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CFD-based methodology for onshore petrochemical control room layout

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ABSTRACT

A 2-step approach was proposed, in which the CFD-tool FLACS was used to estimate the layout of control room in onshore petrochemical. The initial step was to carry out a "worst-case" simulation by evaluating the consequences if a full stoichiometric gas cloud was ignited. As a second step, if potential consequences of the initial step was unacceptable, mitigation measures could be considered. Simultaneously, a coal gasification factory was selected as an illustrative example to show the application of the approach. The over-pressure of several Vapor Cloud Explosion (VCE) scenarios on the six potential control room positions nearby three mainly assessment units were analyzed. The comparison results indicated that the optimal layout of control room would be arranged in West-North (WN) position. The water spray system should be provided in the unit of sulfur tolerant shift for decrease the VCE blast on control room.

Introduction

Petrochemical plants have a higher explosion frequency than the other facilities because petrochemical plants contain many high-pressure equipment or devices containing lots of hazardous materials. Once the plant exploded, it is prone to cause huge casualties and property losses. The control room which is the essential building of petrochemical plants was destroyed in some explosion accidents [1]. For example, one of the control room was damaged in the Alon big spring refinery explosion accident which occurred in 2007. The layout is important protective measures for decrease the blast damage on control room in explosion accident. It makes sense to assess the potentially capability of control room against on the explosion accident blast. Computational Fluid Dynamics (CFD) analysis techniques for gas explosion safety have been widely used for risk assessments on control room within the oil and gas industry for more than a decade [2–4]. Kees adopted FLACS software to study the safe distance between petrochemical cracker and control room [5]. Hansen used FLACS software to assess the consequences of gas cloud with an accident [6]. Hoorelbeke summary studied the latest research on risk assessment of explosion using CFD technology [7].

However, CFD-Based Methodology for onshore petrochemical Control room layout were seldom reported in China. This work has been carried out in order to extend assessment on the layout of control room with CFD-tool FLACS.

Simulation model

3-D model which is based on the factory's actual situation is shown in Fig. 1. This model is established according to the actual sizes of petrochemical plant in the design files and

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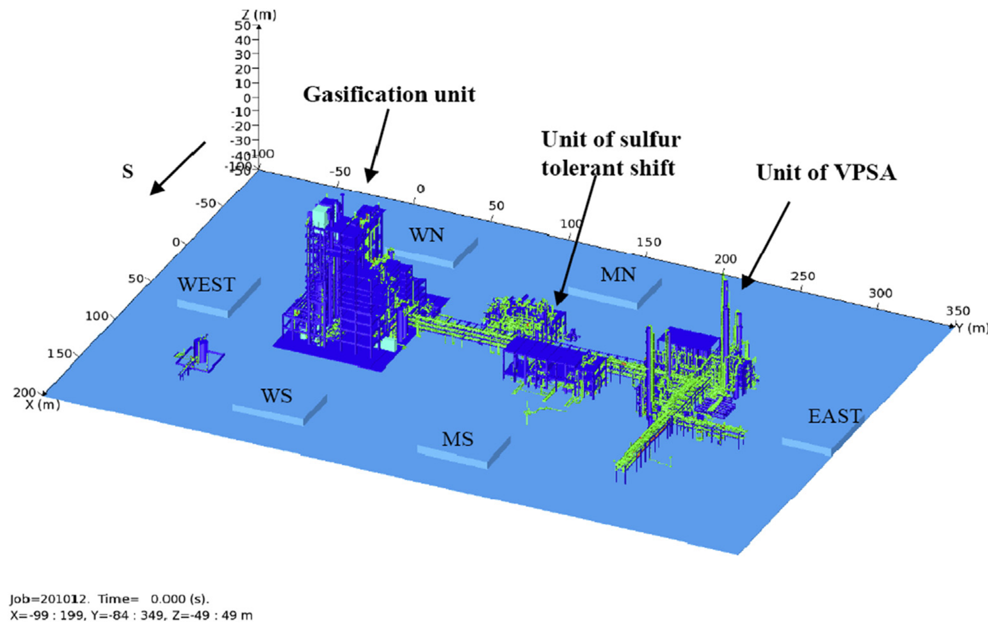

Fig. 1 – Three dimensional model for simulation.

pictures with the Microstation Software. This plant include three main units which named gasification unit, unit of sulfur tolerant shift and VPSA unit. The pipes with the diameter larger than 2 cm are provided in this model. The size and position of pipes were same as to those in the design files. Shapes of the key equipment and buildings are modified. The total simulation size was 350 m × 200 m × 50 m.

Six potential control room positions which named EAST, Middle-North (MN), West-North (WN), WEST, West-South (WS), Middle-South (MS) of the facility were analysis in this article. The distance between each of those control rooms to the edge of assessment unit is 40 m.

Explosion scenarios

Assessment unit

The three mainly assessment units are connected by pipe gallery with three layers. The high of pipe gallery is 15 m.

The gasification unit is a frame structure with ten layers and high of 45 m. The ground of each layer is made of aluminum grid plants. The potential control room positions nearby this unit are placed at WN, WEST, WS.

The unit of the sulfur tolerant shift have two frame structure parts and each of them has three layers with high of 15 m. The ground of each layer is made of aluminum grid plants. The potential control room positions nearby this unit are placed at MN, MS.

The mainly structure of VPSA unit is 25 m high with some towers high of 40 m. The mainly equipment in this unit are pumps and small tanks. The potential control room positions nearby this units placed at EAST.

Layout of those three assessment units are shown in Fig. 2.

"Worst-case" scenarios

Several worse scenarios were chose to simulate the consequence of credible gas explosion accidents. The identification of worse case scenarios is the key step for risk assessment in process industries. Three types explosion scenarios could be

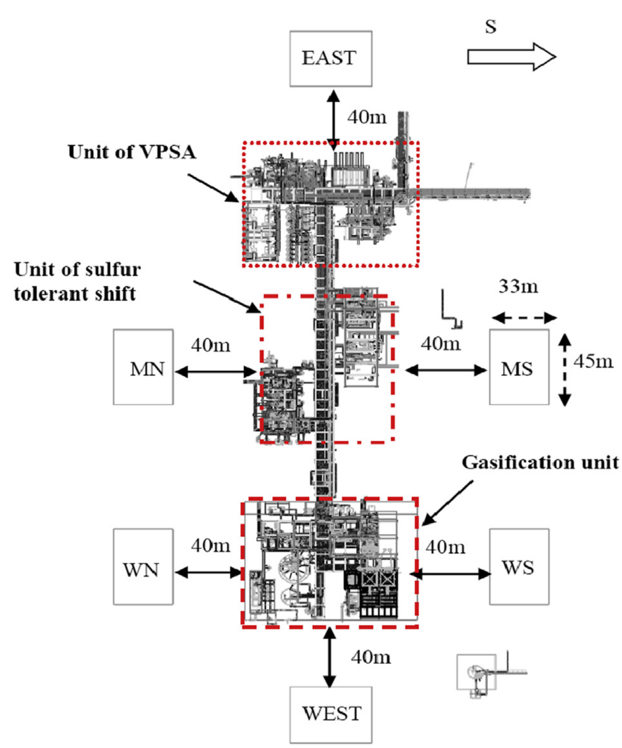

Fig. 2 – Layout for the assessment unit.