ABSTRACT

To meet the need of identifying the fire loads on FPSO topsides, this paper put forward a CFD based method for the heat flow analysis of floating production storage and offloading (FPSO) topside model by taking into account the effects of wind speed and direction. The Fire Dynamics Simulator (FDS) program is employed in this method. The model for heat flow analysis is a 1/14-scale FPSO topside model presented in the wind-tunnel experiments. The results of FDS simulation on that topside model are presented in this paper. In the simulation, the speed and direction of the wind are varied, and the temperature distribution is measured. With the results compared with the experimental results, it can be concluded that FDS simulations are in good agreement with the experimental results. The work done in this study will be very useful for the fire engineering of FPSO topsides.

KEY WORDS: FDS simulation; FPSO topsides; Heat-flow analysis; Wind direction; Wind speed; Temperature; Experiment.

INTRODUCTION

Fire Dynamics Simulator, is a Computational Fluid Dynamics (CFD) model of fire-driven fluid flow. The code has been developed at the National Institute of Standards and Technology (NIST), USA. FDS solves numerically a form of the Naiver-Stokes equations appropriate for low-speed, thermally-driven flow with an emphasis on smoke and heat transport from fires. FDS is an increasingly popular CFD choice for fire engineers and academic researchers.

Validation of FDS was undertaken by the developers of the program and also by other researchers and bodies using it. FDS Technical Reference Guide provides a concise summary of the validation work carried out for the program. An interesting method used by NIST to validate the hydrodynamic model in the early versions of FDS was based on salt water experiments. Salt water flows can resemble the smoke flow in the early stages of a fire. Following the fire caused by the derailment of a freight train in the Howard Street Tunnel in Baltimore on the 18th of July 2001, a study was undertaken by McGrattan and Hamins (NIST) to assess the thermal environment in the tunnel during the fire. FDS was used in this study to simulate the fire’s growth and spread in the tunnel. In order to assess the accuracy with which FDS can predict the thermal environment in a burning compartment, a series of large-scale experiments were conducted by NIST in 2003. A detailed description can be found in NIST NCSTAR 1-5E report. Wen etc. have done research on the simulation of a medium-scale methanol pool fire by FDS. The simulation used predominantly the existing features in FDS except that an additional sub-grid-scale combustion model based on the laminar flamelet approach of Cook AW and Riley J J [Combust and Flame 1998; 112:593–606] was used alongside the default mixture fraction combustion model for comparison. The predictions of the two different combustion models for temperature and axial velocity distributions were found to be in reasonably good agreement with each other and the experimental data. Piotr Smardz studied the accuracy of FDS predictions for a scenario in which smoke spreads from a small compartment into an adjacent larger space, from which it is then extracted using powered ventilation system. The comparison between the FDS predictions and the experimental values made in his study showed that the resolution of the numerical grid is critical for accurate results. P. Coyle and V. Novozhilov did further validation of FDS using four smoke filling scenarios reported in the literature. Careful comparison was made to experimental data available for those scenarios.

Most validations mentioned above are about smoke flow, fire scenarios and parameter studies. As FDS is becoming more and more accuracy in simulation and can be easily download for usage, FDS tends to be the choice for more and more CFD simulation users. In the offshore industry, the production, processing, storage and transportation of hydrocarbons present an inherent risk of fire and explosions. Floating production storage and offloading (FPSO) topsides, in particular, have a high probability of fire and explosion accidents being caused by the leakage of oil or gas (Cullen, 1990; HSE, 1999, 2003; Czujko, 2001; Paik and Thayamballi, 2007). Simulations of fire scenarios of FPSO topsides are more necessary with the increasing usage of FPSO for transporting and supplying the energy from deep sea area. There is still much validating work to do. B. J. Kim etc. studied the feasibility of a CFD method to examine the effect of wind on the thermal-diffusion characteristics of FPSO topside models subjected to fire. It is motivated