Air-Water-Foam Mix Chamber For Fire Protection Of Fossil Fuel Containers: Modeling And Optimization

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Abstract

Since the industrial demand in the energetic, mining and oil & gas sectors has increased exponentially these last decades, security standards and fire protection methods are extremely important not only for the employees, but also for the infrastructure involved in production areas and processes. Throughout the fire protection circuits on site where fossil fuels are stored and manipulated, the risks of explosions and fire are part of a huge percentage of incidents and accidents. Therefore, hazardous sites and locations are a research priority and investment for obtaining optimal and novel fire protection systems. A foam chamber (Figure 1) is a fire protection hardware normally located in the highest section of fossil fuel tanks and containers. Its objective is to absorb air into the foam solution consisting on water and foam concentrate, to create a uniform layer in the final mixture to extinguish fire inside the aforementioned tanks. In consequence, foam concentrate mixtures need to be continuously improved to make sure that the corresponding mixture chambers comply with the highest standards for safety and property loss prevention, thus pushing industry's envelope towards the design of new and more efficient hardware. A typical fire foam solution is made of three fluids, i.e., water, air, and foam concentrate. Water and air as Newtonian fluids are part of approximately 95% of the final mixture; while the remaining 5% is occupied by the foam concentrate as a non-Newtonian fluid, and these concentrations could change depending of the properties of the fossil fuel. The physics of the problem involves multi-phase fluid interactions (Figure 2) which make it attractive for academic and industrial research, which by means of theoretical and computational methods improve and optimize the design of fire protection foam chambers in order to create a more efficient fluid mixture.

The objectives of this research study are: i) to understand the physics behind the mixing process of water, foam concentrate and air to create the new final mixture used for fire extinction, ii) to optimize the mixing chamber geometry in order to improve the production and the quality of the final mixture by applying computational and theoretical methods. These will be achieved by first, creating a 3D CAD model of the mixing chamber in AutoDesk Inventor. Second, the 3D CAD file will be exported to COMSOL Multiphysics® in order to simulate the mixing process. Third, the geometry of the chamber will be optimized with respect to the results obtained in the previous steps. Numerical modeling, testing and design of this kind of equipment help to save important amounts of money and time, as well as human related risks in comparison to their experimental counterparts.

Figures used in the abstract

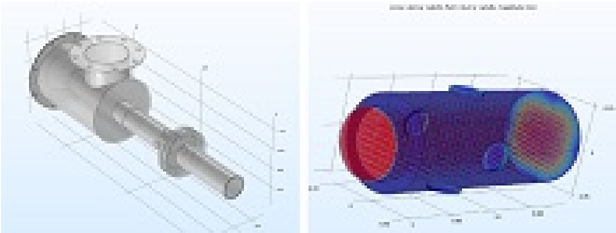

Figure 1 : Figure 1 & 2: Fire Protection Foam Chamber and Middle Section Simulation.