Experimental and modelling studies of
Compartment Jet Fire Suppression Using Water Spray

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The safe design and operation of process plants requires an ability to predict hazard consequences reliably. A particular hazard is a jet fire that might arise from the ignition of an accidental release of pressurised gas or liquid. Mitigation systems involving agents such as Halon, which are perceived to be environmentally damaging, are currently out of favour and interest has revived in the use of water sprays.

The objective of this study is to assess the effect of fine water spray droplets on a propane jet fire which burns at 0.1 kg/s inside a compartment 6 m long, 2.5 m wide and 2 m high (fig.1). The total volume is 30 m^3 with reduced ventilation to simulate accidental fires in offshore modules. The vertical jet nozzle size is 1.5 cm. in diameter.

Mathematical modelling was done by using the computational fluid dynamics programme FLUENT. The modelling approach used divided the domain of interest (i.e. the compartment) into a number of discrete cells (25000) and the conservation equations was solved for each cell to obtain the field variables such as the fluid density, species concentrations, and temperature. The geometry was specified to be open at one end with induced ventilation arising from the jet entrainment.

In the initial stages of this study, the modelling of the development of the jet fire and the associated movement of combustion products within closed system of inter-connected compartment was carried out. This was followed by the development of the model for the dispersion of water spray droplets.

The simulation starts by first running the code without combustion to do the cold flow calculations in the compartment. Following that, the jet fire is ignited and the calculation was resumed until the dispersion of water spray is activated, the code tracks the flow of water droplets in the compartment and the interaction between the droplets in terms of mass, momentum and heat transfer. The water flow rates used in the studies were 0.05, 0.075,0.1, 0.15 or 0.2 kg/s in each time for different spray(s) locations.

For propane flame, fuel dilution due to water evaporation decreased the CO_2 and CO production rate and the O_2 depletion rate, figures 2-6. Less hydrocarbons were burned and the hydrocarbon percentage was observed to increase as the water application rate was increased with further increase in the water application rate, dilution effects become dominant and the flame gets extinguished.

The result shows that, for this study, oxygen depletion is not the main cause of extinguishment as there is still enough oxygen in the compartment to sustain the combustion.

The result of this work will be validated with experimental result.

References:

1. Cowley LT, Behaviour of oil and gas fires in the presence of confinement and obstacles, Health and Safety Executive; Steel Construction Institute, ISBN 0118820354, HMSO Books, United Kingdom, 1992. 307p.

2. Dinenno P.J,..et al, The SFPE handbook of fire protection engineering, first edition, 1993, National Fire Protection Association and Society of Fire Protection Engineers.

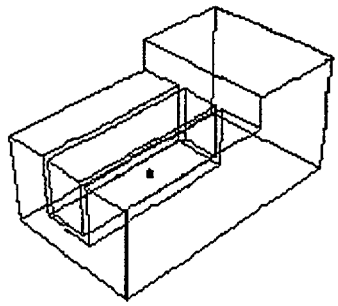

fig. 1 compartment geometry.

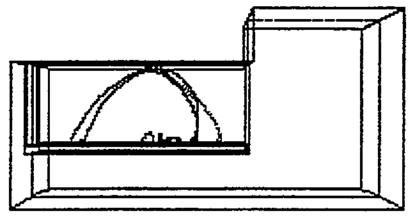

fig. 2. water spray droplet trajectories.

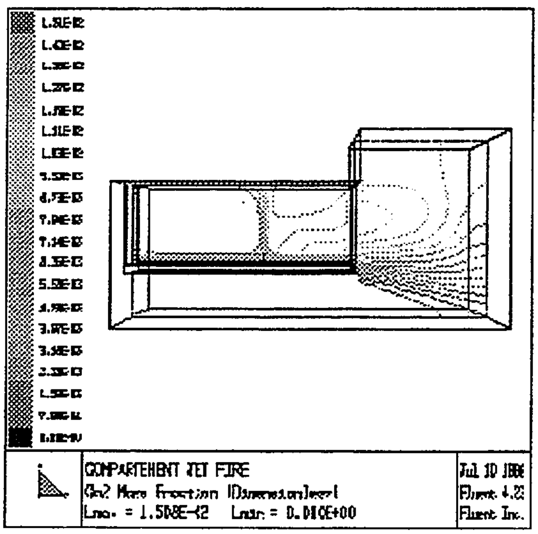

fig. 3. CO_2 mass fraction inside the compartment.

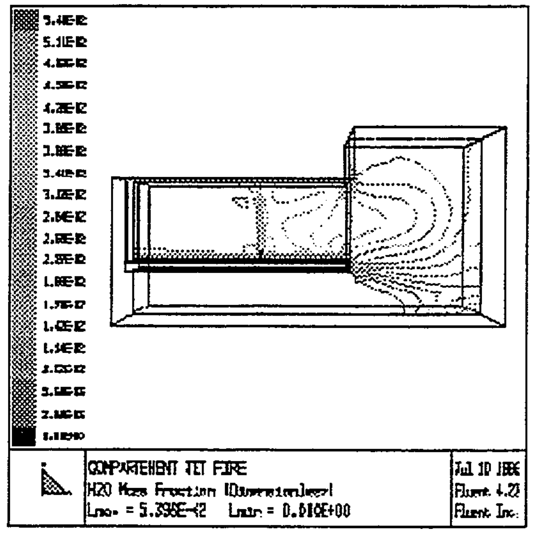

fig. 4. H_2O mass fraction inside the compartment.

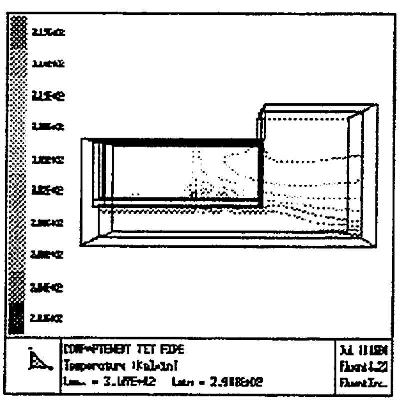

fig.5 temperature contours.

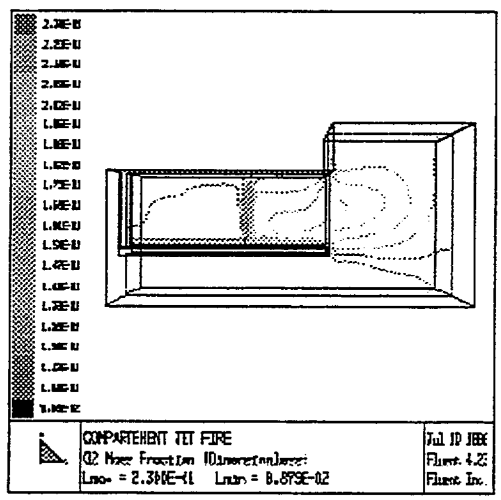

fig. 6. O_2 mass fraction inside the compartment.