore installations that handle hydrocarbons are in serious danger of fires and/or explosions. Pool fires are a significant risk related to major fire accidents, and active protection systems such as water deluge systems are used to reduce the consequences of high temperature and radiation resulting from pool fires. Thus, it is important to decide on the locations of water deluge nozzles for effective fire suppression, and the aim of this study is to introduce an efficient methodology for selecting the locations of water deluge nozzles. The locations of water deluge nozzles are selected using a proposed water deluge location index based on the characteristics of pool fires. The methodology is based on probabilistic approaches associated with credible scenarios representing possible events on offshore topside structures. This methodology, applied to examples, is used to determine the efficient arrangement of water deluge nozzles on a hypothetical FLNG topside structure. The effectiveness of the new methodology is verified through comparison with uniformly distributed nozzles using a computational fluid dynamics simulation.

1. Introduction

Onshore and offshore platforms have the potential for various hazardous risks. In particular, fires with high temperatures may result in catastrophic consequences such as significant human casualties, economic losses and serious environmental pollution. The fire risk assessment and management, which includes presented rules and recommended practices, have been identified for reducing the risk of fire accidents (Czujko and Paik, 2012a, 2012b; Spouge, 1999; NORSOK, 2010; ABS, 2014; LR, 2014). In addition, design guidelines have been established to detail the methods of fire risk assessment and management (Nolan, 1996; Walker et al., 2003; Vinnem, 2007; Paik and Czujko, 2009, 2010; 2011, 2012; Paik et al., 2011).

Risk control options are effective means of minimising the probability of an event and its associated risk (UKOOA/HSE, 2006). Generally, active protection devices such as gas detectors and water spray systems are used as preventive and/or mitigating safety systems against fire accidents. Most installations have a two-tier alert system for preventing spurious shutdowns and unnecessary alerts. System failures generally occur when a detector fails to detect the specified information such as flammable gas, flame, smoke, heat, toxic gas and oil mist, or when the alarm or signal transmission systems fail to alert operators or activate emergency mitigation systems (DeFriend et al., 2008).

Water deluge systems are designed to cool equipment and control the growth of a fire by providing a simultaneous application of water over the entire fire hazard (ISO, 1999). For the efficient application of such water deluge systems, the location of the water deluge nozzles is important for ensuring their performance. The locations of the water deluge nozzles are usually selected through engineering judgments based on the deterministic approach (Dembele et al., 2007). However, the conventional method has an element of uncertainty in light of human error and accidental fires. To reduce the risk of such un-

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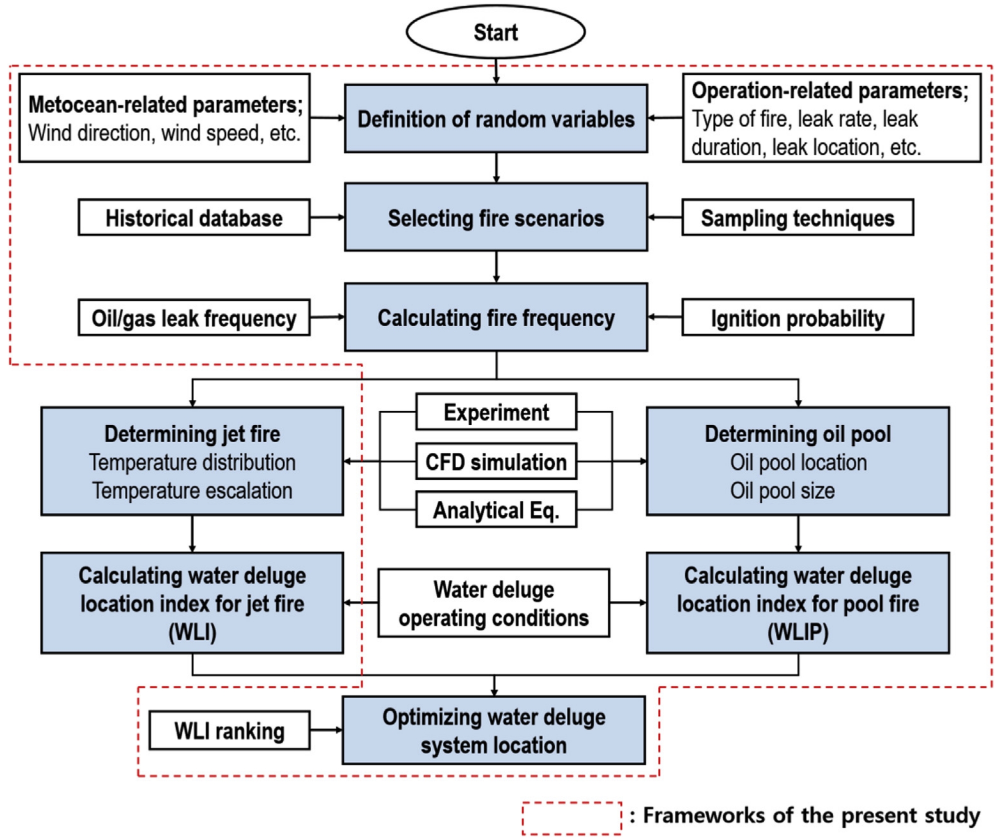


Fig. 1. Water deluge nozzle arrangement procedure for the control of jet (Kim et al., 2016) and pool fires.

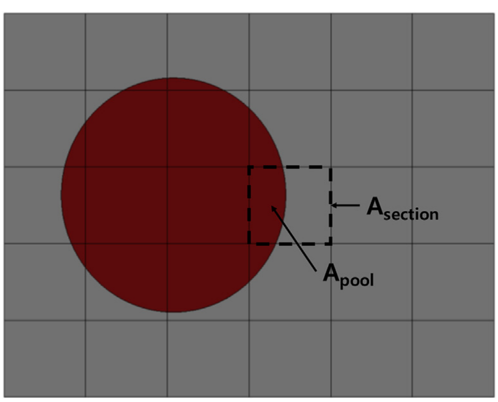
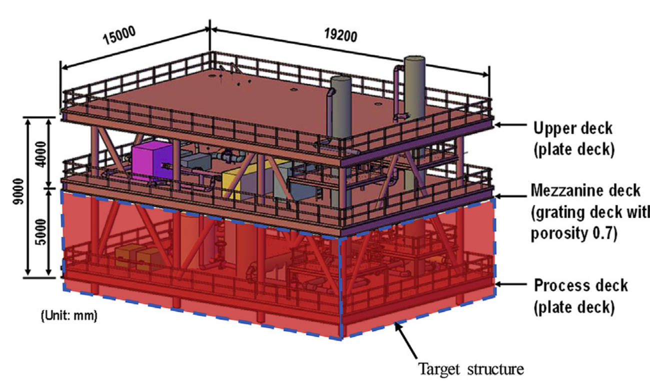


Fig. 2. Example of sections and calculation of efficiency values at each section to calculate the WLIP. (The circle represents an oil pool).

(a) Hypothetical FLNG topside structure at the KOSORI test site



(b) Schematic of target structure

Fig. 3. Three-dimensional view of the FLNG topside separation module considered.

certainty, a probabilistic approach, based on credible fire scenarios, becomes necessary to select the locations of water deluge nozzles.

Numerous studies of fire-fighting systems have been performed (Svensson, 2002; Himoto and Tanaka, 2012; Jee et al., 2013; Alarifi et al., 2014). McCaffrey (1984) investigated the effect of water deluge on jet fires, and Prasad et al. (1999) conducted an experimental test for the suppression of pool fires with water deluge systems. Gosse and