Engineering Intrinsically Safe Plants

-- K Rajamani

The best way to design intrinsically safe plants is to avoid chances of accidents occurring, by thinking over the probabilities of them occurring and avoiding the sources or build in safety factors to mitigate the impact.

The author charts a path to be followed in conceptual design, basic engineering and detailed engineering, of a chemical plant to build-in factors to avoid and if not possible, reduce the chances of accidents clearly spelling out actions to be taken incase of disaster to reduce the impact to men, environment and plant.

Safety as a Corporate Policy

The philosophy of putting safety above all as a corporate policy is the beginning of engineering of intrinsically safe plants. Thinking of safety by everyone at all times and imbibing safety as the first priority under all circumstances by the organization ensures scientists, process engineers, and engineers of all disciplines take safety as prime consideration, at every stage of design. While it may sound repetitive, this is essential to drive in the importance of safety into everyone so that it becomes natural for the individual to build safety into the process, engineering, construction, operation and maintenance.

Building safety

Having understood the importance of safety, let us go ahead and see how we can build safety into the plant from conceptual stage. The birth of a chemical plant starts with the idea of a chemist or chemical engineer conceptualizing the process of manufacturing a product with identified raw materials going through the process developed by him. The process engineer develops his thoughts through process flow diagram with heat and mass balance and critical controls required to carry out the process to manufacture the product to the specification required. At this stage, it is important to study the eventual fall out of the process implementation and the likelihood of accidents due to process going out of control.

All the aspects related to functioning of the process control resulting in unsafe conditions as well as related safety features to be built in the process must be studied. This can be achieved by a hazard and operability (Hazop) study in its preliminary form, raising questions and ‘what if’ situations related to process functioning only. It must be understood that Hazop study is a continuous process starting with the conceptual stage of the project running through basic engineering, detailed engineering and construction stages of the project. This study must be taken seriously and the recommendations implemented at every stage. The commitment of the owner to respect and implement all the recommendations goes a long way to avoid or minimize the possibility of accidents.

Hazop Study

Once the conceptual stage is over the concept is taken through basic study with the development of process flow sheet, piping and instrumentation diagrams and preparation of process data sheets, giving process requirements of equipment and instruments of the plant. At this stage, the functional requirements of equipment and instruments of the plant. At this stage, the functional requirements of the plant are finalized. A detailed Hazop of the various divisions of the manufacturing process is under taken, since the control requirements and safety requirements have been finalized.

It is very important to study every control loop of the process and look into the effects of various conditions like less flow, more flow, no flow, etc and identify the changes required in control system, safety system equipment and instruments. At this second stage of hazop study, most of the possible reasons for malfunctioning of the plant leading to unsafe conditions would have been identified. A detailed study of each and every P and I diagram to study various scenario of flow pressure temperature and sequence of operation with the participation of all disciplinary engineers along with the process engineers and process control experts is undertaken at this stage. What is essential is the implementation of the recommendation in process flow of sheets, piping and instrument diagram, process data sheets for equipment and instruments. The owner, process licensor, and detailed engineering contractor must implement the recommendations arrived at the end of the hazop study.

The chairman of the hazop study, normally a process engineer with commissioning and operating experience, who conducts the study by asking questions of various situations that may arise during the operating experience, who conducts the study by asking question of various situations that may arise during the operation of the plant due to variations in flow, pressure and temperature of the fluids due to unexpected and undesirable conditions, must present recommendations to ensure an intrinsically safe plant with due respect to the cost of the plant. Incase the cost of designing the plant to avoid accidents is prohibitive, a through study of mitigating the same in terms of detailed operating procedure and training the operating personnel must be identified and documented to ensure the same is implemented. Precautions to be taken, must be clearly indicated in P and I Diagrams and Operating manual, with special care taken to alert operating personnel to their role in preventing accidents.

Detailed Engineering Stage

The project now moves on to the detailed engineering stage which involves in preparation of specification for procurement of equipment and drawings for the plant layout civil and structural drawings, piping layout drawings, electrical drawings for location of motors and cable routing and lighting layouts and Instrument layout drawings and construction detail drawings to construct the plant. In addition, the procurement of items from vendors having adequate experience in the manufacture of the items required in time and within estimated cost is also taken care in this phase of the project.

This phase of the project is the interface between concept and concrete and hence, the most vital part of the project in terms of detailing. This stage also involves development of utilities required for the project, the piping and instrument drawings for generation and distribution of utilities and process data sheets for equipment and instrumentation. Once the documents are ready for design, a hazop study is carried out again and the recommendations are given. This hazop study looks into the details of the developed plant and if previous hazop have been performed well, comes out with minimum recommendations.

As the project progressive, procurement of equipment, piping, electrical and instrument items are finalized; it is time again for a hazop study to take into considerations the features of the equipment as given by the vendors. Specific package items which were identified as black boxes so far, get developed based on vendor chosen and the effect of vendor design of the equipment and package items is studied, to make sure the safety built in so far is intact. The hazop also involves operating and maintenance at this stage since the detailed documents are available for the plant to enable operators and maintenance personnel to understand the plant better.

This hazop is important since the recommendations will indicate factors to be covered in Standard Operating Procedure, to avoid occurrence of unsafe conditions. Further, this is the last stage where modifications can still be done with minimum cost impact. The recommendations also involve the operators and maintenance personnel. All aspects related to operation and maintenance have also been taken into account.

3D Plant Design

With the advent of 3D plant design system, it has become easier to understand the plant in 3D with facilities to simulate ‘walk through the plant’ to check the access ways, obstruction if any in the access ways, maintenance space obstructions if any for the same and operability of valves and associated facilities. Infact constructability can be assessed and construction sequences can be decided based on the model. Intelligence use of the model combined with hazop studies at various stages, above all the corporate philosophy of health safety and clean environment can reduce the possibility of occurrence of disaster. Further, the remedial actions can be planned in the unlikely event of disasters, well before the commissioning of the plant. Proper documentation of Standard Operating procedures backed by continuous training of plant personnel to understand and follow the documents will go a long way in reducing the possibility of occurrence of unsafe conditions.

With the 3D model it is now possible to get the operating and maintenance personnel to participate in a meaningful way in the building of intrinsically safe plant. This is possible since these staff, normally not comfortable with 2D drawings, can see the plant in 3D and walk through the plant to ensure that facilities required for operation and maintenance are given good thought by the engineering contractor. The accessibility of valves for emergency operation and access ways for trouble-free operation and adequate space for maintenance and above all constructability can be reviewed with

mock operations. A through review at this stage results in construction of an intrinsically safe plant first time right.

With these procedures it is possible to eliminate causes for occurrence of accidents. However, the last hazop study is done once the construction is complete. Before commissioning of the plant, process engineers study the plant with respect to documents produced to ensure construction conforms to documents reviewed by all. This continuous study of the plant with respect to safety, operating the plant as per Standard Operating Procedure and carrying out timely preventive maintenance will guarantee a safe, smooth operating plat where everyone has contributed.

Conclusion

Think safety, design with built-in safety and inspire plant personnel to think of safety all the time. In short, 'Just Care'. This attitude is fundamental to have an intrinsically safe plant.

It must be understood that intrinsically safe plant is not built but continuously evolved with the active participation of process engineers, detailed engineering contractors, experienced construction contractors, alert operating personnel and ever watchful of a socially conscious owner.

Author

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Reference Book:

Chemical Industry Digest
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