Integration of Fire Safety with Industrial Automation using Water Mist System

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***Abstract*— In most of the industries, fire imposes the greatest threat both in terms of financial loss as well as loss to life and property. The presence of combustible materials, their physical arrangement, the likelihood of ignition and the necessary amount of heat required are the factors on which the risk of fire depends upon. This project provides a better & efficient way to prevent losses of life and property due to fire in industrial environment with the help of technological improvements in detection & extinguishing. Selection of Fire & Gas Detection sensors according to Classification of Fire plays a vital role in Accident Prevention. Applicability of Smoke sensing and Flame detection based on different sensing methodologies enable rapid detection and corrective action against Fire. Different Fire Extinguishing agents and their efficacy are analysed and the scope for better fire safety through its integration with Control Systems like Integrated Circuits or Programmable Logic Controllers is explored in this work. The lifts are closed and power system of lift and machineries are shutdown, automatic alarm systems will activate, water sprayers will activate and smoke sensing sensors will monitors the environment to prevent and alert the employees of industries. The objective of this project is to minimizing the loss of life, resources and properties by using automatic sensing systems which alerts, prevent and take an appropriate action against the fire accident.**

***Keywords*— Avoiding the fire in industrial environment, Automatic alarm systems, Smoke detection sensors, Water Mist Fire Extinguishing agents.**

I. INTRODUCTION

A key aspect of fire protection and the role of fire detection and alarm systems is to identify a developing fire emergency in a timely manner, and to alert the building's occupants and fire emergency organizations. Generally fire detectors are designed to respond at an early stage to one or more of the four major characteristics of combustion, heat, smoke, flame or gas. No single type of detector is suitable for all types of premises or fires. Heat detectors respond to the temperature rise associated with a fire and smoke detector respond to the smoke or gas generated due to fire.

Sensor selection depends on the overall structure and design of automatic fire alarm system and fire alarm control software. Fire extinguishing agent selection is the most challenging aspect with respect to reduction in loss of life and assets. This project proposes usage of novel & economical fire extinguishing agent integrated with the automatic sensing systems which alerts, prevent and take an appropriate action against the fire accident.

II. PROBLEMS IDENTIFIED

- Lack of proper Fire Safety system.
- Electrocution Hazard of Sprinklers.
- Adverse Nature of Halon extinguishers.
- Accident Prone CO2 extinguishers.

III. PROPOSED SYSTEM

The fire detectors detect the fire at the place of vicinity and the fire detectors electrical signal fed to the main control panel through the fire alarm panel,

Once the main control panel gets the signal, it send operating signal to the motor control panel to start the pump and also send signal to the solenoid valve located at the place of vicinity. So, the solenoid valve opens and allows the water pumped by the hyper mist pump to the piping installation at the place where the fire exists.

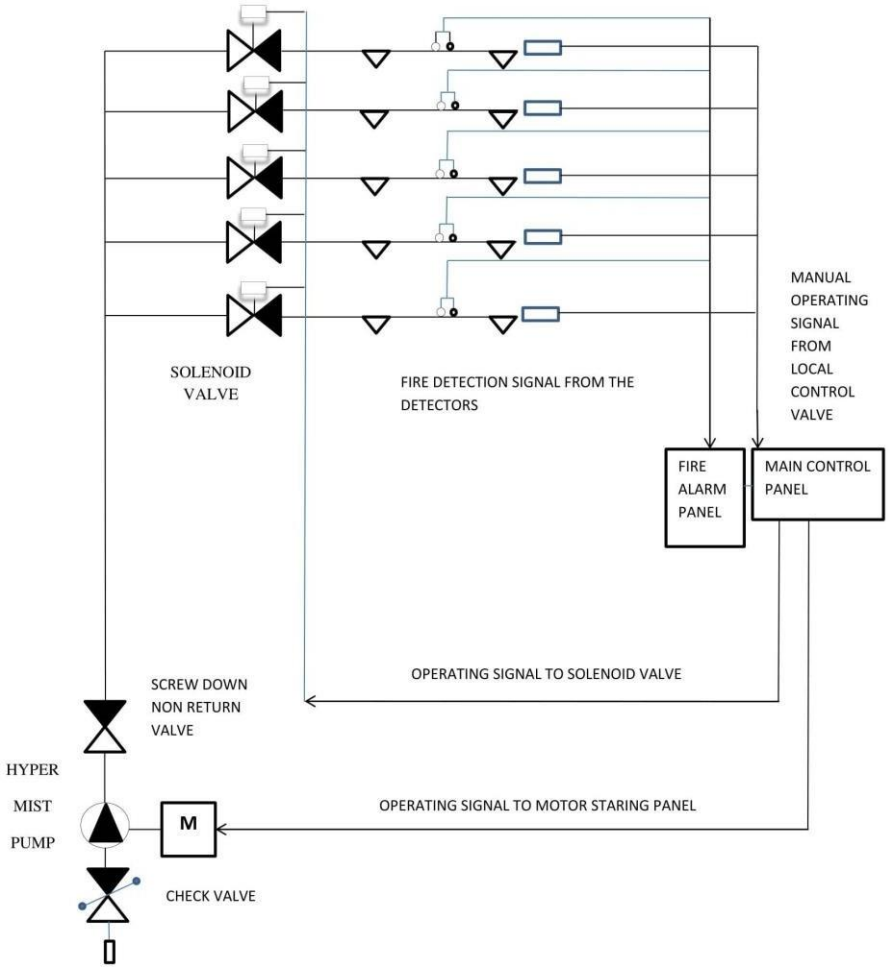

Fig. 1 Block diagram of proposed System

IV. COMPONENTS DESCRIPTION

A. Hyper Mist Pump

It is multistage centrifugal pumps which have the capacity of pumping out the water 350 litres/min at 10 bars. The starting and stopping can be done by activating starting or stop switch at local control panel, or otherwise by the main control panel through motor control panel.

B. Hyper Mist Nozzle

It is a convergent type nozzle which spraying out the water in the form of mist by converging the water stream. It can discharge 16 litres/min @ 8 bar.

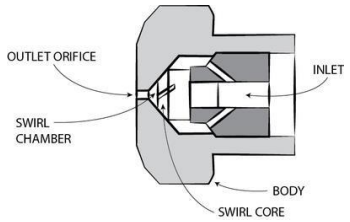

Fig. 2 Nozzle Schematic

C. Solenoid Valve

It is an electrical driven valve and it is control by the opening and closing signal from main control panel with respect to the fire detection system.

Fig. 3 Electric Solenoid Valve

D. Fire Detectors

There are two types of fire detectors are incorporated in this installation.

1) Flame detector:

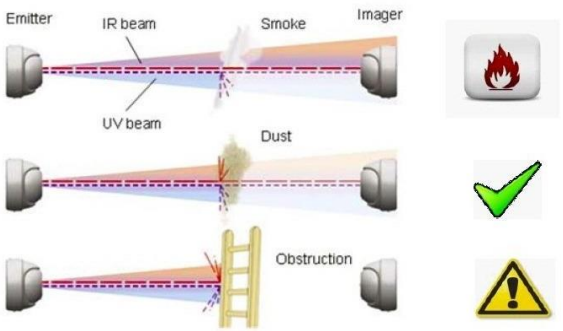

Fig. 4 Flame Detector working principle

2) Smoke detector:

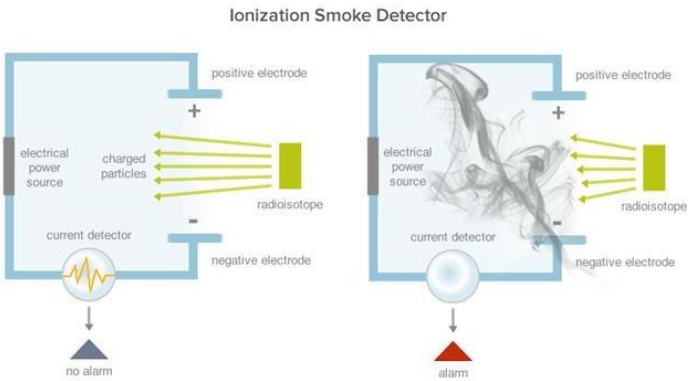

Fig. 5 Smoke Detector working principle

E. Check Valve

It is fitted at the suction side of the pump to check the flow of water.

F. Screw Down Non-Return Valve

It is unidirectional non-return valve fitted on the discharge side of the pump which is used to avoid the back flow of water into the pump.

G. Strainer

Strainer is a filtering material used to remove any impurities comes along the flow of water which may clog the nozzle.

H. Main Control Panel

It gets alarm fed from alarm panel or it can also be activated by using Local control panel [LCP] manually. It indicates the region or section of building in fire.

I. Fire Alarm Panel

It gets the fire detection signal from the fire detectors situated at the location of vicinity; it sends signals to Main control panel & to the alarm system. NOTE: The Main control panel consists of Auto/Manual switch. We can change the settings to our convenience and also for Maintenance purpose.

Fig. 6 Fire Alarm Panel – For Indicative Purpose only

V. EXPERIMENTAL SET-UP

To demonstrate the fixed water mist system, a model is made with the use of following components.

A. Model Compartment

MI sheet of l mm thickness is used to prepare a model compartment

MI Sheet is made into a compartment of 1200mm X 600 mm X 600mm

A frame is made for both ends of the compartment for strengthening purpose by using L-angle of size 600mm X 600mm

By using Metal Arc welding, the frame is fixed to the compartment.

Both longitudinal ends of the compartment is kept unclosed for demonstration and observing purpose.

B. Water misting Nozzles

Single fluid, flat orifice nozzle

Four misting nozzles were used.

The nozzle specifications,

Nozzle tip diameter: 0.01mm
Nozzle bore diameter: 0.8 mm
Operating pressure: 12 bar
Operation: spring tensioned
Nozzle tip material: ceramic
Number of tip: one

C. Pipelines

Stainless steel pipe of 22.4mm for 5 ft were used.
Material specification: S-202
One end of the pipe is blocked, hence the water pressure will be developed inside the pipeline.
Four nipples were TIG welded at unique interval for fixing the nozzle

D. Hand operated hydraulic line testing pump

Maximum operating pressure: 70 bar
Accessories: a pressure gauge; a drain valve; high pressure pipe of 1m
Candle lit piece of paper.

E. Fire source

Candle lit piece of paper.

VI. ADVANTAGES

Water is perceived as a tremendous fire extinguishing agent, it's readily available, it's inexpensive and it's environmentally non-problematical. Further, the concept of using it in a mist form makes water even more attractive as a fire extinguishing agent since: The high effective surface area of the water mist ‒particles‖ makes it more capable (than a heavy stream of water) in its process of cooling the fuel and the surroundings and in readily evaporating (turning into steam) and diluting the oxygen, thus inhibiting the fuel burning rate and that increased effectiveness then translates into requiring very small quantities of water to achieve extinguishment (when compared to more conventional water application methods) thus minimizing the largest single objection to water systems - the collateral damage done by the water. To fight a fire, a traditional sprinkler system spreads water droplets over a given area, which absorbs heat to the cool the room. Due to their large size relatively small surface, the main part of the droplets will not absorb enough energy to evaporate and they quickly fall to the floor as water. The result is a limited cooling effect

By contrast high pressure water mist consists of very small droplets, which falls more slowly. Water mist droplets have a large surface area relatively to their mass and during their slow descent towards the floor, they absorb much more energy. A great amount of the water will follow the saturation line and evaporation, meaning that water mist absorbs much more energy from the surroundings and thus the fire. That's why high pressure water mist cools efficiently per litre of water up to seven times better than can be obtained with one litre of water used in a traditional sprinkler system

The water mist with fine sprays was very efficient in controlling liquid and solid fuel fires, and suppressing hydrocarbon mist explosions method of generating water mist and some factors that influence performance of water mist.

Water mist in fire suppression, however, does not behave like a "true‖ gaseous agent. When water is injected into a compartment, not all the sprays that are formed are directly involved in fire suppression. They are partitioned into a number of fractions as follows:

Droplets that are blown away before reaching the fire; Droplets that pre-wet adjacent combustibles to prevent fire spread.

Droplets that penetrate the fire plume, or otherwise reach the burning surfaces under the fire plume, to inhibit pyrolysis by cooling, and the resultant steam that dilutes the available oxygen; Droplets that impact on the walls, floor and ceiling of the compartment and cool them, if they are hot or otherwise run-off to waste;

Droplets that vaporize to steam while traversing the compartment and contribute to the cooling of the fire plume, hot gases, compartment and other surfaces.

VII. CONCLUSIONS

Integrated fire safety system using Water Mist Extinguishing in Industrial Automation is a passive fire protection system since it does not fight the fire actively and prevents the spread of fire. Most may argue that the pre-existing active firefighting system, the Sprinkler systems are more effective. But being innovatively used in high rise industries, it topples the sprinklers in many ways.

Water Mist uses less than 1/4th of water used in sprinklers. Like sprinkler heads, Mist nozzle doesn't need any replacement after operation. The main advantage of Mist over any other Fire protection system is that it does not affect the appliance exposed to it. It won't cause any electrocution in case of any. By absorbing the heat from the fire the water mist itself evaporate into stream hence easy to clean while other mediums take minimum of seven to nine days for cleaning.

As stated above it reduces the wastage of water comparatively to that of sprinklers and water fall system. The reason for using both Manual and automatic, gives the benefit of using Manual in case of any failure in automatic system. By automatic operation, the hyper mist can extinguish fire in its initial stage and prevents fire spread to greater degree by reducing the temperature bellow auto ignition of the material. With Specific requirements and specification, it can be installed in any of the buildings & installations with appropriate modifications.

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