

HAZOP STUDY FOR THERMAL SPRAY SYSTEM IN AN HEAVY ENGINEERING INDUSTRY**T. Dheenathayalan* & Dr. H. Abdulzubar****

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Abstract:

This project deals about hazard and operability study (HAZOP) for thermal spray coating system. Thermal coating system is used to coat the nozzle diaphragm of turbines. There are different types of thermal spray coating systems are available. Generally, the coating quality increases with increasing particle velocities, so High Velocity Oxygen Fuel Spraying (HVOF) system was used but high velocity oxygen fuel spraying (HVOF) is a critical spraying process. In HVOF coating process kerosene is used as a fuel for thermal spray coating which is highly inflammable. Oxygen is used as the source of combustion for thermal spray. Nickel chromium is used as a coating agent, it is very dangerous in the form of fumes and nitrogen is used as a carrier gas for the transportation of Nickel chromium powder. So the hazard operability study is very important for the thermal spray system to identify the hazards that occurs in the piping systems during working of the thermal spray. HAZOP study can be done by using the guide words to reduce the risk level.

Key Words: HAZOP, Deviation, Intention & Study Node

1. Introduction:

Thermal spraying can provide thick coatings (approx. thickness range is 20 micrometers to several mm, depending on the process and feedstock), over a large area at high deposition rate as compared to other coating processes such as electroplating, physical and chemical vapor deposition. Coating materials available for thermal spraying include metals, alloys, ceramics, plastics and composites. They are fed in powder or wire form, heated to a molten or semi molten state and accelerated towards substrates in the form of micrometer-size particles. Combustion or electrical arc discharge is usually used as the source of energy for thermal spraying. Resulting coatings are made by the accumulation of numerous sprayed particles. The surface may not heat up significantly, allowing the coating of flammable substances.

High Velocity Oxygen Fuel Spraying (HVOF):

During the 1980s, a class of thermal spray processes called high velocity oxy-fuel spraying was developed: A mixture of gaseous or liquid fuel and oxygen is fed into a combustion chamber, where they are ignited and combusted continuously. The resultant hot gas at a pressure close to 1. MPa emanates through a converging – diverging nozzle and travels through a straight section. The fuels can be gases (methane, propane, propylene, acetylene, natural gas, etc.) or liquids (kerosene, etc.). The jet velocity at the exit of the barrel (>1000 m/s) exceeds the speed of sound.

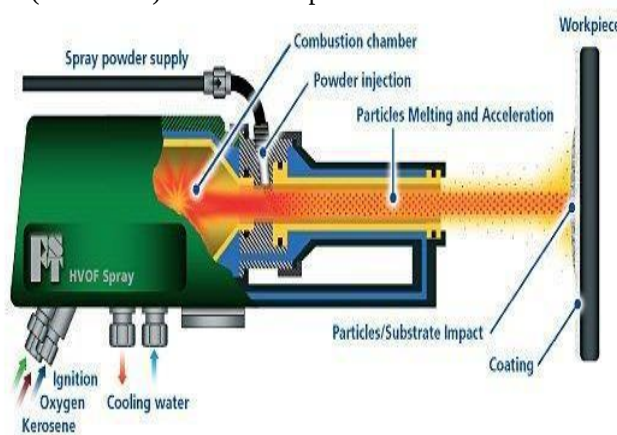


Figure 1: High Velocity Oxygen Fuel Spraying Equipment

2. Literature Survey:

Feng Wang et. al., (2012) published a paper on the A novel knowledge database construction method for operation guidance expert system based on HAZOP analysis and accident analysis. An expert system for operation guidance will contribute to identifying the operation problems and indicating the resolutions thereof, because the information stored in the expert system can be utilized to resolve the corresponding technical problems. However, there are several problems that should be solved in the practical application of the expert system, such as lack of corresponding knowledge or resolutions utilized to cope with the problems, inapplicable resolutions, too many resolutions for the operators to choose from to obtain the best one in the first time, etc. Obtaining and storing as much as information in the database of the expert system are important issues in

the construction process of the expert system. The accident analysis results contain a limited number of accident cases and the HAZOP analysis only refers to a single deviation analysis. This paper has presented a novel knowledge database construction method for an operation guidance expert system based on the HAZOP analysis and the accident analysis, which can be used to resolve the above problems. The HAZOP analysis results are combined with the accident analysis results and the combination information can be stored in the database of the expert system, and can be employed to forecast accidents or identify accident causes. The residuum hydro treating process expert system is taken as an example to illustrate the knowledge database construction method. With the aid of this expert system, the operators will well understand the operations and adopt the best resolutions to deal with the abnormal situations. Also the operators can identify potential risks existing in the plant which will result in accidents according to the accident analysis results associated with the HAZOP analysis results. Jinsong Zhao et al., (2009) published a paper on the title Learning HAZOP expert system by case-based reasoning and ontology. This paper said that generally the chemical process is divided into sessions called analysis nodes before study. Then meaningful deviations in every analysis nodes are generated by combining process parameters and HAZOP guidewords including MORE OF, LESS OF, NONE, REVERSE, PART OF, AS WELL AS and OTHER THAN. For each deviation, the HAZOP team has to identify all of its credible causes and all of possible adverse consequences. Once the causes and consequences are recorded, the team has to list the existing safeguards for the identified hazards and give necessary recommendations accordingly for hazard mitigation, if the required risk level cannot be achieved by the safeguards. The process is repeated deviation by deviation and node by node until the analysis of the whole process is completed.

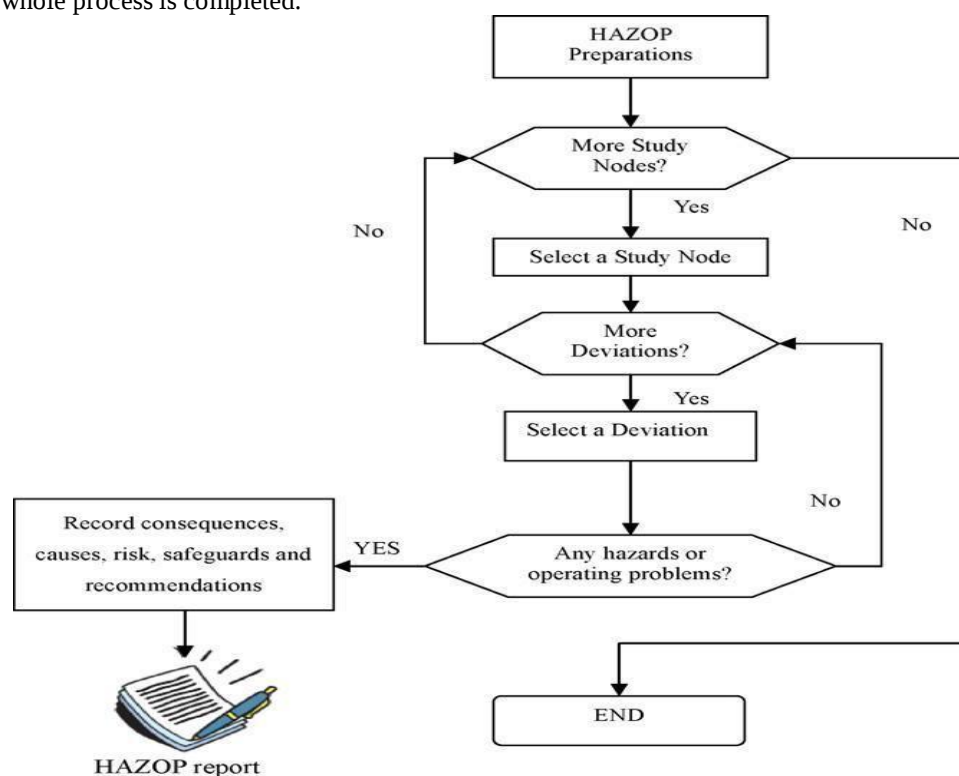


Figure 2: HAZOP Study Procedure

Faisal i. khan et al., (2001) published a paper on the Risk analysis of a typical chemical industry using ORA procedure. This paper presents a risk assessment study of a typical chemical process (sulfolane manufacturing) industry using optimum risk analysis (ORA) methodology recently proposed by these authors (Khan, F. I., & Abbasi, S.A. (1995). Risk analysis; a systematic method for hazard identification and assessment. *Journal of Industrial Pollution Control*, 9(2), 66; Khan, F. I., & Abbasi, S. A.(1998a), Techniques for risk analysis of chemical process industries and *Journal of Loss Prevention in Process Industries*, 11(2), 91.) The paper also describes briefly the different steps of ORA methodology and the available techniques and tools to conduct each step of the ORA. The study suggests that the reactor and the storage units of the industry are highly vulnerable to accidents and need elaborate safety arrangements. The damage potential of these units and its impact would permeate far beyond the plant boundaries and would cause damage to nearby areas. A few recommendations have been made to reduce the existing risk potential. However, the industry still needs to have high level safety arrangements and emergency procedures in position to counter any unwanted situation in the industry. E. Cagno et. al., (2002) published a paper on the title Risk analysis in plant commissioning: the Multilevel Hazop. This paper said that HAZOP is selected as the most suitable approach in forecasting particular risks of this project stage. Starting from the limitations of both Hazop and Human Hazop (the extension of the technique to the field of procedures performed by humans), a new technique is suggested which identifies in advance all the criticalities of each commissioning activity and defines actions to reduce risk and optimize dedicated resources. HAZOP identifies all deviations which can actually occur and analyses the respective causes and consequences. This approach lends itself well to the identification of possible preventive and protective measures which can be implemented in the system.

Shankar Viswanathan et. al., (2000) published a paper on the title A hybrid strategy for batch process hazards analysis. In this paper we present a framework that addresses the three main parts of a process hazards analysis (PHA) study – hazard identification, hazard evaluation, and hazard mitigation. The framework utilizes a hybrid methodology that effectively combines a qualitative digraph model-based technique for performing hazard identification and a quantitative optimization-based technique for performing hazard evaluation and hazard mitigation. Faisal I. Khan et. al., (2000) published a paper on the title towards automation of HAZOP with a new tool EXPERTOP. The group of experts conducting HAZOP is helped along by guide words which enable them to cover all possible malfunctions in the plant in a systematic way. The guide words often used are: none more of less of more than other than when these guide words are applied to the process variables in any unit of a plant, one gets the corresponding process variable deviations to be considered in the HAZOP analysis.

3. Methodology:

Hazard and Operability Study (HAZOP): A hazard and operability study (HAZOP) is a structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation.

HAZOP Terminology: Process Selections of equipment with definite boundaries (e.g., a line between two vessels) within which process parameters are investigated for deviations. The locations on P&IDs at which the process parameters are investigated for deviations (e.g. reactor)

Intention: Definition of how the plant is expected to operate in the absence of deviation. Takes a number of forms and can be either descriptive or diagrammatic (e.g., process description, flowsheets, line diagrams, P&IDs)

Guide Words: Simple words that are used to qualify the design intention and to guide and stimulate the brainstorming process for identifying process hazards

Process Parameter: Physical or chemical property associated with the process. Includes general items such as reaction, mixing, concentration, pH, and specific items such as temperature, pressure, phase, and flow

Deviations: Departures from the design intention that are discovered by systematically applying the guide words to process parameters (flow, pressure, etc.) resulting in a list for the team to review (no flow, high pressure, etc.) for each process section. Teams often supplement their list of deviations with ad hoc items

Consequences: Results of deviations (e.g. release of toxic materials). Normally, the team assumes active protection systems fail to work. Minor consequences, unrelated to the study objective, are not considered

Safeguards: Engineered systems or administrative controls designed to prevent the causes or mitigate the consequences of deviations (e.g. process alarms, interlocks, procedures) *Actions (or Recommendations)* Suggestions for design changes, procedural changes, or areas for further study (e.g. adding a redundant pressure alarm or reversing the sequence of two operating steps)

Guide Word	Deviation
No	No forward flow/ reverse flow
More of	More of any relevant physical property there than should be Eg: higher flow, higher temperature, higher viscosity, higher pressure
Less of	less of any relevant physical property there than should be Eg: lower flow, lower temperature, lower viscosity, lower pressure
Part of	Composition of system different from what it should be Eg: change in ratio of component or component missing etc
As well as	A transfer of some component in addition to the intended component. Eg: transfer of water with benzene in the transfer line.
More than	More component present in the system
Not	If something is not operating Eg: control valve
Other than	What else can apart from normal operation Eg: static electricity

Table 1: HAZOP study guide words

Hazop Study for Blasting Process

4. Experimental Results:

Guide Word	Causes	Consequences	Safeguards	Action required
No	ball Valve 1 failure	blasting process cannot be done	preventive maintenance should be done	Periodic inspection should be done
	ball Valve 2 failure	blasting process cannot be done	preventive maintenance should be done	Periodic inspection should be done
	pipe rupture	blasting process cannot be done	preventive maintenance should be done	Periodic inspection should be done
	Pipe blockage	blasting process cannot be done	preventive maintenance should be done	Periodic inspection should be done
	Compressed tank rupture	blasting process cannot be done	preventive maintenance should be done	Periodic inspection should be done
	Empty compressed tank	blasting process cannot be done	Pressure indicator need to be provided	Periodic inspection should be done

	Main power failure	blasting process cannot be done	Generator need to set for emergency power.	
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Hazop study for bonding process

Guide Word	Causes	Consequences	Safeguards	Recommendations
No	Ball valve failure	Bond coating cannot be done	preventive maintenance should be done	Periodic inspection should be done
	Pipe rupture	Bond coating cannot be done	preventive maintenance should be done	Periodic inspection should be done
	Pipe blockage	Bond coating cannot be done	preventive maintenance should be done	Periodic inspection should be done
	Empty kerosene tank	Bond coating cannot be done	Level indicator should be provided	
	Kerosene tank rupture	Bond coating cannot be done	preventive maintenance should be done	Periodic inspection should be done

Hazop study for Top coating process

Guide Word	Causes	Consequences	Safeguards	Recommendations
No	Manifold Inlet Valve Failure	Combustion cannot take place in gun	preventive maintenance should be done	Periodic inspection should be done
	Manifold Outlet Valve Failure	Combustion cannot take place in gun	preventive maintenance should be done	Periodic inspection should be done
	Pipe Rupture	Combustion cannot take place in gun	preventive maintenance should be done	Periodic inspection should be done
	Pipe Blockage	Combustion cannot take place in gun	preventive maintenance should be done	Periodic inspection should be done
	Wheel Valve Failure	Combustion cannot take place in gun	preventive maintenance should be done	Periodic inspection should be done
	Empty Cylinders	Combustion cannot take place in gun	Pressure indicators should be provided	Periodic inspection should be done
	Discharge Valve Failure	Combustion cannot take place in gun	Pressure indicators should be provided	Periodic inspection should be done

5. Conclusion:

The consequences determined from the HAZOP study are as follows,

- ✓ The maximum and minimum pressure range cannot be indicated.
- ✓ The pressure range cannot be visible due to the dust accumulation.
- ✓ Temperature indicator for inlet and outlet water pipe for the chiller cannot be provided.
- ✓ The powder hopper is in open condition.
- ✓ The safe guards for these consequences are,
- ✓ The maximum and minimum pressure range should be indicated on the pressure indicator.
- ✓ Periodic inspection and preventive maintenance should be done.
- ✓ Temperature indicator should be provided for the chiller inlet and outlet valves.

6. References:

1. Bragatto, P., Monti, M., Giannini, F., & Ansaldi, S. (2007). Exploiting process plant digital representation for risk analysis. *Journal of Loss Prevention in the Process Industries*, 20, 69–78.
2. Chemical Industry Association (UK). (1977). Hazard and operability studies. London: IChem. E. Crawley, F., & Tyler, B. (2000). HAZOP: Guide to best practice. Rugby, UK: The Institution of Chemical Engineers.
3. Crawley, F., & Tyler, B. (2003). Hazard identification methods. Rugby, UK: The Institution of Chemical Engineers.
4. Friedman-Hill, E. (2003). *Jess in action*. Greenwich, USA: Manning Publications.
5. Gani, R., Hytoft, G., Jakobsen, C., & Jensen, A. K. (1997). An integrated computer aided system for integrated design of chemical processes. *Computers and Chemical Engineering*, 21, 1135–1146.
6. Lawley, H. G. (1974). Operability studies and hazard analysis. *Chemical Engineering Progress*, 70(4), 45–56.
7. Lees, F. P. (2001). *Loss prevention in the process industries* (3rd ed.). Oxford, UK: Butterworths-Heinemann. (Chapter 8).
8. Li, H., Andersen, T. R., Gani, R., & Jørgensen, S. B. (2006). Operating pressure sensitivity of distillation-Control structure consequences. *Industrial & Engineering Chemistry Research*, 45, 8310–8318.
9. Li, H., Gani, R., & Jørgensen, S. B. (2003). Integration of design and control for energy integrated distillation. In Kraslawski, & Turunen (Eds.), *Computer-Aided Chemical Engineering*, Vol. 14. Elsevier Science B.V, pp. 449–454.
10. Lind, M. (1990). Representing goals and functions of complex systems. An introduction to multilevel flow modeling. Dept. of Automation, Technical University of Denmark.
11. Lind, M. (1994). Modeling goals and functions of complex industrial plant. *Applied Artificial Intelligence*, 8(2), 259–283.