Research of 3D Simulation of Dangerous Goods Accident in Port

Jiezhe Geng and Yuchang Hu

China Waterborne Transport Research Institute, No.8 xitucheng road, Haidain District, Beijing 100088, PR China.
Email: gengjz@wti.ac.cn
*Corresponding Author Email: yuchang.hu@wti.ac.cn

Abstract. Through the analysis of the safety risk of dangerous goods storage and transportation in port, leakage, fire and explosion are the common accident types. The mechanism research of common accidents is carried out to understand the occurrence and development process of accidents, find out the key blocking links, and improve the efficiency of emergency disposal. A three-dimensional numerical simulation scheme of major accidents is proposed, which can simulate the whole development of accidents, and can be used for quantitative risk analysis before accidents and emergency decision-making in the process of accident disposal.

1. Introduction
There are more than 2000 dangerous goods transport vessels operating on the Yangtze River, with an average annual transportation of more than 200 million tons of dangerous chemicals. In recent years, the fire and explosion accidents of dangerous chemicals transport ships have occurred frequently, causing great property losses and casualties. Through the three-dimensional simulation research on the port dangerous goods major accidents, it is of great significance to improve the quantitative analysis level of port dangerous goods, which is of great significance to reduce the occurrence of accidents and the auxiliary decision-making after accidents.

2. Common Risk Analysis of Dangerous Goods in Port
Dangerous goods refer to substances, materials or articles with explosive, flammable, toxic, corrosive, radioactive and other dangerous characteristics, which are easy to cause personal injury or death, property damage or environmental pollution in the process of port operation, and need special protection.

According to the survey, the main dangerous characteristics of common dangerous goods are as follows:

(1) Flammability
Flammable or combustible substances, and the fire risk classification of class a goods are mostly, such as benzene, toluene., etc. are class A and B goods, with low flash point and strong volatility. As long as there is a small ignition energy in the air, it will flash and burn, and the combustion rate is very fast, so it is a liquid chemical with high combustion risk.

(2) Explosiveness
When the concentration is within the explosion limit range, when the concentration is within the explosion limit range, the explosion will occur when there is a certain energy ignition source. The wider the explosion limit range is, the lower the explosion limit is, the greater the explosion risk is.
For example, the explosion limits of methanol, ethylene glycol, acetone and butanone are very wide, so the explosion risk is also very large.

(3) Toxicity
Many liquid chemicals and their vapors are harmful to human body, such as benzene, aniline, methanol and toluene. Liquid chemicals are generally toxic. Under normal operation conditions, the concentration of liquid chemicals in the air of workplace can reach the national standard, which will not cause serious damage to operators. However, once abnormal conditions occur, such as leakage accident, it will cause harm to field operators.

(4) Corrosiveness
Sulphuric acid, liquid alkali and other corrosive products contact with human skin, eyes, lungs, etc., will cause damage to epidermal cells and tissue, resulting in burns, and the wounds burned by corrosive substances are not easy to heal. It can cause serious internal burns. Especially when contacting with sulphuric acid, it can cause severe pain and tissue necrosis. If not treated in time, it will lead to serious consequences.

3. Mechanism of Leakage Fire and Explosion
There are four forms of combustion:
(1) Diffusion combustion. Edge mixed with combustible oxygen,
(2) Mixed combustion. Combustible gas and flame retardant gas are mixed first, and then they burn when they meet the ignition source. It can cause heavy losses.
(3) Evaporative combustion. Combustible liquid vaporizes in heat and oxidizes and decomposes vapor.
(4) Decomposition combustion. In the process of combustion, combustible materials first decompose into combustible gas by heat and then burn with oxygen.

The main characteristics of explosion are the sharp increase of pressure at the explosion point and its surroundings. According to the energy source, it can be divided into physical explosion, chemical explosion and nuclear explosion. The basic risk degree $H = (L_{upper} - L_{lower}) / L_{lower}$, - in general, the larger $h$ is, the wider the explosion limit range is, and the greater the explosion risk is.

Both combustion and explosion require leakage or scattering of dangerous goods.
According to the statistics of port safety accidents in the past, most of dangerous goods accidents are leakage, fire and explosion. For example, at 1757 o'clock on May 19, 2020, when the empty ship "Q" sailed to the red floating water area of Tuqiao waterway, leaking lead to flash explosion, causing crew members injury and deformed cabin.

**Figure 1.** Leaking lead to flash explosion
4. 3D Simulation of Leakage
 Fluent software is used to simulate various complex flow fields from incompressible to hypersonic, including pressure based separation solver, density based implicit solver and density based explicit solver. Flexible unstructured grid, solution based adaptive grid technology and mature physical model can be used to simulate complex flow problems such as hypersonic flow field, heat transfer and phase change, chemical reaction and combustion, multiphase flow, rotating machinery, dynamic / deformation mesh, noise, material processing and other complex mechanisms.
 To construct the scene of chemical gas leakage, the colour depth demonstrate the concentration of the leaked gas.

5. 3D Simulation of Fire
 Fire Dynamics Simulator developed by National Bureau of standards and technology, is a computational fluid dynamics (CFD) model to simulate the fire energy driven fluid flow. A set of Navier Stokes equations (viscous fluid equations) describing the low-speed flow driven by heat are solved numerically. The emphasis is on the calculation of smoke flow and heat transfer in fire. In this paper, the finite volume technique is used to calculate the thermal radiation and turbulence in the fluid flow on the same grid. The generation and movement of fire gas are tracked and predicted. The growth and spread of fire are calculated by combining the external environment and meteorological factors. A series of data such as temperature, CO concentration, CO₂ concentration, O₂ concentration and visibility can be obtained.

![Figure 2. Simulation of fire heat](image)

6. Conclusion
 Through the analysis of the main safety risks in the storage and transportation of dangerous goods in the port, the leakage is the initial stage or pre condition of the common accidents. Through the three-dimensional numerical simulation of the leakage process, the diffusion process can be traced and judged, which can be used to stop the occurrence of subsequent accidents, and can be used for quantitative risk analysis before the accident and emergency decision-making in the process of accident disposal.
7. Acknowledgments
The 3D simulation was strongly supported by The Aerospace Information Research Institute (AIR).

8. References
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