Journal of Material Science and Mechanical Engineering (JMSME)
Print ISSN: 2393-9095; Online ISSN: 2393-9109; Volume 2, Number 5; April-June, 2015 pp. 430-433

http://www.krishisanskriti.org/jmsme.html

Enhancement of Safety in Process Industries Using HAZOP Study

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Abstract— *The difficulty of the process in industrial plants is increasingly becoming hard to rectify and identify as a result of continuous new development in technology. This has resulted in a demand to check design for errors and risk occurrence, a task which has traditionally been achieve, The Hazard And Operability Analysis (HAZOP) procedure has been used in this paper. The process is split into various category and models of the separate sections are processed. Those models are used in the plan of the HAZOP procedure to determine the magnitude of the deviations from normal operation conditions that may lead to serious accidents and to test design modification to improve the safety characteristic of the process.*

Keywords: *HAZOP, safety, process industry, risk, hazard and operability.*

1. INTRODUCTION

Process Safety has lagged far behind the growth of the chemical process industries. The potential loss of life and the economic costs due to accidents are enormous. With the world's fastest industrial growth, most of the process industries must prevent accidents and minimize their consequences, for that this paper deals HAZOP technique.

Hazard and operability (HAZOP) is one of the best and most rigorous techniques for identification of hazard and operability problems in a chemical plant. The HAZOP procedure formally examines step by step all equipment as well as deviations from their normal operation conditions and considers what failures can appear. The HAZOP report includes all the deviations, their causes, consequences in equipment performance, analysis of such consequences, implemented protection (active and/or passive), and resulting suggestions. It can be successfully applied not only for existing plants, but also for new designed technologies and equipment. This procedure holds promise of greatly reducing the time and effort required in HAZOP making the study more smooth and detailed and minimizing the influence of human factors. HAZOP is carried out by a multidisciplinary team of experts in a qualitative manner. The new system is examined consistently, section by section, looking for inefficiency in design, which may lead to serious accidents. A series of guide words (such as ''None'', ''More of'', ''Less of'', etc.) are used to assure that all the possible deviations from normal operating conditions are recognized. For all deviation the available causes are listed and the consequences and actions required are considered. Often the action required is a change of the design in order to reduce the probability of a particular deviation, or to reduce the severity of its consequences. In a few cases, where deviation from usual conditions may lead to disastrous events. Incorporating HAZOP into process safety education is a real challenge as often the demonstration of the potential consequences of deviations from normal operating conditions is rather difficult.

2. USAGE

HAZOP is best suitable for determining hazards in facilities, machinery, and processes and is capable of determine systems from multiple perspectives:

2.1 Design

- Compute system design proficiency to meet user particularization and safety standards
- Identifying elegance in systems

2.2 Operational and Procedural Controls

- •Determining engineered controls (ex: automation), progression of procedure, operational controls (ex: human interactions) etc.
- Assessing various operational condition – startup, standby, normal operation, steady & unstable states, ordinary shutdown, emergency shutdown, etc.

2.3 Physical and Workable Environments

- Compute environment to ensure system is appropriately placed, promoted, polished, comprise, etc.

3. HAZOP PROCEDURE

Essentially, the HAZOP examination procedure consistently questions every part of a process or operation to determine qualitatively how deviations from normal operation can occur

and incase further careful measures, modified operating procedures or arrangement changes are required. The inquiring is continuously focused around a number of guide words which are derived from method study proficiency. The guide words ensure that the questions posed to test the virtue of each part of the design will explore every conceivable way in which operation could deviate from the design purpose. Some of the causes may be so faint that the derived consequences will be rejected as not being relevant. Some of the consequences may be incidental and need to be considered no further. However, there may be some alteration with causes that are possible and residual that is potentially severe. The built-in problems are then noted for corrective action. The actual solution to a problem may not be obvious and could need further consideration either by a team member or perhaps a specialist. All decisions taken must be recorded.

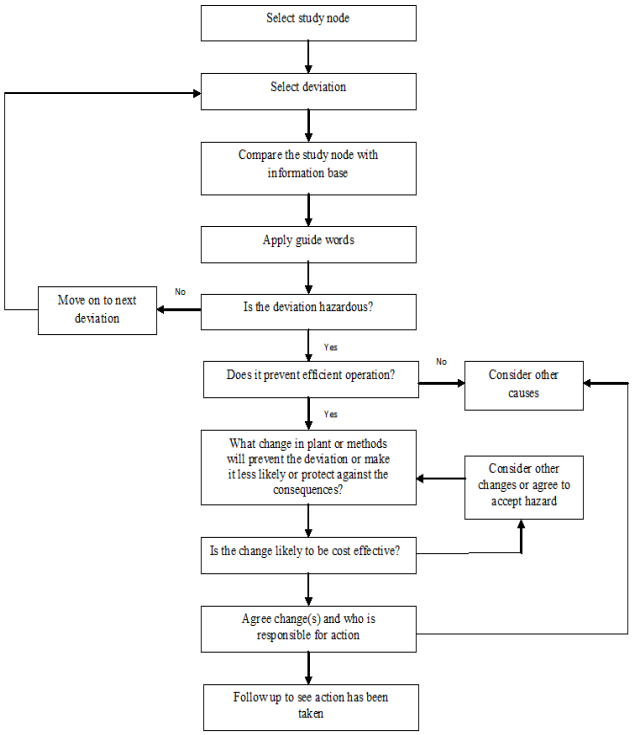

Fig. 1: A flow chart for HAZOP procedure

4. THE BASIC CONCEPT

Essentially the HAZOP procedure involves taking a full description of a process and systematically questioning every part of it to establish how deviations from the design intent can appear. Once determined, estimation is made as to whether such deviations and their consequences can have a negative effect upon the safe and efficient operation of the plant. If examine necessary, response is then taken to remedy the situation. This critical analysis is applied in a structured way by the team of HAZOP, and it relies upon them delivering their imagination in an effort to discover credible causes of deviations. In process, many of the sources will be moderately obvious, such as pump breakdown causing a loss of circulation in the cooling water facility mentioned below. However, the great advantage of the technique is that it encourages the team to consider other less obvious ways in which a diversion may occur, however strange they may seem at first attention. In this way the observation becomes much more than a mechanistic check-list type of review. The result is that there is a good chance that potential failures and problems will be identified that had not previously been experienced in the type of plant being studied.

5. MAJOR HAZARDS

Major hazards arise while working

- Decline to hand-over plant in secure condition on completion of work/cancelling of work permit;
- Manual error in controlling the valve;
- Mismatching in the allocation of work leads to failure
- in operation and creates unsafe condition in the plant;
- Without monitoring the initial setup of the machine, carrying over the operation is hazardous to both equipment and worker;
- Unauthorized staff performing work permits function; Poor management of the work permit system; and Insufficient monitoring of the work permit system.

5.1 Occupational Health And Safety

Peculiar health and safety hazards should be spot out based on job safety analysis or general hazard or risk assessment using well established methodologies such as a hazard identification study [HAZID], or hazard and operability study [HAZOP].

The most essential occupational health and safety hazards occur during the operational aspect of a TiO2 processing facility and primarily include the following:

• Process Safety

• Oxygen-Enriched Gas Releases

• Inhalation hazards

• Fire and explosions

5.1.1 Process Safety

Process safety programs should be implemented, due to industry-special unique characteristics, comprising complex chemical reactions, multistep reactions and use of hazardous materials like toxic, reactive, flammable or explosive compounds. Process safety management includes physical testing hazard analysis, preventive maintenance, employee training, and emergency planning.

5.1.2 Oxygen-Enriched Gas Releases

An installation of automatic Emergency Shutdown System can identify and notify the uncontrolled release of oxygen from the oxygen-enriched atmosphere, whether it will be onsite or offsite exposure. According to these good housekeeping practices help to reduce easily flammable materials, fire prevention and control equipments.

5.1.3 Inhalation Hazards

Inhalation hazard occurs due to atmospheric air pollution by the chemical industry (Titanium dioxide plant) releases reactive gases like Sulphur dioxide, sulphur trioxide and droplets H_2SO_4. These reactive gases formed are removed by means of water wash (Using scrubbers), followed by two soda washes (venture washer and tower).

5.1.4 Fire and explosions

Fire and explosion is one of the most common and dangerous problem occur in chemical industries due to chemical reaction and flammable material. By installing fire fighting devices like smoke detector, water sprinkler and fire extinguisher and by keeping away the flammable materials from the chemicals can reduce the fire accidents.

6. HAZARD IDENTIFICATION IN TIO_2 PLANT

- Leakage of chemicals
- Over temperature
- Thermal fatigue
- Erosion of tank
- Over flow of tank
- Corrosion fatigue

The following table consists of guide words of HAZOP study

Table 1: Guide words

General parameters	• **No** • **More** • **Part of** • **Less** • **Reverse**
Time parameters	• **Sooner** • **Later**
Position & Source parameters	• **Where else** • **Other than**
Temperature, Pressure parameters	• **Higher** • **Lower** • **More** • **Less**
Other parameters	• **Where else** • **Before/After** • **Early/Late** • **Faster/Lower**

For each key word, the HAZOP team will list the possible causes and the consequences regarding the operating procedures and the safety aspects from both personnel and material point of view. If the consequences are considered as being out of the normal operating range, the HAZOP team will investigate the installed safeguards:

a) The detection devices, to ensure that the operator will be familiar that something unusual is happening.
b) The safety devices installed, to reduce the consequences of the process upset. Analyze the devices which are considered adequate for the considered risk, the next key word will be reviewed, then the next parameter, then the next process lines or equipment.

The following table gives an overview of general guide word - parameter and interpretations of them in TiO_2 plant

Table 2: General Parameters

Parameter/Guide word	More	Less	None	Reverse	Part of	Other than
Flow	High flow	Low flow	No flow	Reverse flow	Contamination	Deviating material
Pressure	High pressure	Low pressure	Vacuum	Back pressure		Explosion
Temperature	High temperature	Low temperature				
Level	High level	Low level	No level			Different level
Time	Too long/ Too late	Too short/ Too soon	Skipping the step	Backwards	Extra action	Wrong time
Agitation	Fast mixing	Slow mixing	No mixing			
Reaction	Fast reaction	Slow reaction	No reaction			
Start up/Shut down	Too fast	Too slow				
Draining/Venting	Too long	Too short	None		Wrong timing	
Utility failure(power, air supply)			Failure			
Vibration	Too low	Too high	None			Wrong frequency
Maintenance			None			

7. HANDLING TITANIUM POWDER

- Avoid any action that tends to suspend or float powder particles in air.
- Take steps to limit the size of fire or an explosion and to hold any resulting damage to the very minimum.
- In transferring titanium powder, dust clouds should be kept at a minimum, powder should be transferred from one container to another with as little agitation as possible.
- Avoid every possible action that generates static electricity, creates a spark, or otherwise result in reaching the ignition temperature.

Cause.-Process failures are always occur due to the fact that some section of the titanium industries is, too weak to withstand the pressure of the pulp. This may be due to one of two causes: Either the pipe line is not strong enough to safely carry its proper pressure, or else the pressure has been allowed to rise above the usual point by some manual errors (like adjusting valve) or some similar cause.

Some type of major hazards and its percentage of occurrence in titanium production plant are listed below.

Table 3: Hazard Occurrence Rate

Hazard variety	Frequency rate
Leakage of pulp	27
Leakage of utility(Water, Air)	17
Fire and Explosion	3
Exposure to harmful substance	6
Cornered and Extinguish	2
Machinery	9
Electricity	7
Transport	18
Others	11

8. ACCIDENT REPORTING, INVESTIGATION AND REMEDIAL ACTION

- Collect first information of the accident and to inform DGM.
- Analyze the accident to find out the root cause and suggesting remedial action to prevent reoccurrence.
- Follow the suggested remedial action for concurrence.
- Assisting HR department to send the report to Factory Inspectorate.
- Getting the man days lost from HR department.

8..1 Conducting safety audit and corrective actions

- Safety audit to be conducted to find out unsafe condition & act once in six months.
- Corrective actions to be suggested
- Action plan to be prepared with responsibility and target date
- All concern to be communicated and the followed up Progress to be reviewed during safety committee meeting.

Table 4: Hazop Worksheet

SI. NO.	COMPONENT	DEVIATION/ GUIDE WORD	POSSIBLE CAUSES	RECOMMENDATION ACTION
1	Primary pulp inlet pressure	More flow	▪ Leakage at inlet valve ▪ Over formation of cake	▪ Check inlet valve position ▪ Install pressure gauge at inlet
2	Temperature of pulp	More temperature	▪ Damage the filter press cloth ▪ Formation of cake takes more time	▪ Check the temperature and then give feed ▪ Install temperature monitor in feed tank ▪ Digital temperature indicator with high alarm
3	Feed time	Too long	▪ Leakage of pulp through filter plates ▪ Escape of pulp through spent acid	▪ Standardize the time for each feed ▪ Check the cake thickness in definite interval
		Too short	▪ Formation of cake takes more time ▪ Cake thickness will be less	
4	Mixing of water	More	▪ Reduces pulp property ▪ Increases feed time	▪ Level sensor are recommended in water mixing ▪ Provision for Automatic flow control valve in water line
5	Agitator	Less agitation	▪ Sedimentation of pulp in tank ▪ Create choke in circulation/outlet valve	▪ Proper agitation to be provide by installing sensor ▪ Immediate processing to be required

9. CONCLUSION

This paper focuses on preventing the accident in process industry by using HAZOP study through periodic inspection. In that, hazards will be identified and minimized. Study is carried out by visiting various work process in titanium dioxide industry, hazardous present in work through HAZOP study. Possibility for prioritizing scenarios is supplementing HAZOP study with qualitative risk analysis. This approach allows identifying the most important issues of assessed technology and assists to design an appropriate technical/organizational measure to minimize the identified risks.

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