VOL. 12, NO. 10, MAY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
©2006-2017 Asian Research Publishing Network (ARPN). All rights reserved.
www.arpnjournals.com

SIMULATION IN DEVELOPMENT OF SKILLED AND COMPETENT OPERATORS

Sritharan Sangaran[1, 2], Rajeswari Raju[3], Saharudin Haron[2] and Ihsan Mohd Yassin[4]
[1]Petronas Chemical Olefins SdnBhd, Terengganu, Malaysia
[2]Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia
[3]Faculty of Computer and Mathematical Sciences, Universiti Teknologi Mara, Dungun, Terengganu, Malaysia
[4]Faculty of Electrical Engineering, Universiti Teknologi Mara, Shah Alam, Selangor, Malaysia
E-Mail: sritharan_sangaran@petronas.com.my

ABSTRACT

Modelling and Simulation helps industry to get information about how something will behave without actually testing it in real life in real industry scenario which will incur cost. One can compress the time frame, and study the behaviour of a scenario without engaging it. The use of this within engineering is well recognized. It became necessity or need in an industry. It plays various roles, from fulfilling the requirement in front end task up to furnishing the needed areas in back end task. In a petrochemical plant especially in Ethylene crackers, training operators to operate plant safely and consistent is a need. Highernumber in employees 'migration does play a role in a need of training simulator. When an operator with many years of experience left the company, he brings with himself a valuable portion of knowledge and data and training new personnel will incur money and time cost. The training of ethylene plant new operators now need to rely on senior operators experiences from different plant life cycle and will vary with different trainers. Need of simulation that can represent the real world scenario is a mandatory to give a valuable training experience and loss of billions dollars can be avoided.

Keywords: ethylene crackers, training simulators, chemical plant, operators.

INTRODUCTION

The panel man and field man are trained by using real time events. Plant abnormalities and unplanned events should be avoided. A worldwide survey shows that in United State alone, almost $10 billion are lost annually because of plant unplanned events [1]. Operator training plan is crucial step to reduce the monetary as well as the risk of operating the plant. Operator Training Simulators (OTS) are beneficial for educating employee action when faced with unplanned events, educating panel man and field man faster and succeeding quicker cracker startups [2]. A dynamic simulation model of the Ethylene crackers was developed. The model was developed using a Dynamic Simulation Software. This software incorporates dynamic behaviour of cracker process and provides a comprehensive dynamic training.

Operators are assets of a plant. In petrochemical plant capturing and retaining the knowledge of most experienced operators (panel man and field operators) are essential in leveraging the performance of the chemical plant. Simulators teach employee (operators) how to operate the plant with confidence and skill. The operators also can get the experience they need to be ready for any scenario [3]. Training simulators must fulfill the needs of panel man and field man [4].As chemical plants and process controller become more sophisticated, more effective solution is needed to maintain successful daily operation. Industry studies of the 170 largest industries, shown that the damage losses over the last 30 years in the hydrocarbon processing industry have shown that 28% are due to operational error or plant upsets [9]. Operational error due to lack of training and not capable of handling plant upsets result in the largest average dollar loss of all accident causes [14].

Chemical plant accidents worldwide

Table-1 shows the chemical plant accidents worldwide, while Table-2 shows disaster recorded in Malaysia Chemical Plants.

Table-1. Chemical plant accidents worldwide from 1970's to 2013, reported on 2015 [22].

Year	Incident	Result
February 3, 1971	Thiokol-Woodbine Explosion, Georgia.	29 died. 50 injured
May 4, 1988	Pacific Engineering and Production Disaster, Nevada	2 died, 372 injured
October 23, 1989	Phillips Disaster, Houston Chemical Complex, Pasadena	23 killed, 315 injured
May 1, 1991	Sterlington Plant Blast, Los Angeles	8 killed, 120 injured
June 13, 2013	Williams Olefins Plant Explosion, Los Angeles	2 killed, 114 injured

In just 2 years, 6 cases being reported publicly and there are also many small incidents that occur but not published in Malaysia. In just 8 months over 2016, 2 cases were reported. Many reasons can be named for as the causes. What we should actually look at is the ways to minimize the incident not to occur in future. According to a case study by [21] from his research back in 1991 till 2016 mentioned that three factors collectively caused accidents in chemical plants: equipment failure (possibly caused by maintenance problems), lack of human factors consideration and organizational factors. David Brown, chief executive of the Institution of Chemical Engineers

ARPN Journal of Engineering and Applied Sciences
©2006-2017 Asian Research Publishing Network (ARPN). All rights reserved.

(IChemE) [23] also quoted that human and organizational errors or failures are the major cause of accidents in chemical plants. To add more, being reported that one in five accidents caused by equipment failures in the chemical process industries are the result of human and organizational errors.

Table-2. Malaysia fire disaster in chemical plant for past 2 years (2015 and 2016).

Year	Incident
8th March 2015	Fire in Chemical Plant in TanjongPenjuru. 3 injured [20].
23rd June 2015	Petrochemical Petlin Malaysia plant catches fire [15]. Blaze was at the stello of the 130 tonnes boiler, which contained ethylene.
12th Sept 2015	Chemical plant fire in Kemuning, Malaysia. 1 died and 3 are badly burnt [19].
25th Dec 2015	Malaysia's Petronas Chemicals reports fire at plant [16].
28th June 2016	Fire Halts Operations at Malaysian Refinery [17].
20th July 2016	Bintulu: Petronas has confirmed that no one was injured in a fire at its Liquefied Natural Gas plant in Bintulu on Saturday [18].

Figure-1 shows the occupational accidents statistics by Malaysia State until December 2015, as published by the Occupational Safety and Health Department (DOSH), Malaysia.

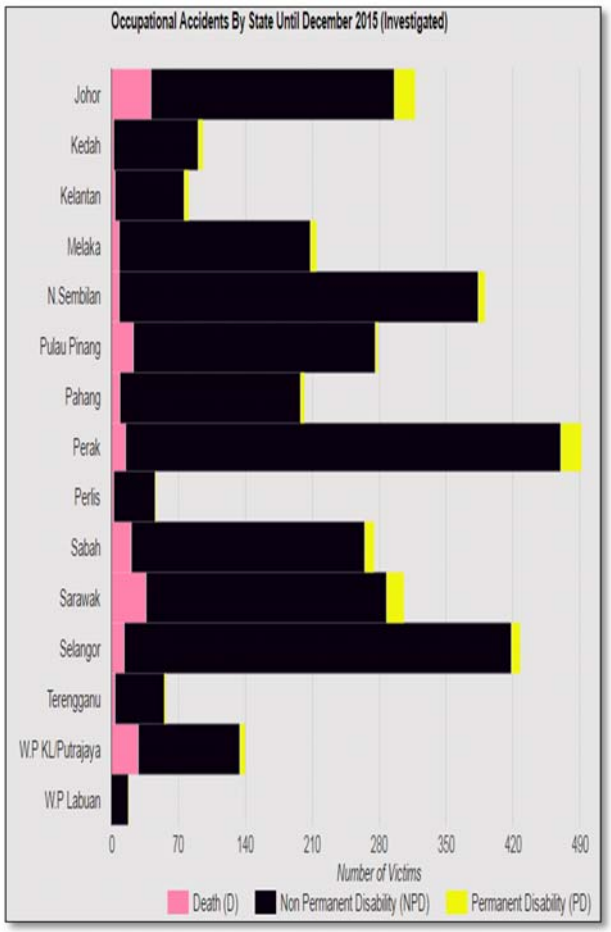

Figure-1. Statistics by Malaysia state for occupational accidents until December 2015.

Simulator

Operator training simulators (OTS) are computer based tools [5] for develop the panel man skill and leveraging the skill throughout the organization in a variety of technical systems [6].Efficiency of the OTS training should fulfill several requirements, in providing a useful platform for the employee to re-form important parts of the actual plant data and system. Ease maintenance, quicker simulation and user friendly models are much preferred in big plant scenarios [7-8].

The most effective methods for people to retain knowledge and sharpen skills [9] are through learning by doing. By using the training simulators, the management can train the operators on infrequent and dangerous process occurrences, practice smooth operation of the daily process, properly prepare an inexperienced operator workforce and create a smooth knowledge transfer process and able to test control system enhancements and the most promising in increasing the overall plant safety [10]. Simulators are designed and built to provide highly realistic process [11] and operations training to operators of a first of a kind petrochemicals plant (ethylene crackers). Simulation trainers are often senior staff who have a good grasp and helicopter view of the whole team-

VOL. 12, NO. 10, MAY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
©2006-2017 Asian Research Publishing Network (ARPN). All rights reserved.
www.arpnjournals.com

based approach [24]. The senior staffs are expected by the organization to be able to interact and provide valuable feedback. They will assist the organization to benefit further from the technology and to reach the set goal.

METHODOLOGY

Developing an OTS is not an easy task for a petrochemical industry. The simulator at least must meet the training requirements. It must represent the plant DCS behaviour. Figure-2 shows the conceptual of how real plants are converted into virtual plant.

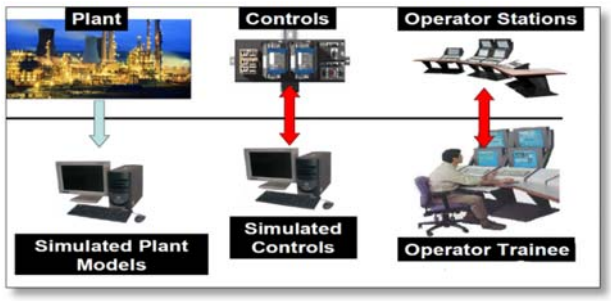

Figure-2. Converting of real plant to virtual plant.

The Figure-3 is the main methodology of developing an OTS in a petrochemical industry.

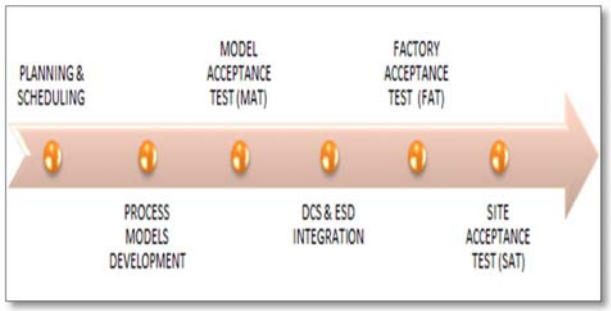

Figure-3. OTS steps.

Once the process model sheet developed then few testing will be done to test the behaviour of the model meets the plant data during Model Acceptance Test (MAT), Factory Acceptance Test (FAT), and Site Acceptance Test (SAT). Start up and shutdown task will be performed to verify the behaviour of the model. Parameters such as temperature, pressure and flow at steady state compare to plant data must match as per setting. For OTS purpose all the control logics and tripping logic are implemented before it is handover to users. It is crucial to understand the dynamic response of the model by varying the conditions under, which the plant is operated. Figure-4 is the examples of models lay out in flow sheets.

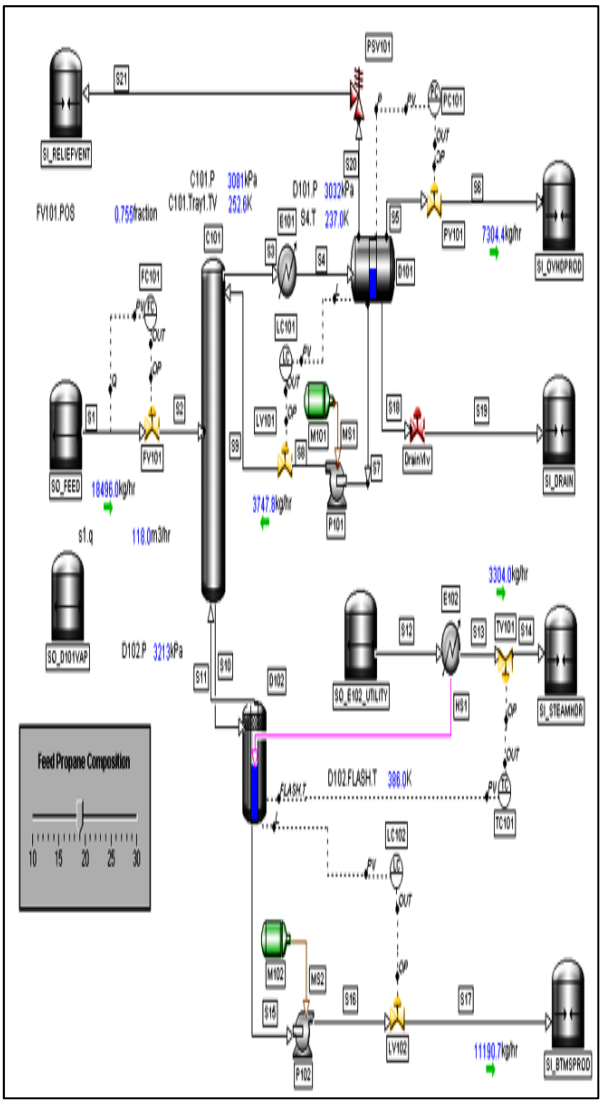

Figure-4. OTS process model layout.

RESULTS AND DISCUSSIONS

Training of panel man and field man is considered as a very important activity in the chemical industry [12]. The operator training simulator (OTS) is a substitute to train operators without actually jeopardizing the plant and personnel. Five senior operators and five new operators are tested in few scenarios as Table-3. The results were showing in average hours new operators took longer time to handle the scenarios compare to senior operators. The differences are almost double. Every hour delays will cause loss of production.

©2006-2017 Asian Research Publishing Network (ARPN). All rights reserved.

Table-3. Comparison of senior and new operators for handling events using training simulators.

Occasion	Experience boardman (Hour)	New boardman (Hour)
1. Start-up CGC	3	8
2. Start Up Reactor	4	8
3. Feed in Furnace	0.5	1.5
4. Start-up Light Separation	8	16
5. Control of DMDS & CO	1	2
6. Control of Hydro Reactor to avoid trip and break thru	1	2
7. Plant load increase	1	2
Total	18.5	39.5

The duration only can be improved with more exposure and practice with Training Simulators rather than learn through real experience. The cost of money and life is higher in occurrences of safety incidents.

The operator training simulators in the chemical industry reported in the open literature since 1990, and till to date are still a topic of interest as it is being successfully in use in many chemical industries. In ethylene plant, a process operator's job is varied including complex decision making and critical job aspects than others [13].

In 2010, when a reactor trip, it took 1.5 days for the experience operators to get the product back as shown in Table-4. When they left and was replace by the new operators, it took almost 3 days to get the products back. Once OTS training was implemented in year 2013, the trained operator took a day to get the product back.

Table-4. Start-up plant after reactor trip.

Date	Shutdown cause	Outage duration (Days)	Ethylene total loss (MT)
24/5/2010	Reactor trip	1.5	2775
4/5/2013	Reactor trip	2.96	5638
21/4/2014	Reactor trip	1	1666

A self-customized simulation is preferred since commercial simulators employed for training purposes focus more on 'fidelity' and not the facilities which will aid the training process [13]. A proper own customized simulators are preferred in many organization to fulfill their entire major and minor requirement. Another major issue why a proper training should be given to operators is not because of monetary issue but because of safety issues. Over the years, many cases being reported that cause peoples' life.

ACKNOWLEDGEMENT

We would like to thank Petronas Chemical Olefins (M) Sdn. Bhd. for funding the project, Ministry of Higher Education (MOE) for providing financial assistance for our research and University Teknologiof Malaysia (UTM) for giving us opportunity to do the research.

REFERENCES

[1] Roe, J. Mason and J. Alamo. 2010. The role of simulator technology in operator training.Control Engineering. 57(9): 1-3.

[2] Siminovich and S. Joao. 2014. Dynamic operator training simulators for sulphuric acid, phosphoric acid, and DAP production units. Procedia Engineering. 83: 215-224.

[3] Devold H. 2013. Oil and gas production handbook: An introduction to oil and gas production. Lulu. Com Press Inc, North Carolina, USA.

[4] D. Mance, R. Totaro and S. Nazir. 2014. How a plant simulator can improve industrial safety. Process Safety Progress. 34(3): 237-243.

[5] Manca, S. Brambilla and S. Colombo. 2013. Bridging between virtual reality and accident simulation for training of process-industry operators. Advances in Engineering Software. 55: 1-9.

[6] S. Mani, S. K. Shoor and H. S. Pedersen. 1990. Experience with a simulator for training ammonia plant operators. Process Safety Progress. 9(1): 6-10.

[7] V. C. Hass. 2005. Verbesserung der bioverfahrenstechnischenAusbildungdurcheinenvirtuellenBioreaktor. Chemie-Ingenieur-Technik. 77(1-2): 161-167.

©2006-2017 Asian Research Publishing Network (ARPN). All rights reserved.

[8] G. Reinig, P. Winter, V. Linge and K. Nägler. 1998. Training simulators: Engineering and use. Chemical Engineering and Technology. 21(9):711-716.

[9] S. W. Morgan, S. P. Sendelbach and W. B. Stewart. 1994. Improve process training with dynamic simulation. Hydrocarbon Processing. 73(4): 51-66.

[10] Adisa S. 2015. Knowledge base/industry applications, chemical: Mimic dynamic simulation for ethylene cracker units. MYNAH Technologies, Missouri, USA. https://www.mynah.com/knowledge-base/mimic-dynamic-simulation-ethylene-cracker-units

[11] O. Olwagen, S. Dasgupta, C. Liu and I. Eggberry. 2010. An operator training simulator for Superflex Unit. In: American Institute of Chemical EngineersSpring National Meeting and Global Congress on Process Safety.

[12] S. Patle, Z. Ahmad and G. P. Rangaiah. 2014. Operator training simulators in the chemical industry: Review, issues, and future directions. Reviews in Chemical Engineering. 30(2): 199-216.

[13] A. Shepherd. 1986. Issues in the training of process operators. International Journal of Industrial Ergonomics. 1(1): 49-64.

[14] S. H. Yang, L. Yang and C. H. He. 2001. Improve safety of industrial processes using dynamic operator training simulators. Process Safety and Environmental Protection. 79(6): 329-338.

[15] A. David. 2015. Petrochemical plant catches fire, no injury. New Straits Times. http://www.nst.com.my/news/2015/09/petrochemical-plant-catches-fire-no-injury.

[16] Reuters. 2010. Malaysia's Petronas Chemicals reports fire at plant. www.reuters.com/article/petronaschemicals-idUSL3E6NQ00L20101226.

[17] R Brelsford. 2016. Fire halts operations at Malaysian refinery. Oil and Gas Journal, Texas, USA. http://www.ogj.com/articles/2016/06/fire-halts-operations-at-malaysian-refinery.html.

[18] The Star Online. 2016. No injuries in Bintulu plant fire, says Petronas. http://www.thestar.com.my/news/nation/2016/07/30/no-injuries-in-bintulu-plant-fire-says-petronas.

[19] Yamkin-Earth Changing Extremities. 2015. Chemical plant fire kills one and three are badly burnt in Kota Kemuning, Malaysia. https://yamkin.wordpress.com/2015/09/12/chemical-plant-fire-kills-one-and-three-are-badly-burnt-in-kota-kemuning-malaysia.

[20] The Star Online. 2015. Three hurt in chemical plant fire. http://www.dosh.gov.my/index.php/ms/osh-global-news/1540-three-hurt-in-chemical-plant-fire.

[21] N. Meshkati. 1991. Human factors in large-scale technological systems' accidents: Three Mile Island, Bhopal, Chernobyl. Industrial Crisis Quarterly. 5(2): 133-154.

[22] Arnold and Itkin LLP, Attorneys at Arnold & Itkin LLP. 2015. Houston personal injury attorney, 6009, Memorial Drive, Houston.

[23] David B. 2013. Human error risk for process industries. Institution of Chemical Engineers, England, UK. http://www.icheme.org/media_centre/news/2013/human-error-risk-for-process-industries.aspx#.WMnt3mbVxYc.

[24] Lateef. 2010. Simulation-based learning: Just like the real thing. Journal of Emergencies, Trauma, and Shock. 3(4): 348-352.