Original Research Article

PHAST Based Influence Range Analysis of Ice Methanol Storage Tank Explosion

Xuefeng Tao

City University of Hefei, Hefei City, Anhui Province, 238076

Abstract: With the continuous development of alkali process to produce VC, methanol is an important raw material of the production process. Methanol is a dangerous chemical, and when mixed with air, it is easy to explode when met with heat source and open fire. Therefore, the storage of methanol is an important part of production safety. Therefore, based on the explosion accident of a company's ice methanol storage tank, this paper uses PHAST software of DNV GL in Norway to simulate the impact of the explosion of ice methanol storage tank on its nearest office building.

Keywords: Methanol; Explosion overpressure; Impulse; Explosion overpressure time

The introduction

Methanol is flammable, and its fire risk is class A, which is a dangerous chemical under key supervision. Its vapor and air can form explosive mixtures. In case of open fire, high heat energy cause combustion explosion. Chemical reaction or combustion in contact with an oxidizer. In a fire, the heated container is in danger of exploding. Its vapor is heavier than air and can be diffused to a considerable distance at a lower place, which will be ignited by an open fire.

1. Project background

The crystallization centrifuge plant is located in the south of the plant, about 17.5 meters high. Several equipment are arranged on the top floor plane, including an ice methanol storage tank with a volume of 5m3. Methanol is the main substance with explosive risk in the operation of the project. The northwest side of the crystallization centrifugal plant is the office building, the north side is the workshop control room, and the northeast side is the alkali conversion workshop. Once the ice methanol storage tank leaks, fire and explosion accidents may be caused, which may damage the surrounding buildings and facilities.

This paper is mainly about the explosion load simulation analysis of the ice methanol storage tank on the top of the crystallization centrifugal plant, focusing on the impact of the explosion on the office building, and obtaining the explosion load results for subsequent transformation analysis.

2. Analysis Methods

2.1 Analysis Procedure

The work content of this paper is the simulation calculation of explosion load, and the accident consequences are obtained. The analysis process is shown in Figure 1.

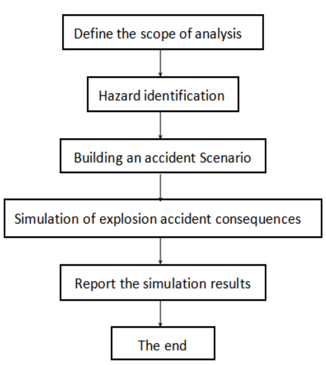

Figure 1 Analysis flow chart

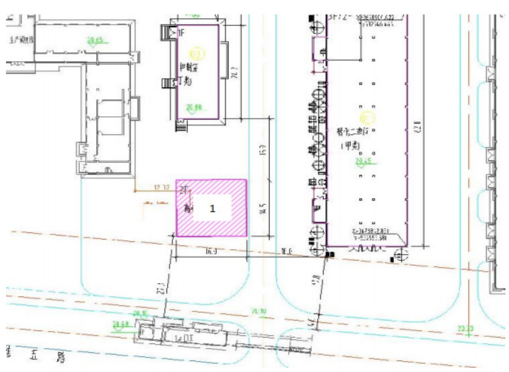

FIG. 2 Block area diagram (numbers are block area numbers)

2.2 Analysis Objectives

The analysis objective of this paper is to identify the damage and determine the failure event of the ice methanol storage tank of

doi: 10.18282/l-e.v10i3.2398

alkali transformation project. The accident consequence (explosion) caused by failure event is simulated and analyzed to determine the accident load of surrounding buildings.

2.3 Hazard Identification

Hazard identification refers to the identification of the initial event and the evolution process of the event that can lead to the serious consequences of the explosion, including the identification of the explosion event and the identification of the consequences of the explosion accident, according to the plane layout, process, operation conditions and material characteristics of the process device.

2.4 Evaluation criterion of explosion load damage to ordinary buildings

Table 1 below lists the damage effects of different overpressure values on ordinary buildings. The data in the table are engineering experience data, relatively rough, and the detailed failure effect needs to be analyzed and calculated in combination with load details and building structure details. Through the data in Table 1, the destructive effect of explosion load on ordinary buildings can be directly observed and qualitatively understood.

Table 1 Destructive effect of explosion overpressure on ordinary buildings

Pressure/kPa	impact
0.14	Disgusting noise (137dB, or low frequency 10 Hz~15 Hz)
0.21	Large glass, already in a state of fatigue, occasionally breaks
0.28	Produce large noise (143dB), glass breakage
0.69	Fracture of small glass under pressure strain
1.03	The typical pressure of glass breaking
2.07	"Safe distance" (below which the probability of not causing serious damage is 0.95); Ejection limit; Some damage to the roof; Ten percent of the Windows were broken
2.76	Limited minor structural damage
3.4-6.9	Large and small Windows are usually broken; Window frames were occasionally damaged
4.8	Buildings suffered minor damage
6.9	The house was partially destroyed and uninhabitable
6.9-13.8	Asbestos board crushing; Steel plate or aluminum plate wrinkle, fastening failure; Board fixed failure, blowing
9.0	The steel structure of the building is slightly deformed
13.8	The walls and roofs of houses partially collapsed
13.8-20.7	No reinforced concrete walls were destroyed
15.8	Low limit for severe structural failure
17.2	House brickwork 50% destroyed
20.7	Slight damage to heavy machinery (1362kg) in factory buildings; The steel structure of the building deforms and leaves the foundation
20.7-27.6	Failure of self-framed steel panel buildings; The oil storage tank ruptured
27.6	Cracking of cladding on light industrial buildings
34.5	Wooden support columns snapped; Building tall hydraulic press (18160kg) slight damage
34.5-48.2	Houses were almost completely destroyed
48.2	The freight train car tipped over
48.2-55.1	Unreinforced brick slabs of 203.2mm to 304.8mm thickness fail due to shearing or bending
62.0	The carriage of the freight train was completely destroyed
68.9	Buildings may be completely destroyed; Heavy machinery tools (3178kg) were displaced and severely damaged, while very heavy machinery tools (5448kg) were spared

3. Explosion Calculation

3.1 Constructing an Accident Scenario

3.1.1 Selection of typical accident scenarios

(1) Material leakage. Methanol is a kind of flammable and toxic dangerous chemical, which is mainly stored in the 5m3 ice methanol tank V0101 at the top of the crystallization centrifugal plant and transported to the crystallization centrifugal plant for use by pipeline.

(2) Source of leakage. The leakage source selected for the simulation analysis in this paper is ice methanol tank V0101, and its main parameters are shown in the following table

Table 2 Leakage source parameter table

equipment	specifications	Main operating conditions			Distance from office building/m
		medium	Operating temperature/℃	Operating pressure/MPa	
Cold methanol tank V0101	vertical DN1500×3000	methanol	0	Atmospheric pressure	15

(3) Leak scenario. Combined with the actual situation of the project and HAZOP analysis report, the leakage scenario is selected as follows: the operation of the ice methanol tank V0101 is abnormal, the temperature control fails, and the damage with an equivalent aperture greater than 150mm occurs on the tank body, that is, the complete rupture causes a large amount of methanol leakage in a short time

3.1.2 Identification of blocking space

The blocking space that can produce open space vapor cloud explosion in crystallization centrifugal plant is identified and marked with red box in Figure 2.

The crystallization centrifugal plant is a multi-storey building with the top floor plane height of 17.5m. The position of the ice methanol tank is near the middle of the top floor. The top platform is arranged with ice methanol tank, one mother temporary storage tank, two mother temporary storage tank, vacuum buffer tank and other containers, vacuum pump, candle filter and other equipment as well as a number of supporting pipes, surrounded by a cofferdam with a height of about 1.5m. These solid structures are conducive to the flow turbulence, and have a certain constraint on the expansion of gas cloud and dedetonation products, which will promote the acceleration of flame and cause the jump of dedetonation pressure.

3.1.3 Explosion source intensity

The explosion intensity of explosion source is divided into 10 grades by multi-energy method, and the grade of explosion intensity is related to ignition energy, obstacle degree of obstacle area and limitation degree of obstacle area. To determine the explosive intensity level of the explosion source, these three factors need to be considered comprehensively. The corresponding relationship between explosion intensity level of explosion source and combination of the three factors is shown in the table below.

Table 3 Determination of explosion intensity grade of explosion source

The ignition can		Degree of obstruction			Degree of constraint		Strength grade
weak	strong	strong	weak	No blocking	There is no constraint	There are constraints	
	X	X			X		7-10
	X	X				X	7-10
		X			X		5-7
	X		X		X		5-7
	X		X			X	4-6
	X			X	X		4-6
X		X				X	4-5
	X			X		X	4-5
			X		X		3-5
X			X			X	2-3
X				X	X		1-2
X				X		X	1

According to the actual situation of each unit, the multi-energy curve and volume blocking rate of each unit can be seen in the following table:

Table 4 List of blocking zone Settings

The serial number	Block area number	Multienergy curve	model.next
1	1	7	0.10

3.1.4 Meteorological conditions

According to the meteorological conditions where the company is located, bengbu City, Anhui Province has more than 10 years of breezes or no sustained wind direction, so the average wind speed is 2.41m/s. The average daily maximum temperature in summer was 31.5℃, and the average daily minimum temperature was 23.25℃. Considering the conservatism of risk analysis, temperature value of 31.5℃ was selected for simulation analysis. Neutral stability was selected for atmospheric stability. General conditions are selected for the height and lighting conditions of the mixed layer.

3.1.5 Time of leakage

The effective leakage time of hole leakage shall be the minimum of the following three values: a)60min. B) Ratio of maximum possible leakage to leakage rate; C) Leak time based on detection and interlocking cut-off system level. In this simulation, the complete rupture scenario, namely instantaneous leakage, is selected, so the selection of leakage time is not involved.

3.2 Model selection

In order to ensure that the simulation results meet the maximum impact of explosion consequences, the nearest distance between the ice methanol tank and the office building is selected for simulation according to the project layout, and the input parameter data is based on the equipment operating conditions, material parameters and equipment specifications provided by the enterprise.

3.3 Analysis of simulation results

The main protection target of the explosion simulation analysis in this paper is the office building. PHAST software is used to conduct explosion simulation calculation for the scenario of the complete rupture of the ice methanol tank V0101. The calculation results of the overpressure, duration and impulse data of the explosion shock wave generated are shown in the following table:

Table 5 Explosion simulation results in the scenario of complete rupture of ice methanol tank

system	object	The overpressure data/bar	Impulse./ (N.s/m2)	Duration of overpressure/ms
Cold methanol tankV0101	Office building	0.15	60	8

Explosion overpressure, explosion impulse and their influence range are as follows:

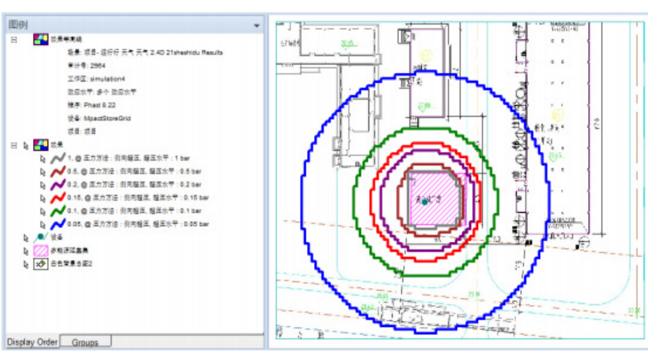

FIG. 3 Explosion overpressure radius of full rupture of ice methanol tank

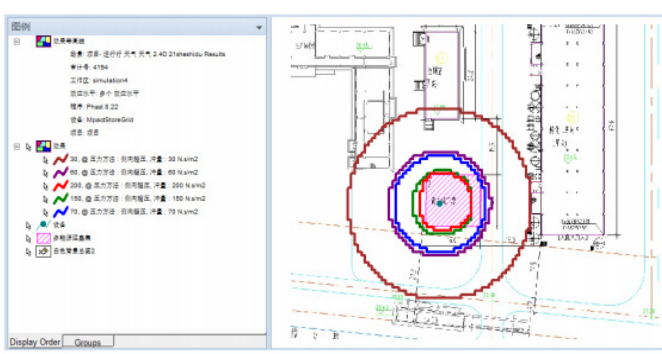

FIG. 4 Impulse radius of ice methanol tank full rupture explosion

4. Conclusion

To sum up: In this paper, PHAST software explosion calculation model is used to simulate the explosion consequences of the ice methanol tank V0101 in the crystallization separation workshop, and the maximum explosion accident load of the office building is obtained.(Next to page 87)

is introduced to large classes, attempts can be made to personalize the curriculum and individual needs will definitely be satisfied, therefore helping language learners to move into their next ZPD, the primary goal of any education.

References:

[1] Sun Jianlei.Theory of Mediation Role and English Classroom Teaching[J].Proceedings of Southwestern University for Nationalities, 2008(1):34-38

[2] Feuerstein R, Klein P S & Tannenbaum A J. Mediated Learning Experience: Theoretical Psychological and Learning Implication[M]. London:Freund,1991.

[3] Vygotsky.L.S.Mind in society[M].Cambridge:Cambridge University Press,1978.

Author introduction:

Chunyan Li (1975.3-), female, Han, Linyi, Shandong Province, master's degree, associate professor, English Language and Literature

(Continued from page 84)

(1) According to the calculation results, in the accident scenario of complete rupture of the ice methanol tank, the explosion overpressure in the nearest area of the office building is 0.15bar, impulse is 60N·s/m2, and duration of overpressure is 8ms.

(2) can be reference for relevant construction failure criteria to assess the explosion overpressure damage of buildings, in order to ensure the building structure has enough antiknock strength and bearing capacity analysis, evaluation of structure, such as walls, doors and Windows, ventilation valve now bear ability of explosion load, according to the results of the analysis, the antiknock reinforced strengthening measures are taken.

References:

[1] Wu Meng, Xu Yuan, Li Zuo, Chen Huifang, Li Bo. Application of improved vapor cloud explosion model in LNG storage tank explosion si mulation. Industrial safety and environmental protection [J], Issue 10, 2019, pages P44-47 .

[2] Liu Jingwei, Zhao Bin. LPG storage tank explosion accident assessment and safety management research progress. Contemporary Chemica l Industry [J], 2016, Issue 1, P67-69.

[3] Yang Jian, Liu Hui, Ye Rongrong. Analysis and visualization study on explosion accidents of pressurized storage tanks. Safety [J], Issue 7, 2012, P4-6.

[4] Wang Qiuhong, Sun Yilin, Li Xin, Jiang Juncheng, Zhang Mingguang, Wang Liubing. Numerical Simulation of Vapor Cloud Explosion Ind uced by Gas Leakage of Ethylene Storage Tank. Explosion and Shock [J], P121-133, Issue 12, 2020.

[5]Duan Yuhang, Dong Shaohua,Fang Zhuoyu,Xie Shuyi,Zhang Guangyu,Peng Yujie.Analysis of fire and explosion accidents of crude oil storage tanks based on AHP_DEMATEL Journal of Wuhan University of Technology (Information and Management Engineering Edition)[J], Issue 2, 2021 P131-136 Page.