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Numerical Simulation Study on Sprinkler Control Effect in UBS Fuel
Tank Room of Nuclear Power Plants

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Abstract

FDS (Fire Dynamics Simulator) is the software to computing fluid dynamics which taking the flowing in fire as the main simulation target. In this paper, a model closed to real fire scenario of UBS (emergency diesel generator) fuel tank room of NPP is established by FDS. By analyzing this model, details on the effectiveness of controlling the fire source heat release rate, the key point temperature and the slices in the process of fire extinction based on sprinkler systems are discussed. In addition, it will show the advantages and feasibilities of FDS in NPP(nuclear power plant) application.

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Keywords: FDS, NPP, Fire protection, Sprinkler effect

Nomenclature

m_f	mass loss rate($\text{kg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$)
m^*_∞	maximum mass loss rate($\text{kg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$)
k	flame attenuation factor
Q	heat release rate in the unit area of combustible materials ($\text{kw}\cdot\text{m}^{-2}$)
H	combustion heat of liquid ($\text{kg}\cdot\text{m}^{-2}$)
<i>Greek symbols</i>	
β	the average light-length correction factor
η	combustion efficiency

1. Introduction

UBS fuel tank rooms of NPP are the places which are suffer from high frequency of fire accidents and when the fire accident occurred, it would be hard to controlled put out. High radiation made by the swift and violent fire which do harm to equipments and tanks nearby may expand the fire disaster. On the other hand, if the fire in fuel tank room touched operation

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functional area in NPP, the condition of reactor will be changed, as well as increasing the risk of the safety of nuclear. Based on this discussion, study on fire hazard in UBS fuel tank rooms is an important subject in NPP fire protection.

In China, studies on fire in UBS fuel tank room of NPP are relatively late, while methods and technology are backward. The second generation improved nuclear power project, which is mainly being used in China, is using a set of manual calculation methods introduced by France. The method is based on normalized thermal program. This program can get the time of the fire lasting in fire district by calculating fire load densities, and then compare with fire resistance of boundary, which cannot get the actual situation of temperature rise in fire and describe the control effect of sprinkle system. Consequently, there are some limitations in this method and technology [1].

In this study, a model closed to real fire scenario of UBS Fuel Tank Room is established in NPP, and details on the effectiveness of controlling the fire source heat release rate, the key point temperature and the slices in the process of fire extinction based on sprinkler systems are discussed. In addition, it will show the advantages and feasibilities of FDS in NPP application.

2. FDS fire modeling

2.1. Introduction of calculation model

FDS is a three dimensional computational fluid dynamics software (CFD), developed by NIST (National Institutes of Standards and Technology) and BFRL (Building and Fire Research Laboratory), based on large eddy simulation (LES), simulating the process of turbulence flowing in fires. FDS solves numerically a form of the Navier-Stokes equations appropriate for low speed, thermally-driven flow with an emphasis on smoke and heat transport from fire [2-4].

2.2. Parameter setting of fuel tank room

The calculation region of fuel tank room is a cuboid's space with $10\text{m} \times 8\text{m} \times 4\text{m}$. The building structure is reinforced concrete materials with a wall thickness of 0.5m. The fuel tank is located in the middle of the region in $8\text{m} \times 2\text{m} \times 2\text{m}$, and the fuel is diesel. The releasing stresses of spray system are 0bar, 0.5bar, 1.0bar and 2.0 bar respectively, the increasing coefficients (K-factor) is $40\text{L}/\text{min}/\text{bar}^{1/2}$, while the responsive temperature is 74°C . It's setted as a square and the intervals are 2m and 3m respectively, the environment temperature is 20°C . The calculation region of fuel tank room is shown in Fig. 1.

And parameter settings of simulating in FDS calculation region are shown in Table 1.

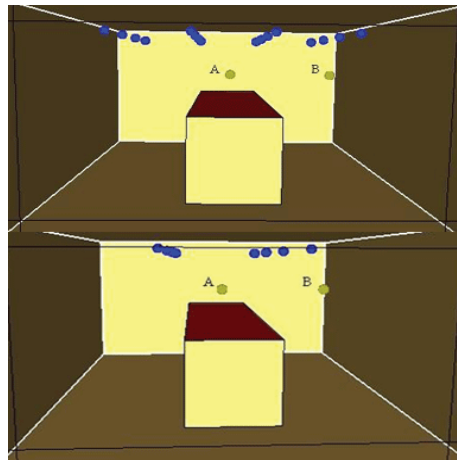


Fig. 1. The calculation region of fuel tank room

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