Design and Development of Fire Fighting System Using Hot Redundant PLC in COVID Situation

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Abstract: A firefighting system is the most foremost part of any industry and buildings as its aim to protect property, human and industrial equipment. In any pandemic situation like COVID19 it is utmost requirement to increase reliability of all important instruments which are directly involve to human life. In case of fire fighter fight against fire, this required time and skilled man power. Under these pandemic situation chances of infection spreading in firefighters and social distancing will not maintain during this situation. Only one way to resolve this problem is by implementation of fully automated reliable system. In this system we are trying to automate the total system by using hot redundant PLC which is fail safe. It consists of mainly three basic parts – fire storage tank, fire pumps and automated distribution system. Fire storage tank contains the water that used against fire. Fire pumps helps to fill the tank and automated distribution system will be activated during fire and instantly distribute water. There are three pumps one is main electrical pump, second one is diesel backup pump and last one is jockey pump. In redundant configuration there are two PLC acting simultaneously and the entire network component and power supply also has back up so that it will never fail. If one of the PLC fails during operation then second PLC automatically take care of the system within few millisecond. Similarly if power supply failure then UPS supply is also there for uninterrupted power supply.
Keyword: Firefighting, Hot-Redundant, Automation, PLC, Covid19.

Introduction:

Fire is a phenomenon with which everyone is familiar. We use it daily to heat our homes and cook our meals. When harnessed, the power and energy from fire serves us well; however, when it is uncontrolled, a fire can quickly consume and destroy whatever lies in its path. While we are all familiar with fire, few of us are aware of its nature and complex processes [1]. So, 3 basic components required for combustion to occur that’s are fuel, oxygen & heat. The process of combustion or burning is nothing but the rapid oxidation of fuel molecules in the form of vapor. Once the oxygen and the fuel vapor molecules mixed properly, then to initiate oxidation an ignition source is needed. Once the oxidation process is initiated, it is an exothermic process. If sufficient amount of energy is released during the reaction process to maintain the elevated temperature of surrounding oxygen and fuel molecules, and there are sufficient oxygen and vaporized fuel molecules available, then the process of oxidation will continue. Automation system may create extreme cost reduction in any plant production system due to accuracy improvement, man power reduction, productivity increase etc. Fire safety also important concerned for any mall and industries [2]. In this paper design and development of a firefighting system using Hot Redundant PLC in COVID situation. In Covid19 pandemic situation should maintain social distancing and avoid all causes of social gathering [3].

Objectives:

Firefighting system for any building or industry is necessary because it saves the equipment from damage, loss of life & loss of equipment can be prevented. In general fighting system requires manual operation to prevent or stop the fire [4]. It requires skilled manpower and much time also, so in this project have discussed about automation of firefighting components & system with redundant system. In this present scenario fault tolerance and redundancy are the two most important concerns in industrial automation [5]. The day by day growing industrial plants in order to increase quantity and quality of the production also increases the dependence on the availability, reliability and stability of the industrial automation systems [6]. For few plants, the malfunctioning or failure of the automation system may stop the production system and the plant has to face an extreme loss. As firefighting system of any plant is the most important part so we need redundant system so that in case failure of primary CPU secondary CPU takes over the control within few milliseconds. Adding of the redundant controller, theredundancy of the controller solution increases the availability, reliability, continuity and stability of the industrial automation control system [7]. This is how the redundancy solution is much important to the system.

Methodology:

In our automated systems are placing two level switches to fill the tank automatically. When water level of tank decreases then automatically motorized valve will on and fill the tank. After filling the tank, it will be closed. Figure 1 shows the fire water tank of the automated system.
Fire pumps are usually housed very near to storage tank as shown in figure 2. There are mainly three pumps, i. Main electric pump ii. Back up diesel pump of same capacity iii. Jockey pump to maintain the pressure.

If electric pump fails during emergency condition back up diesel pump comes into action. Each and every pump is sufficient enough to collect the required amount of water individually. They are identical in capacity. The small pumps e.g. Jockey pumps are attached with the system to balance the exact pressure in the distribution system, normally 1000psi. If there is leakage then this pump will switch on and compensate it. The pump capacity is decided by considering some factors, among them which are area covered by the plant, sprinkler system, area of operation, type & layout of the plant. It is required to paint red the distribution system which consists of steel or galvanized steel pipes. These are welded together to make secure joint are attached with special clamps. When these are placed underground they are bound to wrap with special type of coating that helps them to prevent corrosion and strengthen the protection of the pipe.

Redundant System: basically redundancy is the duplication of critical components or functions of a system with the intention of increasing reliability of the system, usually in the form of a backup or fail-safe, or to improve actual system performance in emergency condition.

Three types of redundancy: i. Warm redundancy ii. Cold redundancy iii. Hot redundancy

i. Warm Redundancy: when the time & response to a failure is become more important but not critical; temporary outage is always acceptable. Example: Fluid transfer system.

ii. Cold Redundancy: For non-critical process where time is not a high priority; human intervention is acceptable Example: pressing machine; sealing machine etc.

iii. Hot Redundancy: offers instant process correction when failure is detected. data transfer between both the PLC is simultaneous. Example: Firefighting system, Nuclear power plant, Mining industry etc.
PLC Component Redundancy: CPU Redundancy: In case of primary CPU failure secondary CPU takes care of the system.

Power Supply Redundancy: If power supply of the panel fails then standby power supply takes control. Communication: Multiple communication system are taken into consideration to avoid communication error.

I/O Redundancy: Multiple I/O channels are used to take care of input, output of the system [8].

Flowchart:

![Flowchart of Fire Fighting System using Hot Redundant PLC](image)

Fig. 3 Flowchart of Fire Fighting System using Hot Redundant PLC
One no of electrical motor driven main pump, one no of diesel operated pump and one no of jockey pump to maintain the system under pressurized condition along with other necessary accessories such as Deluge Valve, Spray Nozzles etc. In this project operation of the all pumps shall be automatic from central PLC and Manual Start/Stop provision from local shall be there. Figure 3 shows the flowchart of the entire system of Hot Redundant PLC based firefighting system. In this system auto actuation of the Deluge valve should be by means of Quartzoid Bulb detector of 79°C. 2 no of Level Switches (for each sump compartment) should feed signal for sump level or water level. Pressure Switches shall be there at outlet of Main, Jockey pumps and Diesel operated Pumps. To operate pumps and valves properly, signals which are to be implemented at feeder is such: start/stop command, ready to start & system healthy feedback, fail to start/open feedback, power on feedback, Trip feedback, Tank level Low/High Feedback, Outlet Pressure Low/High feedback, Upstream/Downstream Valve Open/Close feedback etc. Interlock function (depending upon Level/Pressure feedback signal) to be incorporated for running Main or Jockey Pumps with respect to pipe line pressure condition and the Diesel operated pump shall start in auto if the Main pumps fail to start/trip/not in operational mode/malfunction. Water Tank Levels at sump shall be maintained by motorized valve with open/close command from central PLC. UPS is to be provided with one hour battery back-up to supply power at PLC & instruments. Figure 4 shows the system architecture of the firefighting system. In this system two no of PLCs should be considered which should be Hot Redundant in configuration i.e. redundant Power Supply, CPU & Communication Modules. All the Auto control of the FDA shall be done through the PLC system by 2 no of Engineering/Operating work station.

Fig.4 System Architecture
**Hardware & Software Details:**

**Hardware Used:**

| Sl No. | Components Used                                      | Purpose                                                                 | Qty.  |
|--------|------------------------------------------------------|------------------------------------------------------------------------|-------|
| 1      | PLC: ABB AC500 Series Model: PM591-ETH              | Main PLC controller of the project to control the overall system in redundant condition | 2 nos |
| 2      | Communication Card: CM597-ETH                       | To communicate between two PLCs and cluster module                      | 2 nos |
| 3      | Cluster Module: CI522-MODTCP                        | To connect input output module with main controller through MODBUS TCP-IP protocol | 1 no  |
| 4      | IO Module: DI524 DO524                             | To connect field input & output devices like Sensors, Limit switches, Indicator, Hooter etc | 1 no each |
| 5      | Network Switches: Managed Switch: ORING Unmanaged Switch: Siemens | To communicate between two redundant CPUs, communicate with cluster, HMI, Programming device | 2 nos each |
| 6      | Power Supply: Siemens PS 24V DC,10 A with power Oring unit | To provide power to all the modules of PLC and other components | 2 nos |

**Software Used:**

| Sl No. | Software                          | Purpose                             |
|--------|-----------------------------------|-------------------------------------|
| 1      | Automation Builder V2.2           | ABB PLC programming software        |
| 2      | ABB Bulk Data Manager             | To configure the redundant system   |
| 3      | Panel Builder 600                 | To design the HMI Panel             |
IO Module: DI524 & DO524:

| PARAMETER   | DI524                      | DO524                      |
|-------------|----------------------------|----------------------------|
| Type        | Digital input card         | Digital output card        |
| Base        | TU516                      | TU516                      |
| Dimension   | 76 x 62 mm                 | 76 x 62 mm                 |
| IO capacity | 32 DI                      | 32 DO                      |

Fig. 5 Snapshot of IO Module of Hot Redundant PLC firefighting system

Conclusions:

For different kind of industries reliability in process control means differently. Depending on some of the facts like, interruption, the severity of the consequences or the governing regulations, some automation systems require PLC redundancy to keep people and equipment safe. Control & instrumentation engineers have to balance the cost of redundant PLCs. Figure 5 shows the snapshot of IO module of Hot Redundant PLC. Any kind of minimum investments, extra control hardware and intelligent software can reduce the chances of damage and inconvenience when any of the system controller doesn’t work properly. After a risk assessment of the specific application, it may make sense to beef up the reliability of a PLC-base control system. As firefighting is the most important part for any industry so redundancy in this is highly recommended for safety of equipment and human. Figure 6 shows the setup snapshot of Hot Redundant PLC firefighting system.
Future Scope of the Project:

Sources of water: In this project water sources for fire tank are from external nearest river or pond. But can reuse the water of that industry after filtration and water treatment. Waste water produced in any industry can be reused for that industrial purpose, thus no water is being wasted and water can be recycle and reuse. Industrial wastewater can be recycled on or off site depending on space constraints and budgetary considerations. Recycling wastewater is important for the environment as it avoids straining drought-stricken areas and natural habitats such as wetlands. Integration of Remote monitoring system: In future we can extend this system to remote monitoring system by using some extra module. With the help of Ethernet protocol, can send data to cloud and if data is in cloud so that can access it from anywhere of the world. We need some extended module to enable remote monitoring system in our system configuration.

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