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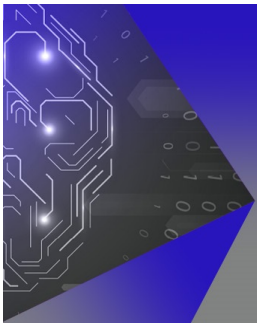
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Fault Detection and Automation in the Liquid Storage Terminals

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Abstract: Conventional approaches do not have the real time monitoring mechanism to detect the abnormal conditions in the industrial processes. The existing industrial processes in conventional way are not safe because of lack of monitoring systems. A considerable enhancement in chemical industries in recent years through automation increases the attention towards the advanced monitoring of systems. Real time monitoring and automation systems are capable of reducing the time to market, effectiveness and availability within the plant, as well as reducing plant costs. Every chemical plant across the globe needs to be equipped with the various solutions that exist in terms of commissioning as well as taking advantage of automation services when and where possible. The automation systems in industry communicated with every equipment and instrument, much like a nervous system that touches every muscle and receptor in the body. In order to improve the performance, this paper proposes the automation solution and strategy for a liquid storage terminal.

INTRODUCTION

Chemical industries and chemical Storage systems need to be highly automated due to hazardous chemical properties. However, the safety system increases with the implementation of automations but still many accidents happened in chemical industries. Some accidents are caused by the work environment, due to lack of skilled manpower deployment and some of due to external processes i.e. short circuit incidents etc. In order to reduce the failures and accidents, proper monitoring and diagnosis of operations and equipment's are required. Fault diagnosis including real time, reliable and advanced monitoring, plays a vital role in system fault detection and tracking. In 2003 it is described that the Abnormal Event Management Field of Research primarily work on fault detection [1].

The purpose of the automation is to reduce the faults with the proper monitoring and identification of parameters with undesirable variations in the chemical industries. Fault diagnosis is a multi-classification task because it not only identifies the symptoms of fault but also detects the type of fault. In the large-scale storage yard, it is necessary to detect the fault and diagnosis them because a failure leads to major accidents, damages to human life and environment. In 2015 author seeks the attention towards the Industrial statistical analysis which describes those 70-90% of faults are caused by human errors [2]. Chemical storage yards deal with massive data and long processes so a strong correlation between every stage and monitoring of each and every intermediate stage is necessary. In 2018, A canonical correlation analysis-based fault identification method identifies the false alarm and used to detect the fault in input and output sections [3]. In 1985, two fault detection approaches such as the experience-oriented method and the logic-oriented method in the chemical industries are introduced by the authors [4]. Fault detection and diagnosis process include these all parameters and find out the root cause by which fault happened. In 2002 it is described that Fault detection and diagnosis is the combination of observation of symptoms and failure types and through the several methods like numerical method or on-line fault detection and isolation unwanted variation are detected [5,6]. This will be helpful to minimize the hazard probability and enable a response system at the very initial stage of abnormality

BACKGROUND STUDY

There were many incidents occurred, many workers lost their life, loss of property and adverse impact on environmental conditions; case studies are as follows:

IOCL Accident

On 29th October 2009, there were massive explosion at IOCL terminal Jaipur (India) the accident took place as there was a huge leakage of gasoline from the 'Hammer Blind Valve'. Due to rapid evaporation the operator loses consciousness while other operating crews were not able to initiate control action and leakage remains uncontrolled and spread in the installation. In some report on this accident, it was mentioned that ignition occurred due to non-flame proof electrical fittings or starting of some vehicles in the premise. total 2000 mt amount of gasoline was released which engulfed whole installation. Total 11 persons lost their life and more than 150 persons were seriously injured.

Static Electricity Accidents

As many as 12 tank accidents were caused by static electricity. During the sampling of storage tanks containing flammable liquids at the open access ports causes 6 accidents. The operators in a 1965 accident and a 1972 accident in Japan (Takagi Nobuo, 1994), and a 2002 incident in Kaohsiung, Taiwan (Lin, 2003) were using the metal devices or container connected with nonconductive threads.

Such an accident shows the need for advanced supervision, monitoring of process seeks attention towards the fault detection process. For the detection of the fault, various methods are used. In the data-driven designs, authors describe dynamic modeling of systems, data acquisition and comparative analysis of processes which are commonly used methods for detecting faults [7].

In 2020, The Deep Forest method has been offered for detecting faults and false alarms. Through k-fold, cross-validation performance of the system enhanced [8]. Although several supervisory methods are available, in 2006, limit checking method is presented which is a basic one in fault detection. Threshold values easily identify the changes in the measurable variables. Signal prediction, predict a difference equation with the number of epochs and identify the accuracy of the system [9]. Prediction of signal works with the knowledge-based method, data checking, and acquisition plays a vital role in the prediction of fault [10].

In 2016, run to run looping introduces the fault detection in the complex manufacturing system; run to run looping integrates sensors in the process. The placement of sensors detects small variations or changes in measurable variables and helps to predict the fault before the unscheduled accidents occur [11]. Various other techniques such as cutting-edge techniques, vibration measurement, framework for resource-aiding constrained devices, self-configuration, and statistical fault detection techniques are proposed for the fault detection [12, 16]. In 2012 author describe one of the most famous mentioned methods to risk evaluation as the failure mode and effect analysis (FMEA) method and in 2020 DEWRPN framework proposed as FMEA expert. [17,18]. In 2013, the FMEA method, risk assessment involves the failure occupancy (O), detectability (D), and severity (S) of the undesired failure scenario [19]. In 2019, EDBM and ERBM methods are used for fault detection in the row data which is used in the industries [20].

DESCRIPTION OF STORAGE SYSTEM

Process of import and export of a chemical industry is shown in the figure 1.

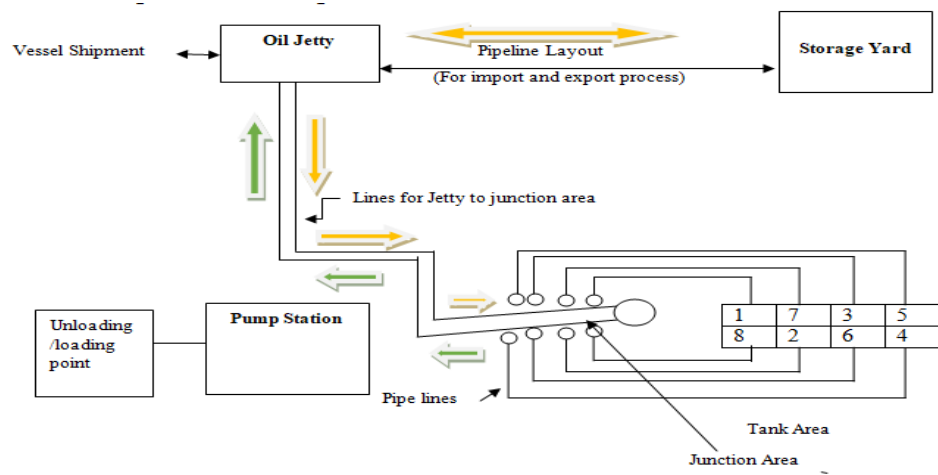


FIGURE1. Import Export Chemical Industry Process

Process of loading and unloading is shown in the figure 2.

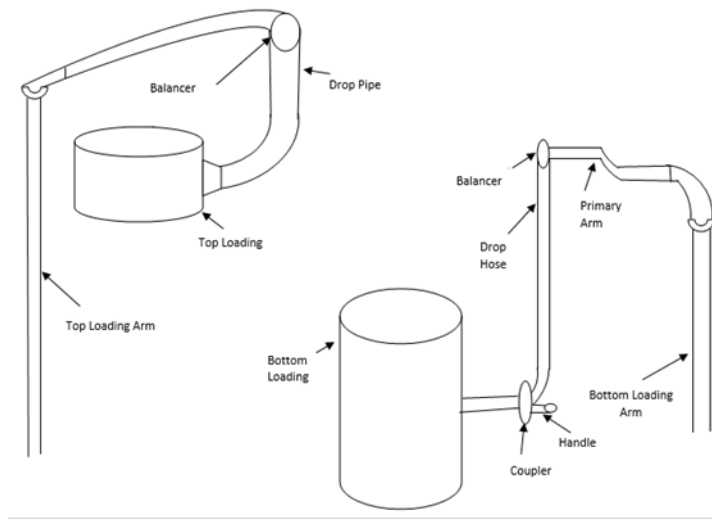


FIGURE 2. Loading and Unloading to Truck Source

PROCESS OF VARIOUS ACTIVITIES

Sampling at Pipeline

While import or export some amount of material is first flushed and then the sample is taken.

Tank Cleaning Procedure

Tank cleaning is done for the removal of dust or any other particles. To remove the dust or chemicals particle caustic soda is mixed with water and blasting is done. Caustic soda or chemical 1350 both products are used according to the need for blasting. The first round of caustic soda is done the second round is of freshwater; mostly 2 rounds of freshwater are done for cleaning.

Sampling of Tank

For the Storage of different products, random sampling is done from inside the tank. Toluene is used as a sampler for the sampling. So, if there will be any defect then the toluene transparent color will be changed into light yellow-brownish shade color. Check for any rust or dust also needs to be done

PROBLEM DESCRIPTION

During Import and Export

In the import and export process, Ship/vessel is connected at the jetty where there is different size of pipes other fittings are available. Different chemicals are stored in a particularly dedicated tank through these pipelines. So, it is a critical location from a safety perspective because inaccurate sampling leading the flushing of chemicals and introduces environmental hazards which creates various health issues.

Loading and Unloading Issue from the gantry

Chemical flushing from the loading arm in-tank seeks attention towards various possibilities of fault such as leakage in the loading arm, in checking of the level of the tank due to it's a manual process and untrained workforce. As the loading and unloading contain the flow of combustible gases so the situation of fault not only affects the process flow but also creates health issues.

Tank Cleaning

Tank cleaning is an important part of the process shown in figure 1, cleaning of tanks done by chemicals like Caustic soda, CH1350, etc. Flushing of the wastewater during cleaning produces environmental issues.

Transfer of Chemicals from one Tank to another Tank

Interchanging chemicals from one tank to another tank leads to several issues such as lose connection, wrong sampling, flushing of chemicals and inhalation of chemicals, etc. These possibilities of process failure show the needs for automation, through which advanced monitoring takes place in the process described in figure 1 and 2.

METHODOLOGY

In order to automate the conventional approach followed in the plant for performing the required operations, the proposed approach may be followed for making the process automated:

- Survey of the plant for which automation to be implemented.

- Identify critical part of the process.
- Identify the sensors and actuators.
- Identify the appropriate communication channels to communicate with sensors / actuators and controllers.
- Develop a algorithm to monitor the process and decision making.
- Analyze the performance of proposed real time monitoring system.

PROPOSED SOLUTIONS FOR AUTOMATION AND FAULT DETECTION

At present the demands of chemicals are increasing day by day, it has become more important to increase the capacity to store as a modest investment in these facilities can lead to a real edge in today's market. Enactment of storage space automation is become the finest way of cost reduction; reduce the chances of accidents and increasing the production. Although, industries in India are moving towards automation, but, still long way to go for automation.

Advantages for Storage Space Automation

Storage space efficiency

Primary requirement of any storage space is efficiency. System efficiency is based on the accuracy, reliability and availability of the devices. Automation creates a remarkable impact on efficiency through pivoting of algorithms.

Safety or security of system

False alarming, overfilling leads the mitigating risk, automation play a vital role against these all incidents and introduce a most safe and secure system which help in the regulation.

Sensor Implementation

Figure 3, indicating the implementation of sensors in the import and export process. Ship/vessel is berthed at the jetty where there is different size of pipes and other fittings are available, Pipes of different material such as MS or SS are laid to the storage yards.

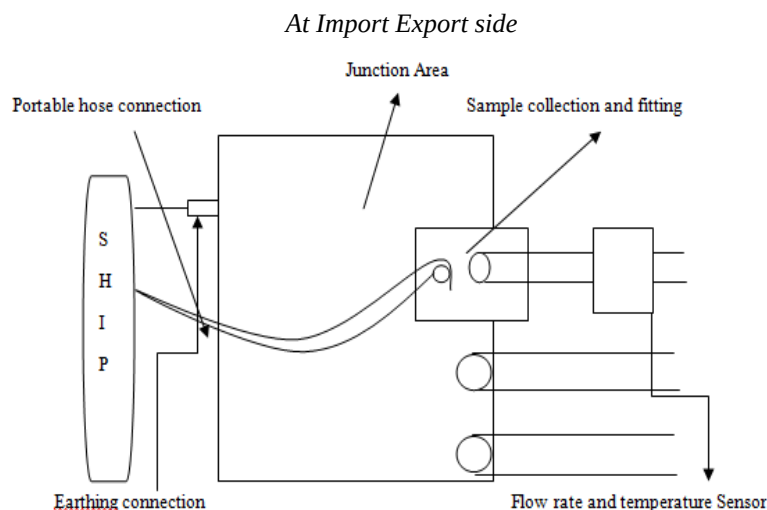


FIGURE 3. Sensors at Import Export side

This is a critical location from a safety perspective because there is a loose connection attached to the pipe fitting, due to the continued movement of water ship got unbalance, flashing of the chemicals into the sea so to reduce the

hazards present over there sensory of various types such as gas detection system for the leakage, temperature, and pressure sensors, level sensors flow rate sensors are used.

Loading from Gantry

The unloading of the material from the tank to the trucks where it is placed is called gantry the figure 4 shown the system available for it. As it is a highly hazardous process as combustible gases are continuously present over there so even a small spark can make a fire or explosion so for the protection and to reduce the exposure of the people to vapors area sensors can be placed for the detection and operations such as gas detector for the vapors, level indicators for the measurement, fire detection system for firefighting appliances, earthing detection, flow indicators, etc. In the recent decades, several fatal accidents have occurred around the world at petroleum storage sites leading to fire, explosion and toxic release scenarios. Such accidents result in huge loss of lives and property, along with widespread environmental damage due to improper coordination and communication in the emergency response. Therefore, emergency response planning is an integral and essential part of the safety and loss prevention strategy and comprises of the actions taken to manage, control and mitigate the immediate effects of an incident.

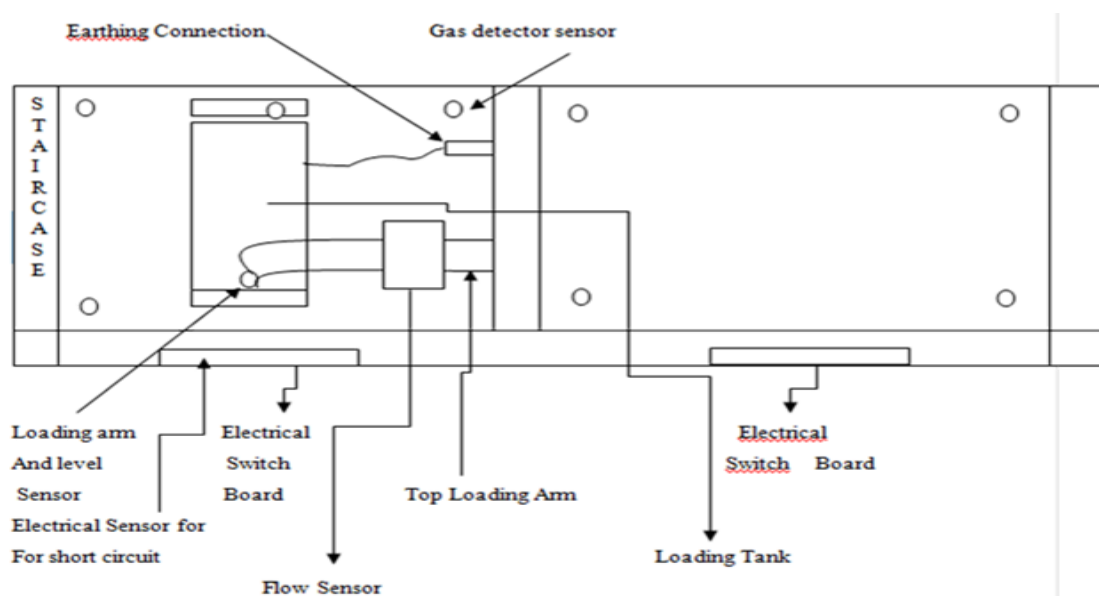


FIGURE 4. Sensors at Gantry Side

At Tank Side

All the chemicals are stored in the tanks are of different types such as fixed roof tanks, floating roof tanks constructions of the tanks are also different materials such as MS or SS as the chemical is more acidic it is stored into SS tanks other products can be stored in both tanks as it becomes highly hazardous as the capacity is up to 4500KL storage so special care is needed to take care of sensors plays a key role for various parameters such as flow meter, leakage sensors high-level sensors, high temperature and pressure sensors actuating the safety valves such as PRV or EV shown in figure 5.

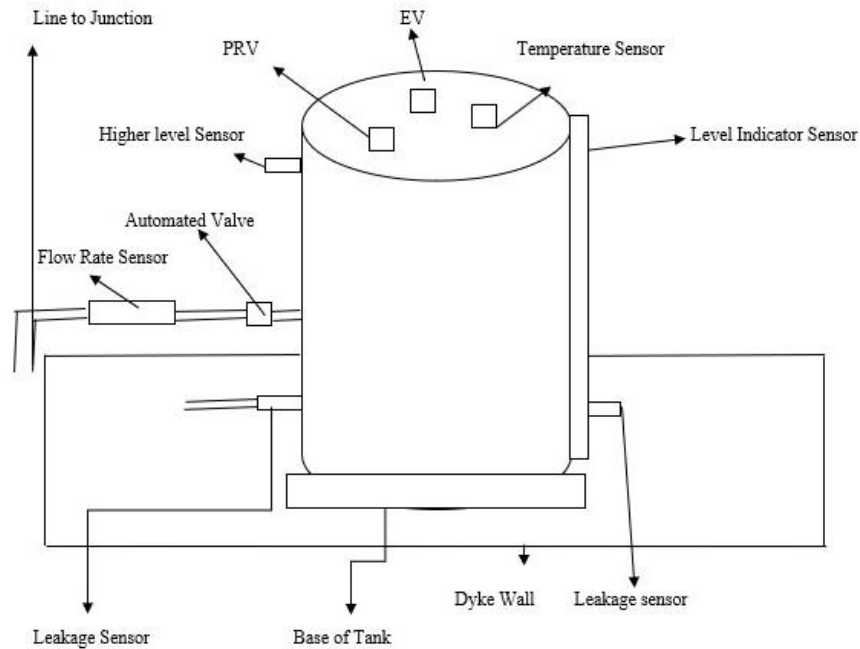


FIGURE 5. Sensors at Tank Side

These sensors' implementation helps to automate the whole system and measure the unwanted variation occur in the system.

Flow Chart

Proposed flow chart shown in figure 6 describes the process flow after implementation of automation in all the section. Deployment of sensors helps to monitor the process in more effective manner, according to the flow chart when the chemical transported from ship to storage area, if there any leakage found then process automatically stopped.

Process for Import & Export of products

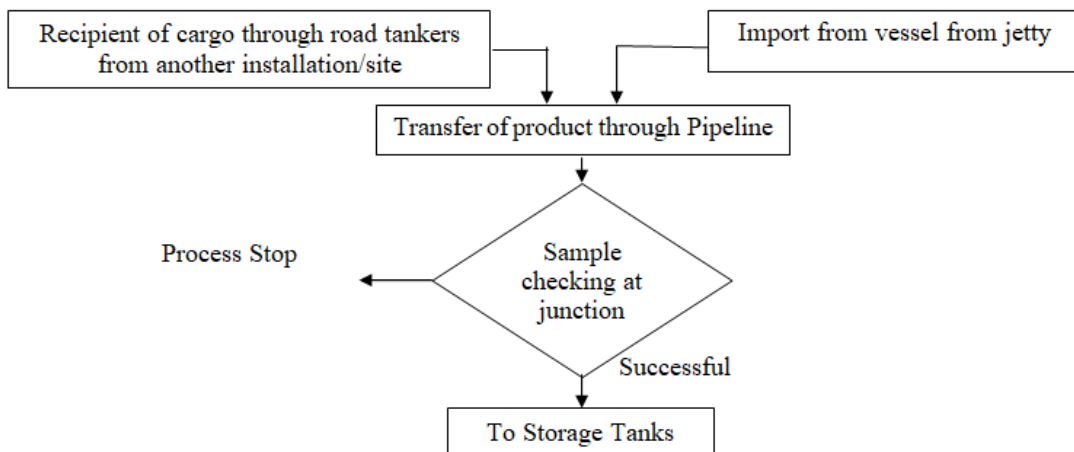


FIGURE 6. Import and Export process flow chart

Procedure for Selection of the storage tank

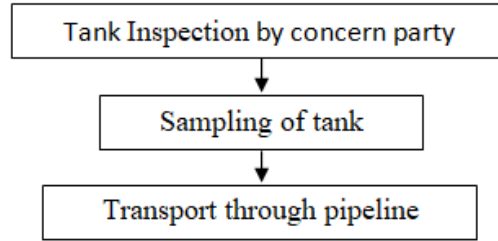


FIGURE 7. Steps for Storage tank Selection

Otherwise, chemicals loaded in the junction for storage in the respective tanks. Here a selection of a dedicated tank for the particular chemical is an important step which is shown in figure 7, so the selective sampling will take place. This sampling is monitored by the inspection team through the sensors.

Proposed model for the process

Propose the automation process model shown in figure 8 to monitor the whole process here tank inventory system connected with the PLT operator. Various sensors are used in each part of the system considered such as process control level gauge, overfill sensor gauge, etc. These sensors provide all information to the processor then to inventory system. PLT operators get the information through the inventory system and take appropriate action during abnormal conditions.

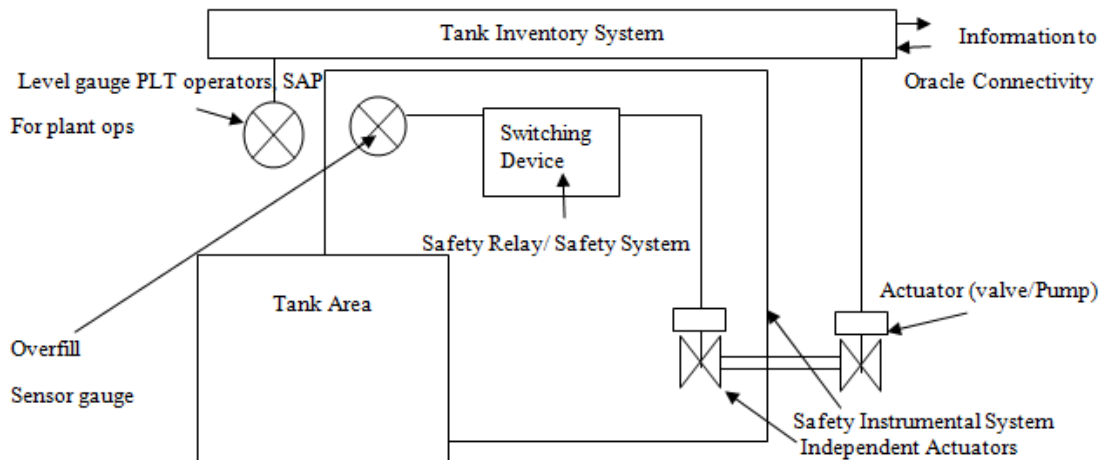


FIGURE 8. Proposed Automotive Process model

Proposed process monitoring flow Chart

Propose flow chart in figure 9, introduces advance monitoring of the import-export chemical process which is described above. Implementation of sensors such as level detector, flow sensor, pressure sensor and temperature sensors in various parts of the process measures the parameters of the process and store the information. Collected information fetched in the control room of PLT operator.

After receiving the input from sensors PLT operators analyze it and detect unwanted variation if occurs in the process. If any abnormal condition observed then through the Safety function applied on protection layer linked with the process takes the corrective measures. For the whole process, safety risk factor is calculated after the allocation and

process is interrupted till the essential modification take place at the time of high risk. These modifications in the system manage functional safety in all conditions. After the modification all changes will be verified and then applied to the system, this whole process continuously in operation and will be monitored.

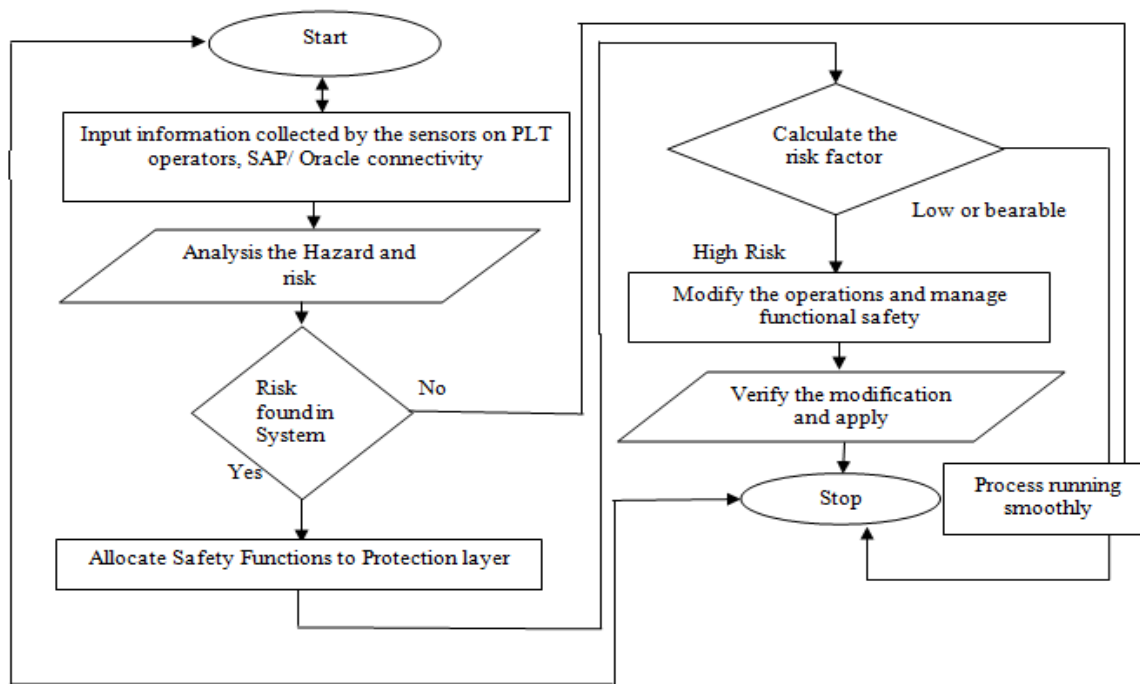


FIGURE 9. Flow Chart for given process monitoring

APPLICATION OF CASE STUDY

The proposed case study is suitable to make a route map for the implementation of automation in the conventional plants such as Chemical industries, LPG boiler, Petrol / Diesel storage, process industries, Petroleum refineries, manufacturing processes etc.

CONCLUSION

This paper considers the chemical storage terminal for the implementation of automation and real time monitoring system. It includes the selection of suitable sensors (i.e. flow measurement, level measurement, pressure detector, temperature detector etc), actuators and appropriate communication channels. The methodology for implementation of automation in plant has been developed. The algorithm suitable for the considered chemical storage terminal has also been developed.

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