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CFD-BASED METHODOLOGY FOR ONSHORE PETROCHEMICAL CONTROL ROOM LAYOUT

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ABSTRACT

3D FLACS method was used to study the layout of control room in onshore petrochemical. Six potential control room positions were provided in this article.Several worse scenarios were chose to simulate the consequence of credible gas explosion accidents. Overpressure of those VCE scenarios were simulated by the CFD-Based method. According to the compared simulation results, it was suggested that control room was settled at WN position. The water spray system shall be provided in the unit of sulfur tolerant shift for decreasingthe blast on control room.

Keywords: FLACS; petrochemical plant; layout; control room

I. INTRODUCTION

Control room is the head of petrochemical plants. The layout of control room is important in case of damage in explosion accident.Once the plant explodes, it is prone to cause large huge damages on the buildings and some control rooms were also affected in those incidents [1]. For example, one of the control room in the Alon big spring refineryexplosion accident which occurred in 2007 were damaged. It makes sense to assess the potentially capability of control room against explosion or facility against explosion accidentand determine where the control room should be placed.Some researchers used the conventional assessment approaches, such as FLACS software [2-3]. Kees et al. adopted FLACS software to study the safe distance between petrochemical cracker and control room [4]. Hansen et al. used FLACS software to assess the consequences of gas cloud with an accident [5]. Hoorelbeke et al. summary study the latest research on risk assessment of explosion using CFD technology [6].

However, CFD-Based Methodology for onshore petrochemical Control room layout were seldom reported in China.In the paper, assessment on the layout of control room with FLACSwas performed.

II. SIMULATE MODEL

3-D model based on the factory's actual situation is shown in Figure 1. This model is established according to the actual sizes of petrochemical plantusing the design files and pictures with the Microstation Software. This plant include three mainly units which named gasification unit, unit of sulfur tolerant shift and VPSA unit. The pipes with the diameter larger than 2 cm were provided in this model. The size and position of pipes were the same to those in the design files. Shapes of the key equipment and buildings were modified. The total simulation size was 350m × 200m × 50m.

Six potential control room positions which named EAST, MN, WN, WEST, WS, MS of the facility were analysis in this article. The distance between those control roomsto the edge of assessment unit is 40 meter.

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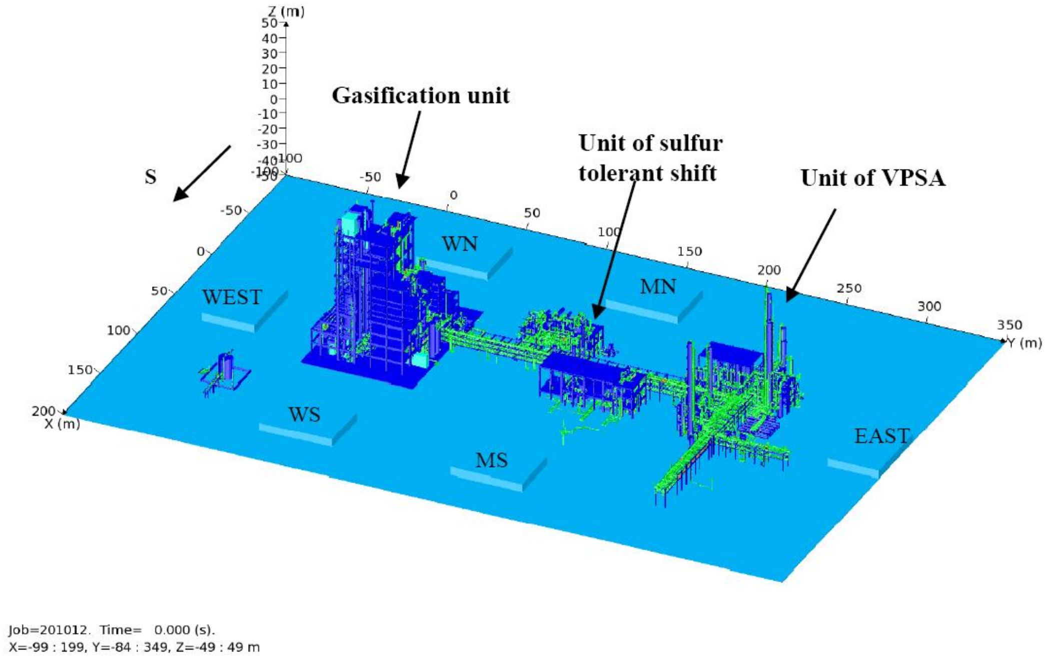

Fig.1 Three dimensional model for simulation

III. EXPLOSION SCENARIOS

Simulation unit

This plant include three mainly assessment units which named gasification unit, unit of sulfur tolerant shift and VPSA unit.Those parts are connected by pipe gallery with three layers and 15m high. Layout of those three assessment unitis shown in Figure 2.

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

The unit of sulfur tolerant shifthave two parts frame structure with both have three layers with 15m high. The ground of each layer was made of aluminum plants. The potential control room positionsnearly this unit are placed at MN, MS.

The mainly stucture of VPSA unitis 25m high with some of tower 40m high. The mainly equipment in this unit are pumps and small tanks. The potential control room positionsnearly this unitis placed at EAST

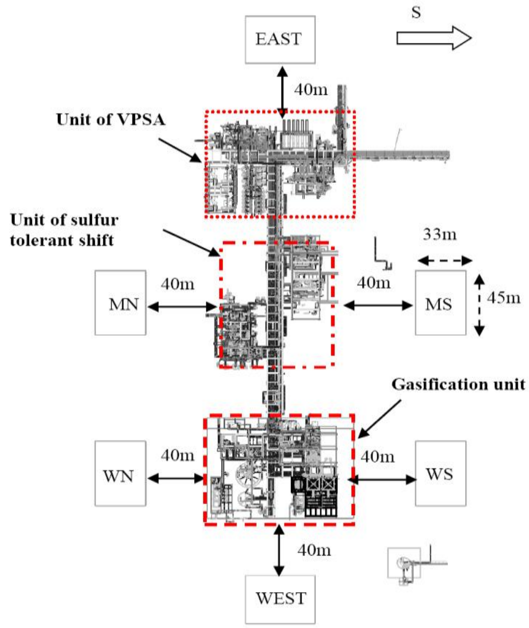

Fig.2 Layout for the assessment unit

Explosion Scenarios

Several worse scenarios were chose to simulate the consequence of credible gas explosion accidents.Three explosion scenarios could be chose to calculate the blast of the VCE explosion according to the guidelines of Blast Protection and Fireproofing suggested by ExxonMobile. The design basis vapor cloud scenario No.3 in this guideline was used for assessment the maximum credible vapor cloud explosion in this article. The sized vapor cloud namely 30000 cu m which containing a stoichiometric of LPG type material was chose. All of the vapor cloud were involved in the highly congested/confined area in the assessment unit of facility.We simplified the shape of this gas cloud as cubes with the size of 30×30×33.4 m3 and 37.5×40×20 m3. All of those cube gas clouds were placed in the highly congested area with threedifferent ignition positions. The used grid for explosion simulation is the cube with size of 0.5×0.5×0.5 m.

IV. RESULTS AND DISCUSSION

Maximum overpressure on control room

Several worse scenarios were chose to simulate the consequence of credible gas explosion accidents. Two types of gas cloud with size of 30×30×33.4 m^3 and 37.5×40×20 m^3 were chose for simulation. Those gas cloud were located at seven different places inthe gasification unit, and four place in the unit of sulfur tolerant, and five placesinVPSA unit. Three ignition position with the center, edges and corner of the vapor cloud were considered for each gas cloud position.

The time history of explosion blast wave on control rooms at WEST position is shown in Figure 3. Eight explosion scenarios could affect this control room and the maximum overpressure would be as high as 16.8kPa.

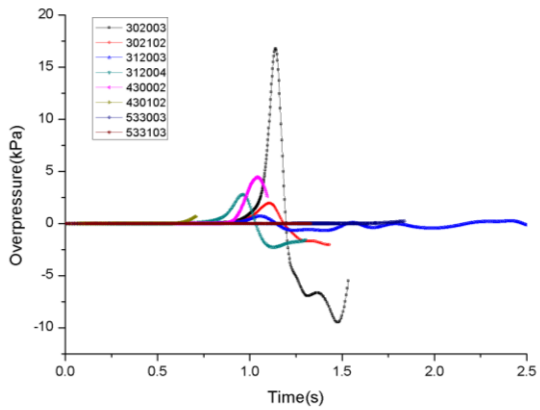

Fig.3. Summary of overpressure on control room at WEST position

The time history of explosion blast wave on control rooms at WS position is shown in Figure 4.The maximum overpressure on this control room would be as high as 23.8kPa.

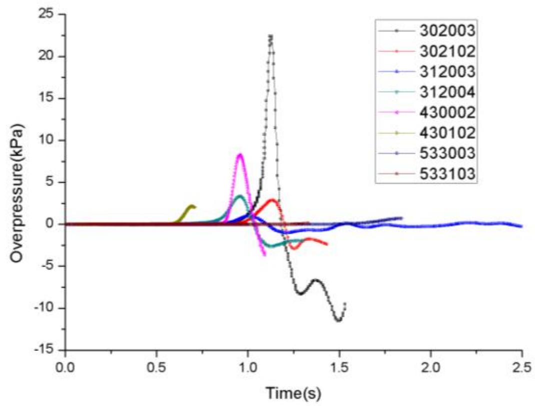

Fig.4. Summary of overpressure on control room at WS position

The time history of explosion blast wave on control rooms at WN position is shown in Figure 5. The maximum overpressure on this control room would be as high as 15kPa.

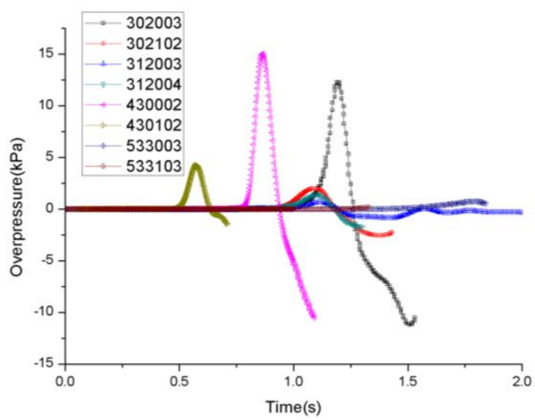

Fig.5. Summary of overpressure on control room at WN position

The time history of explosion blast wave on control rooms at MN position is shown in Figure 6. The maximum overpressure on this control room would be as high as 57.4kPa. According to the requirements in the safety design codes for control room in China, control room would against the blast of 21kPa with during time 100ms or 21kPa with during time 20ms.

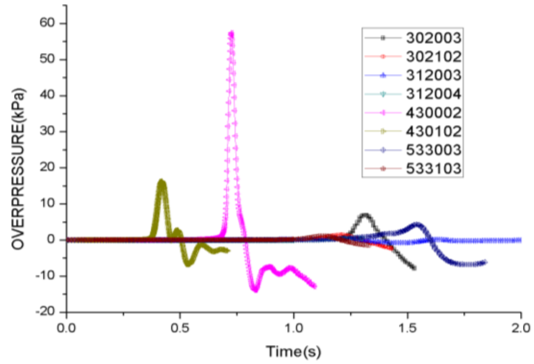

Fig.6. Summary of overpressure on control room at MN position

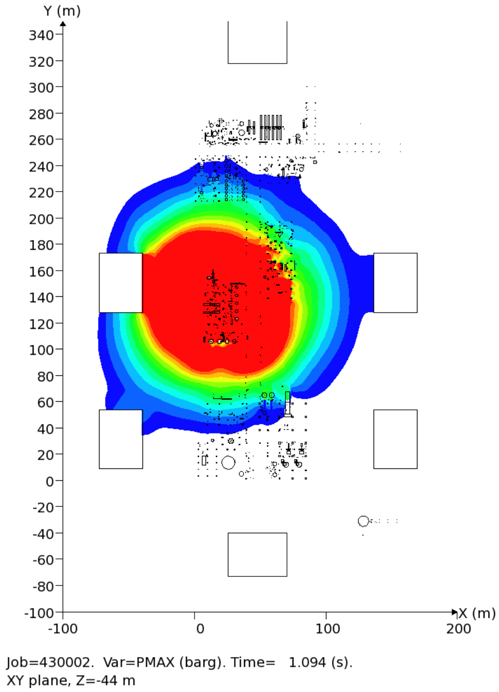

Fig.7. Explosion overpressure of worst scenario for sulfur tolerant shift unit (colorbar from 21 to 69kPa)

Figure 7 shows overpressure simulation results for the worst explosion scenario in sulfur tolerant shift unit. The overpressure over 21kPa is shown in red color.It was suggestion that the water spray system shall be provided in the unit of sulfur tolerant shift for mitigation the blast on the control room with placed in the MN location.

The time history of explosion blast wave on control rooms at EAST position is shown in Figure 8. The maximum overpressure on this control room would be as high as 22.3kPa.

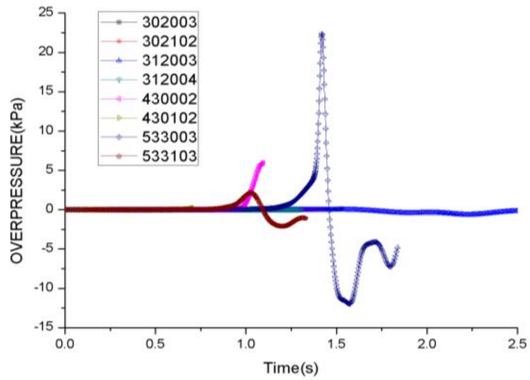

Fig.8. Summary of overpressure on control room at EAST position

Table 1 shows the summary resultsof maximum blast for control room under different the explosion scenarios.The blast value sequence of the six potential locations of the control room with maximum overpressure of the VCE was MN> WS > EAST > MS >WEST > WN. The worst layout for control room was the MN location with the overpressure faced to the blast was 57.6kPa. The better layout for control room was the WN location with the overpressure faced to the blast was 15kPa.

Table 1 Summary of the maximum blast

Location of the control room	WEST	WS	MS	EAST	MN	WN
VCE occurred in the gasification unit	16.8	23.8	11.1	-	8.2	12.5
VCE occurred in the unit of sulfur tolerant	4.4	9.0	18.2	6	57.4	15
VCE occurred in the VPSA unit	-	-	6.5	22.3	8.4	2
Maximum overpressure of the VCE(kPa)	16.8	23.8	18.2	22.3	57.4	15

V. CONCLUSIONS

A CFD-based methodology was used for onshore petrochemical control room layout. Six potential control room layout were analysis in this article. The results shows as follows:
The blast value sequence of the six potential locations of the control room with maximum overpressure of the VCE was MN> WS > EAST > MS >WEST > WN. The worst layout for control room was settled at MN position with the maximum overpressure is 57.6kPa higher than the requirements of the safety design codes for control room in China. It is suggestion that the water spray system shall be provided in the unit of sulfur tolerant shift for decreasing the blast on control room.
In conclusion, this article was conducive to develop advanced method of control room layout for onshore petrochemical

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