COOLING EFFECT INDUCED BY FLOW IN DELUGE PIPE EXPOSED TO JET FIRE

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Abstract

Since offshore oil & gas platform processes hydrocarbon liquid or gas, it is exposed to risk such as gas leak, fire and explosion. With regard to fire hazard, jet fire features higher heat flux and flame temperatures, so that its engulfment can cause structural collapse or vessel / pipe rupture. When a fire occurs, a deluge fire-fighting system acts to extinguish or cool the fire in Topsides. To perform these roles in emergency situation, the integrity of the deluge system must always be maintained. Because the pipe internal flow absorbs heat from the steel (cooling effect), the pipe may not be failed in spite of jet fire engulfment. To provide a fast and robust tool for realistic judgement of pipe temperature rise, the analytical solution is derived and developed by comparing with CFD simulation results. Regarding the fire heat input, the analytical method is adopted from API Std. 521 6th Edition and uses the Stefan-Boltzmann radiation equation. Since the parameters used in analytical method are normally unable to determine, the API Standard guides boundaries and recommended values. Cu/Ni 90-10 pipe (UNS C 70600) which is commonly used in deluge pipe and seawater as fluid will be used in this research. Horizontal pipe engulfed in jet fire is assessed. Instead of modelling jet fire, it is assumed that the air temperature around pipe is equivalent to flame temperature and the uniform heat flux is loaded on pipe. To anticipate peak temperature, the local peak heat flux (350 kW/m2 for jet fire) is applied. Analytical solutions are derived based on energy balance equations using lumped capacitance method/Finite Difference Method and estimate the temperature in pipe versus time profile. For numerical analysis, time-dependent CFD simulation is conducted by using commercial software Star CCM+. The horizontal pipe will be modeled and it is heated by circumferentially banded hot air. Comparing the analytical solutions with numerical solution, more precise analytical solution is selected and developed.

Keywords: *Safety, Heat engulfment, Jet fire, Cooling effect*

References

[1] ANSI/API Standard 521. (2013). Pressure-relieving and depressuring systems (6th ed.).

[2] Biswas, S., & Fischer, B. J. (2017). Application and validation of the API analytical fire method in pressure-relieving and depressuring systems. Journal of Loss Prevention in the Process Industries, 50, 154-164.

[3] Energy Institute. (March 2003). Guidelines for the design and protection of pressure systems to withstand severe fires, ISBN 0 85293 279 0.

[4] Incropera, F. P., and D. P. DeWitt, “Fundamentals of Heat and Mass Transfer,” 7th ed., John Wiley, New York (2011).

[5] Ito, Y., Tsuruoka, A., Waki, Y., & Osedo, H. (2016, July). Calculation and Analysis for Pressure Vessel Rupture Study Under Fire in Plant. In ASME 2016 Pressure Vessels and Piping Conference (pp. V003T03A033-V003T03A033). American Society of Mechanical Engineers.

[6] Lowesmith, B. J., & Hankinson, G. (2012). Large scale high pressure jet fires involving natural gas and natural gas/hydrogen mixtures. Process safety and environmental protection, 90(2), 108-120.

[7] Salater, P., & Overa, S. J. (March 2004). Pipes exposed to medium sized jet fires - Rupture conditions and models for predicting time to rupture. Paper presented at Fire and Blast Information Group (FABIG), London and Aberdeen, January 2004 and Houston.

[8] SCANDPOWER. (March 31, 2004). Guidelines for the protection of pressurised systems exposed to fire. Report no. 27.207.291/R1-Version 2.

[9] Zamejc, E. (2014). API Standard 521 new alternative method to evaluate fire relief for pressure relief device sizing and depressuring system design. Journal of Loss Prevention in the Process Industries, 27, 21-31.

Biography

The author has worked as a safety engineer in Offshore & Engineering Division of Hyundai Heavy Industries (HHI). Sponsored by the committee of Korea-UK Global Education Program for Offshore Plant, he participates in dual-degree program. Currently, he is studying MSc program (Offshore Floating Systems) in University of Strathclyde.