An Analysis of Dust Explosion Incidents in Industries and Mitigation Best Practices within Malaysia

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Abstract-The trends of process safety incident have been put in the statistical research and development in order to prevent and mitigate the phenomenon. One of the incident are known as dust explosion that represent a constant hazard to industries including any manufacturing using and handling of combustible dust materials. Lack of sharing and know how on best practices in managing the workplace to avoid this phenomenon happening throughout the industries. The severity and the consequences of not practicing it before it happens were not been fore seen by the process team until it too late. This present paper discusses the best practices in managing the hazards from the catastrophes to be happening again. In addition, the mitigation response was also being explored thoroughly by database of best practices. The work summarizes in Microsoft Access database related to incident were tabulated according to the types of industries involved in dust explosion, the equipment that involved, the types of combustible dust, the sources of ignition points, and also the impact from the incident. All incident being summarized from the literature review and also documentation review respectively. Triangulation method was used in managing the data and verified with industries by having interview session, observation and documentation review.

Keywords: *Process Safety Incident, Dust explosion, best practices, database, mitigation*

1.0 INTRODUCTION

An increasing number of accident related to dust explosion have been recorded and been discussed since 1785 worldwide, it come to the new cases leading to a significant problem of injuries, fatalities, destruction of equipment and property loss. This event may still occur in various industries handling particulate organic and inorganic powders and dust. Those industries include grain and food, metal and metal finish products, power generation, textile manufacturing, coal mining and also chemical manufacturing.

The incident normally happened in the unit operations such as grinders, silo, mills, dust collectors, bucket elevators, conveyors, and other modes of transportation. Abbasi and Abbasi do found that the record of dust explosion incidents shows that on average, one dust explosion could happen in each industrialized country every day [1]. Unfortunately, there is still lack of publications whether in printed or soft copies present in developing countries that provides details information available on dust explosions.

Even though no coal mining industry is commercialized in Malaysia, there is a risk of having coal dust explosion due to transportation, storage and uses of coal in power generation industry, cement industry and other manufacturing industry that use coal as fuel or raw material of their products. Coal dusts are commonly difficult to ignite and have low explosibility however it can pose a danger hazard when exploded [3].

Bo and his co-worker in 2015 have collected across two hundred of dust explosions cases in Chine alone from 1949 until 2007 [2]. But in Malaysia, event the trend is increasing, but the reported case highlighted by DOSH Malaysia only 3 cases since 2008 until 2013 in DOSH website.

2.0 LITERATURE REVIEW

2.1 MECHANISM OF DUST EXPLOSION

A dust explosion is initiated by the rapid combustion of flammable particulates suspended in air. Any solid material that can burn in air will do so with a violence and speed that increases with the degree of sub-division of the material [10]. Higher the degree of the particle size, more rapid and explosive the burning, till a limiting stage is reached when particles too fine in size tend to lump together.

If the ignited dust cloud is unconfined, it would only cause a flash fire. But if the ignited dust cloud is confined, even partially, the heat of combustion may result in rapid development of pressure, with flame propagation across the dust cloud and the evolution of large quantities of heat and reaction products.

The furious pace of these events results in an explosion. Besides the particle size, the violence of such an explosion depends on the rate of energy release due to combustion relative to the degree of confinement and heat losses. In exceptional situations a destructive explosion can occur even in an unconfined dust cloud if the reactions caused by combustion are so fast that pressure builds up in the dust cloud faster than it can be dissipated at the edge of the cloud [8].

The oxygen required for combustion is mostly supplied by air. The condition necessary for a dust explosion is a simultaneous presence of dust cloud of appropriate concentration in air that will support combustion throughout the process and a suitable ignition source.

Many combustible dusts if dispersed as a cloud in air and ignited, will allow a flame to propagate through the cloud in a manner similar to (though not identical to) the propagation of flames in premixed fuel–oxidant gases [4]. Such dusts include common foodstuffs like sugar flour, cocoa, synthetic materials such as plastics, chemicals and pharmaceuticals, metals such as aluminum and magnesium, and traditional fuels such as coal and wood. All dust explosion elements were summarize as Fig. 1. All elements must be present in order to have dust explosion event.

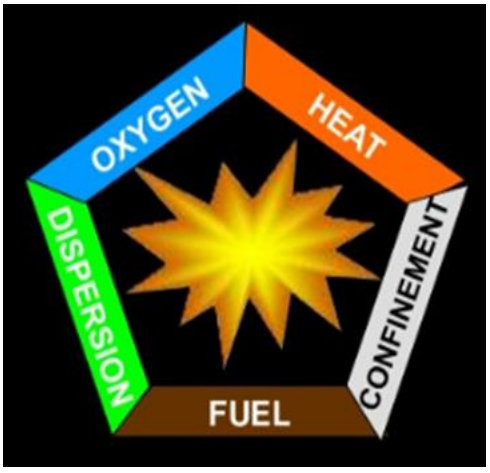

Figure 1: Dust Explosion Pentagon (DOSH website)

2.2 DUST EXPLOSION CASES IN MALAYSIA

There are several cases reported in the website of Department of Safety and Health which is happened in Mac 2008 in Lumut, Perak. The incident takes place at flour factory. The incident was triggered by the hot work activity (welding) in the confined space area filled in with the corn starch dust. The explosion covered vastly in the tunnel. The impact from this incident also involves jetty, conveyor system and destroyed installation in the tunnel with four (4) fatal deaths was concluded.

Meanwhile, in Nov 2010 at Pulau Pinang, the rim manufacturer factory was burned down due combustible dust explosion from the polishing activity in making rim. The origin of the cases was found to start from the fire and resulting with explosion in ducting system which transporting the aluminium dust to the tower duct collector. The impact during this incident have been cause an injury towards eight (8) workers and three (3) factory area was destroyed.

On 25 March 2013, one oleo chemical factory also experienced dust explosion in Seberang Prai industrial area. The stearate based powder exploded causing three (3) workers died. The dust accumulations in work area worsen the incident. This are called secondary explosion after the primary explosion have caused dispersion of dust and resulting with the major explosion.

The next case was reported to be take place at herb factory on August 2013 at Pulau Pinang. The officer reported the incident started from the herb manufacturing process in dust form. The local exhaust ventilation, ducting system and tower dust collector was involved in this explosion. The explosion started from oven that used for heating the herb dust. There are no injuries reported.

Latest case was found to take place in wood chip manufacturing in Gebeng, Pahang on August 2014. The dust collector was found to be in fire and exploded. There are no fatalities reported. There is possibility spark at the conveyor system but official report yet to be confirmed by the authority. Yet the incident was not discussed further in any platform resulting with repeated case will be foreseen in future.

Regardless of the incident that have been discussed, there are a lots more that was not reported due to there are no legislative put in order to keep the informing the authority for process safety incident in Malaysia. The current states of situation are now demand further action by local authorities to put up necessary action in order to manage this event in progressive manner. This is where UMP researcher has started the initiative in make up a proposal on managing the situation.

2.3 DEVELOPMENT OF LESSON LEARNT IN MANAGING PROCESS SAFETY INCIDENT

Thus, regard to this incidents record, the raising numbers of cases keep the society continues to ask why these accidents have not been eliminated. It depends on the effectiveness of learning from reported incidents can be often be questioned. [1] proposed a six-step method for evaluating learning from incidents.

However, the effectiveness of learning from incidents can often be questioned. In many case the learning process stops at the reporting step. The analysis of the incident reports and the following implementation of appropriate measures and improvements are often ineffective and the full lessons are therefore seldom learned [6]. For example, on March 23rd 2005, the isomerization unit at the BP Texas City refinery exploded. Fifteen workers were killed and more than 170 people were injured. The investigation of the BP US Refineries Independent Safety Review Panel (the so-called Baker Panel) found that potential weaknesses in process safety had been highlighted in numerous reports from prior accidents that had occurred previously on the site. According to the Baker Panel, BP had not learned those lessons because of a kind of organizational “learning disability” associated with issues regarding safety management, cost cutting, reward structure, decentralization and leadership [5].

By learning from past incidents operating companies can improve reliability, reduce risk and improve financial performance. In the spirit of ‘safety is not proprietary’, the authors here once again ask the chemical companies and relevant government agencies to share their accident reports. In order for this to work effectively, operating

agencies must be willing to share experience by reporting accidents and near misses to the chemical process safety community at large.

One of the obstacles to an effective and proactive lesson learning effort is the lack of public access to accident investigation reports. While public registers of industrial accidents are available from various government sources, the information disclosed about the accident is superficial. Moreover, finding accidents involving specific substances, processes or equipment in these registers is an additional challenge. To help address these challenges, the authors will present in this paper an overview of lesson learning in Malaysia and identify the areas in need of further research and improvement.

These incidents will be effectively shared throughout the industries by the development of the database that will be the medium of best practices and mitigation plan being kept and discussed by the relevant industries.

The researcher did manage the updated cases in the world as a summary, then described further to build lesson learnt sharing with industries. The participant comprise of chemical, petrochemical, manufacturing and also food product manufacturing. The sharing was carried out in seminar, conference and also case studies basis.

3.0 RECOMMENDATION

In reality, to set compliance with legal frameworks such as the Process Safety Management standards requires substantial resources and may become complex to be implemented but still will bring a lot improvement in SME operation in Malaysia.

According to the statistics noted above the real cases may be more than reported but still there are three main causes to be look into details which is inadequate process hazard analysis, training and emergency response planning. This is the major contributors that contribute significantly to the incident cases to take place in Malaysia.

Thus, the following recommendations are given to the SMEs and the government agencies that intend to help SMEs in accident prevention.

The DOSH department also been approached in the idea for developing a regulation that govern process safety incident to the compliance. This meeting already been carried out with Special Scheme Inspection at DOSH Putrajaya. They shared that the development of Dust explosion guideline is in the progress by technical team. These feedbacks are the commitment shown by the Regulator to enforce Process Safety in near future.

3.1 BUILT THE RELATION BETWEEN LOCAL AUTHORITIES WITH RELEVANT SMES

The relationship between stakeholders in SMEs is a must to improve their understanding on the risk mitigation and control. There are need to establish a simple step by step methodology addressing PSM elements targeting SMEs. The local authorities should review the SMEs operating procedure and discussed the process hazard analysis, training and emergency response planning.

To coordinate PSM related activity between SMEs, industry park administration, local authorities, research centre, university and communities should work along on the assessment and improvement of their operating procedure to reduce the risk. It depends on a strategic approach to prepare for and responding to emergency event with community involvement. This collaboration will have further guidance for learning lessons and developing operation sustainability.

3.2 INVESTIGATION ON ROOT CAUSE INTO PSM SYSTEM LEVEL

The root cause analysis usually is a weak point in accident investigation so that the effectiveness of lesson learning is often questioned. Accident investigations often stop at events close to the accident, which usually concern only the behaviour of the hardware and the operators directly concerned with carrying out the activity.

Changing hardware or disciplining operators will not systematically eradicate the root causes that exist in the safety management system. With the deterioration of the performance of the hardware or the operators, similar accidents will inevitably occur again. Therefore causal analysis should be sufficiently robust such that it does not stop at the technical causes (e.g., equipment failure, human error), but instead it should eventually determine what failure(s) occurred in the process safety management (PSM)'s system that created the conditions for the technical failures to occur. Root causes on PSM elements should be examined and reported thoroughly and systematically.

3.3 DISCLOSURE INFORMATION TO PUBLIC

More information about chemical accident risks and accidents need to be shared with the public, particularly in areas where a significant lack of information has made citizens distrust local agencies. Information also needs to be shared on the causes and lessons learned of accidents so that government and industry experts can improve their accident prevention, preparedness and response programs and procedures. In this regard, the government should establish information systems and requirements that can achieve these goals.

There should be information for the public on accidents that have occurred in a region, on sites where potential accidents could occur, and what to do in case of a major accident on one of these sites. When people are treated with fairness and honesty, and their right to take their own decisions is respected, they are less likely to overestimate small hazards and will support the government and companies actively.

3.4 BUILD DEDICATED WEBSITE FOR LESSON LEARNT

Government and industry also need additional knowledge about causes and lessons learned from accidents that can be used to update their standards, systems and procedures supporting accident prevention, preparedness and response. The government should therefore also create a common register specifically for reporting causes and lessons learned from investigations of major chemical accidents directly by industry or by government on the basis of its own or industry investigations. Full accident reports should be published in a dedicated website that is publicly accessible so that other operators and industries can learn from these accidents. Examples of such websites can be found in Europe (e- Mars) and US (CSB).

3.5 ESTABLISH LESSON SHARING MECHANISM FOR INDUSTRY

While this paper is mostly directed at the role of government, safety is in the end in the hands of industry. The chemical process industries must take a leading role in preventing accidents with big companies in particular investing resources to build industry-wide awareness and capacity. In particular, the industry should establish mechanisms to voluntarily share lessons learned with each other, by expanding existing industry and professional associations to support forums, publications, workshops and training events on risk management and lessons learned. The establishment of the Malaysia equivalents to the Center for Chemical Process Safety (CCPS) and Chemical Safety Board (CSB) of the United States should also be considered.

University Malaysia Pahang stands as pioneering in developing such environment to the related industries in Malaysia. Building up expertise and total understanding in PSM criteria will help fasten the preparation of Malaysia towards process safety incident yet to be happened.

Fig. 2 shows that the database features comprising all related incident that been summarized in access database. The database comprises of two hundred thirteen cases related to process safety incident and 67 related specifically into dust explosion. The detail on the industry types, material that involved and also the source of heat was also being tabulated. This data will be benchmark for industry to evaluate their premises whether they are facing the dust explosion threat or not and can take action to prevent the dust explosion at their facility.

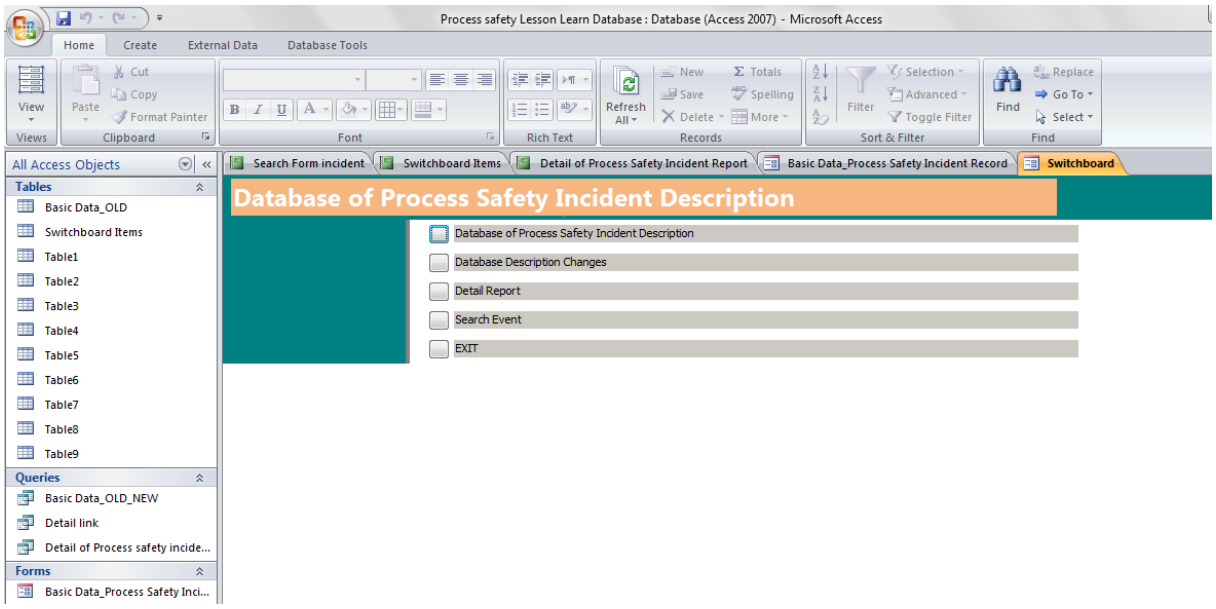

Figure 2: UMP-DEx database contain Process Safety Incident Data

4.0 CONCLUSION

Lesson learning is not only difficult for SMEs that have limited human resources and expertise, but also for large multinational corporations. Incident investigation is regulated under Malaysian law. However, how to effectively and systematically learn lessons from incident investigation reports has not been specified by the standard. Lesson learning does not only require high quality investigation reports, but also a high self-learning capability. A continuously learning organization has been recognized as one of the ten attributes that are important to create a best-in-class safety culture [9].

Learning is not completed until a relatively permanent change of behavior including process design or procedure is verified. Lesson learning should not be constrained within one organization. It should be encouraged and facilitated across industries and countries as a long term process. Priorities for Malaysia SMEs should be put on improving their capabilities in process hazard analysis and emergency preparedness and providing all necessary trainings to their employees. In order for an effective uptake of these practices, the Malaysian approaches introduced in this paper can provide easily applicable methodologies for SMEs with limited resources to coordinate their PSM activities. Improving chemical process safety management and emergency preparedness supports sustainable industrial development.

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