AUTOMATIC FIREFIGHTING SYSTEM USING PLC

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Abstract— A Fire-fighting system, as the name suggests is a system concerned with extinguishing fire using sensors. Such an automated Programmable Logical Controller (PLC) system uses a Jockey Pump, a Main Pump and a Diesel engine. The PLC also monitors the operation of the Diesel engine. In advent of a fire, there should be a continuous flow of water through the hydrant line, pressure of which is regulated using pressure switches. Depending upon the magnitude of fire, the PLC is programmed to interface one of the three, (Jockey Pump, Main Pump or the Diesel Engine) thus extinguishing the fire.

I. INTRODUCTION

Automation is largely used in various industries taking into consideration its various advantages such as, reduction in manpower, improvement in accuracy, efficiency and speed of production. This paper entails how to extinguish fire using Programmable Logical Controller (PLC). In Industries, malls and theatres during advent of fire, there should be a continuous flow of water through the hydrant line, pressure of which is monitored using pressure switches. If pressure of water goes below the specified level then the pumps connected to elimination of the hydrant line are turned ON, which results in increase of water pressure, thereby extinguishing the fire. In case of severe fire the mains supply has to be switched off. So to keep the pressure in the hydrant line constant, diesel engine is used to drive the pump. Thus the diesel engine should be in healthy condition to be able to extinguish the fire [1]. Hence to control the parameters of diesel engine, we are developing the ladder logic for automatic control of *Diesel Engine* by converting the conventional PCB based control panel to PLC based control panel.

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I. LITERATURE SURVEY

The conventional methods need to be modernized and its various functions are required to be automated to achieve reduced cycle time, higher productivity, higher levels of accuracy and high reliability[2]. The age of automation has brought a new meaning to electronics in industry. Modernization and Automation of industrial machines generally comprise modification into a state-of-art Programmable Logic Controller (PLC) wherein the conventional relay control is replaced.

The PLCs are being utilized for a wide variety of automation applications such as in Automobile industries, in process industries and Manufacturing industries etc. Automation is the use of control systems such as computers, microcontrollers or PLC to control industrial machinery and processes, replacing human operators. In the scope of industrialization, it is a step beyond mechanization. Automatic equipment is used in automation, instead of

manual labour. This facilitates the human errors thereby increasing the accuracy of manufacturing a desired product.

II. EXISTING SYSTEM

The existing fire fighting system uses Printed Circuit Board (PCB) based panels. This panel monitors the pressure switches on hydrant line as well as the Diesel Engine. The panel consists of different components like IC 4011, IC 4081, IC 4017, IC 4020, Capacitors and relay cards. The system operates on 24VDC supply.

III. COMPARATIVE ANALYSIS

Most of the existing automated fire fighting systems use Printed circuit board (PCB) based panels [3]. Although such panels are reliable and have low cost they have large number of components which makes the circuitry complicated. Such a complicated circuitry once employed cannot be altered to fulfill customer's demands. Large number of components also makes the detection of faults difficult and the faulty part has to be replaced immediately.

In this age of multi-functionality, where expandability of a utility is of utmost importance the existing system falls short and there arises a need for a more flexible PLC based system. So PLC based system can be used instead of existing system. Such a system using PLC scans digital and analog inputs through different sensors. It can execute the logic with respect to the scanned Inputs, takes necessary decision and sends it to digital /analog outputs. It has the ability to combine Digital and Analog logic which is a powerful tool for the engineers. It can also perform PID control functions and it is easy to program, debug and download which increases its reliability. It also requires less wiring. A PLC easily accommodates the additional I/O's without requiring changes in the existing wiring. PLC can perform a wide variety of control tasks, from single, repetitive action to complex data manipulations. A PLC can be used to establish communication between other PLCs which facilitates data collection and information exchange. Due to aforementioned advantages a PLC based fire fighting system can be proposed to replace the existing PCB based system.

IV. OVERVIEW OF A FIRE FIGHTING SYSTEM

A PLC based fire fighting system consists of Fire Pump, Jockey Pump.

A. Fire pump

The water supply system is a pillar of any Fire Fighting Application .The fire pump is an integral part of the water supply system with the pump intake either being connected to the public underground water supply piping, or a static water source like a tank, reservoir or a lake [4] .A fire pump is indispensible in a fire fighting system in that it provides water at very high pressures to the sprinkler system risers.

The operation of the fire pump varies depending on the method used to power the pump. An electric motor or a diesel engine is usually used to power the fire pump. In a few rare cases even a steam turbine may be used for this purpose.

On the onset of fire, the fire pump starts when the pressure in the hydrant line drops below a threshold value. This mechanism is made possible by the use of pressure switches for the main fire pump and the diesel engine driven fire pump. The hydrant line pressure drops significantly when one or more smoke detectors are exposed to heat above their designed temperature, and the sprinkler opens, releasing water.

Fire pumps serve a particularly important function of providing sufficient pressure when the local municipal water system is unable to provide sufficient pressure to meet the hydraulic design requirements of the fire fighting system. In case of tall buildings, or in systems that require a relatively high terminal pressure at the fire sprinkler in order to provide a large volume of water, such as in storage warehouses, the problem of insufficient available pressure is likely to arise. In case of large reservoirs at the ground levels, a fire pump is needed to meet the sufficient pressure requirements at the sprinkler end.

Types of pumps used for fire service include: horizontal split case, vertical split case, vertical inline, vertical turbine, and end suction

B. Jockey pump

A jockey pump is a small pump connected to the

fire fighting system and is intended to maintain pressure in the hydrant line to an artificially high level so that the operation of a sprinkler in event of a fire will cause a pressure drop which will be sensed by the one of the pressure switches giving an input to the PLC which will then cause the fire pump to start. The jockey pump is essentially a portion of the fire pump's control system.

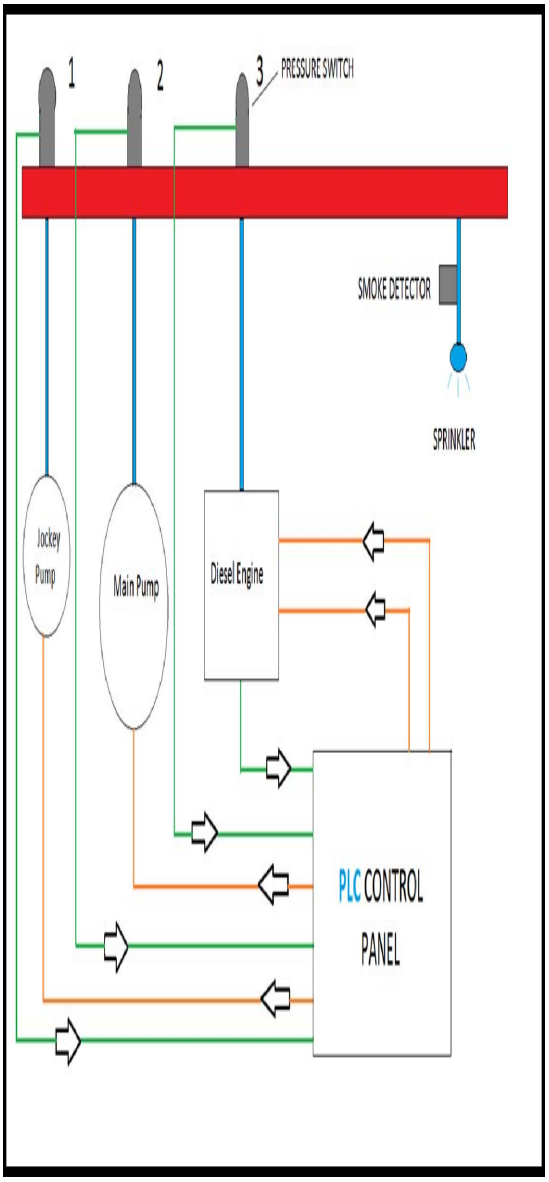

Fig.1. SCHEMATIC OF PLC BASED FIRE FIGHTING SYSTEM.

Fig.1. shows the block diagram of an Automatic Firefighting System using PLC. This system basically uses the drop in pressure across the hydrant line to infer the advent or for that matter, extent of fire. It thus becomes imperative to maintain the pressure across the hydrant line to a fixed pre-determined value.

The hydrant line in all probability may run across a large area with plenty of turns thereby posing many chances for a drop in pressure across it.

In order to nullify the effect of the turns and the long distances and to maintain the pressure across the hydrant line to a fixed predetermined value, a jockey pump is used. A pressure switch across the hydrant line is interfaced for the jockey pump which monitors the pressure across the hydrant line continuously and holds it to a fixed value.

In advent of a fire, the smoke detector detects the smoke to release the sprinkler valve. This causes a drop in pressure across the hydrant line.

Depending on the extent of fire, the corresponding pressure drop across the hydrant line will either fall within the range of the limit set on the pressure switch of the main pump or within the range of the limit set on the pressure switch of the diesel engine. The former case usually means that the fire is of medium proportion while the latter case most certainly means that the fire is quite large. Depending on the pressure drop the corresponding pressure switch will thus send a signal to the PLC which will acknowledge it to give an output in the form of an input pulse to either the main pump or the diesel engine.

The main pump or the diesel engine will then lift the water from the reservoir and into the hydrant line from where it will be used to extinguish the fire via sprinkler. Sometimes during fire, the main supply may be lost, either through a short circuit or by switching it off manually to avoid short circuit. In such a case, the main pump cannot be used to lift the water up into the hydrant line and this is when the diesel engine has to be used, irrespective of the pressure drop across the hydrant line. Thus, the health of the diesel engine is of prime importance as it is unaffordable to lose the diesel engine to some fault when it is in operation of extinguishing the fire.

Fig.2. shows the facial of the PLC panel. It has different push buttons like start, stop and other buttons to acknowledge the different faults mentioned above. The indications on the panel are Mains on, Pump on demand, System on auto, System on manual, Engine running, Engine fails to start, Low lube oil pressure, High engine water temperature, Engine over speed, Fuel tank level low, Mains fail.

A. Switches on Diesel Engine

a. Lube oil pressure switch

This switch is used to sense the oil pressure level.4-5kg oil pressure should be present to run the engine, if oil pressure level goes below the specified level. Then feedback is sent to the PLC panel.

For example: MP 54 and MP 55 oil differential pressure controls are used as safety switches to protect refrigeration compressors against low lubricating oil pressure. If the oil pressure decreases, the controller will stop the compressor after a predetermined time period.

b. Water temperature sensor

When temperature of water goes above 93-94°C, then cooling water is supplied to engine. For example: Temperature sensor. The water temperature detectors used in high temperature and pressure environment are armored with stainless steel package and waterproof connection box. The sensing elements are PT1000 resistors.

c. Level switch

This is used to indicate the fuel level.

Fig.2. PLC PANEL

V. MONITORING OF DIESEL ENGINE

When the Diesel Engine is in the running condition, few faults like Low lube oil pressure (LLOP), High water temperature (HWT), Engine Over-speed (OS), Fuel tank level low (FTLL) occur. It is of prime importance to acknowledge these faults.

As the diesel engine starts running, it consumes lubricant oil and thus the level of lubricant oil in the tank gets low, which sends a signal to the PLC panel through a pressure switch mounted on the lubricant oil tank. This signal is also taken as the feedback for 'ENGINE RUNNING' indication on the panel. Continuous running of the engine, heats the engine resulting in heating of water which is used as a coolant.

This sends a signal to panel in form of 'HIGH WATER TEMPERATURE. A sensor, mounted on the shaft of the engine, gives the feedback of 'ENGINE OVERSPEED'. As the fuel is being consumed, fuel level goes low and the signal is sent to the panel through a pressure switch. This is the signal of 'FUEL TANK LEVEL LOW'. The faults are to be cleared as soon as possible.

These faults are monitored by PLC and gives indication to the operator. The PLC is programmed in ladder logic to monitor the diesel engine and the pressure switches on the hydrant line.

The PLC also monitors the pressure in the main hydrant line. The panel gets the pressure drop feedback signal from hydrant line and acknowledges it. The panel operates in manual and automatic mode. Manual mode is used on site to test the panel before its actual operation on field. Generally the panel is in the automatic mode. It continuously monitors the diesel engine and keeps it in healthy condition. The automatic starting of a diesel engine is done by means of a pressure switch mounted on the delivery end of the fire water pump provided its rotary switch is kept in automatic mode. The normally open Contact (NO) under low pressure of the pressure switch is wired to the control panel to ensure a fail safe operation.

On drop of pressure, the normally close contact (NC) of the pressure switch opens thereby giving command to the PLC.

Fig.3. shows the pump connected to the diesel engine. When diesel engine is ON, it will turn ON the pump and it will control the flow of water. The pump is connected to the main hydrant line.

Fig.4. shows the flowchart of the complete process of monitoring the Diesel Engine.

A. PLC SPECIFICATIONS

The PLC used is Allen Bradley (micro830). Having rating 2A, 24VDC supply. EEPROM Memory, Input output pins-48, input pins-28 pins, output pins 20 pins [5]. It has as many as six high speed counter inputs, High speed input interrupt, Embedded USB port for programming and serial port (RS232/485), Modules RTU protocols(serial port).

B. *COMPONENTS OF PLC PANEL.*

a. SMPS

Switch mode power supply is the most commonly used power supply for dc source. It is very compact in size and works as a dc chopper [6]. It consists of L and C filters to filter the ripples arising due to rapid on off of the switch. The output dc voltage is controlled by varying duty cycles of chopper by Pulse width modulation or by frequency modulation. Ideally, a switched-mode power supply dissipates no power.

Fig.3. COUPLING OF DISEL ENGINE AND PUMP

b. DC TO DC CONVERTER

A DC-to-DC converter is an electronic circuit which converts as source of direct current (DC) from one voltage level to another. It is a class of power converter is also used to give continuous supply of power irrespective of the ripples in the power supply.

c. RELAY

A relay is an electro-mechanical switch. It uses electro-magnetism generated from a small voltage/current (for normal circuits its typically around 5V/6V/12V, 200mA) to switch larger voltages/currents (around, 110V/220V,16A) for household appliances. It provides electrical isolation between control and controlled circuits.

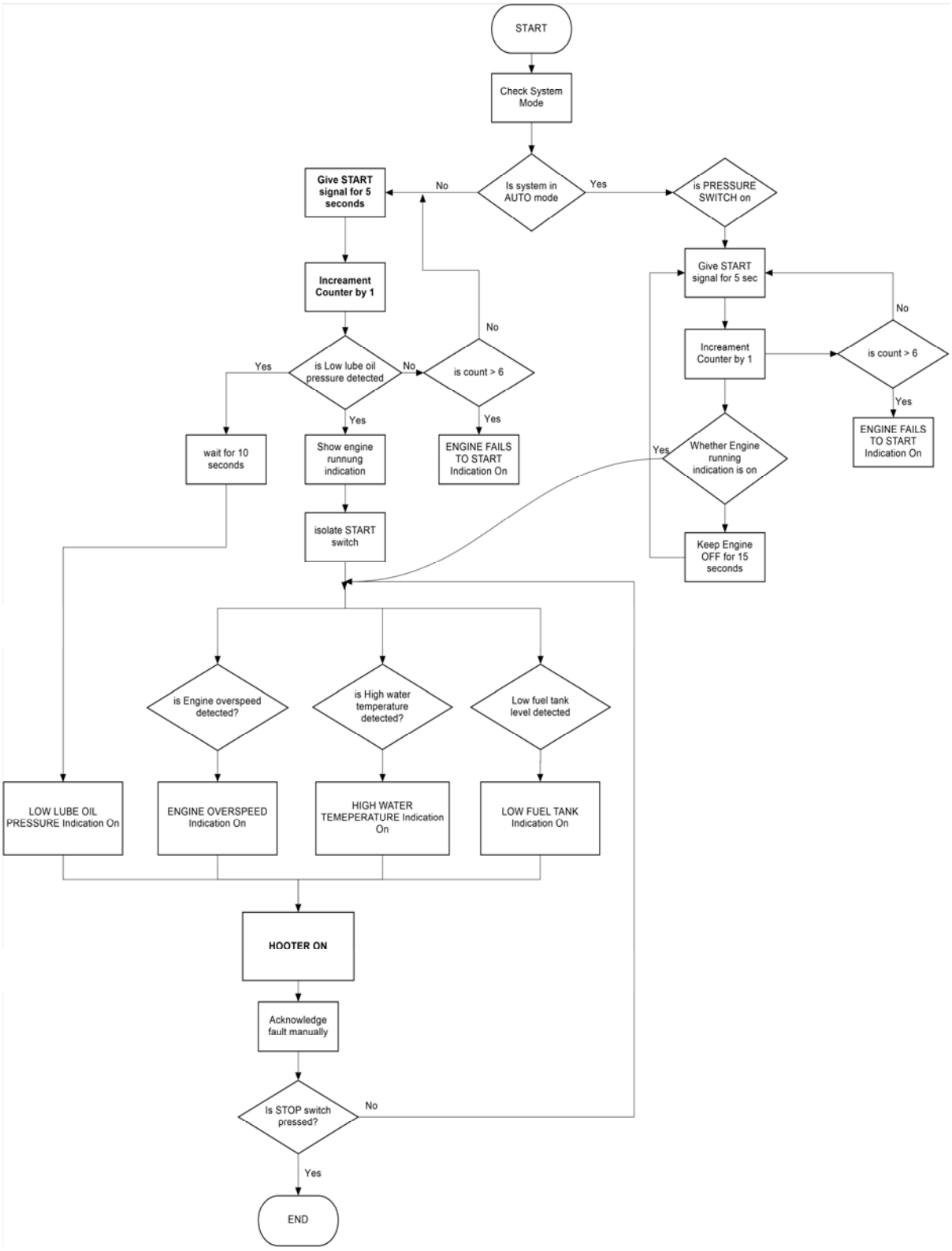

Fig.4. FLOWCHART OF SYSTEM

VI.PROTOTYPE MODEL OF FIREFIGHTING SYSTEM

Prototype model of the fire fighting system was developed. It consists of following components. Fig.5. shows the schematic diagram of the Prototype model built.

A. Thermostat

Thermostat is used as a heat sensing device. It is interfaced with the PLC panel. During occurrence of fire the thermostat detects the rise temperature and sends a signal to PLC. The PLC, according to the program fed gives the signal to the pump.

B. PUMP

Pump is nothing but a 1 phase induction motor used to extinguish the fire. When it receives the signal from PLC it starts running and thus extinguishes the fire.

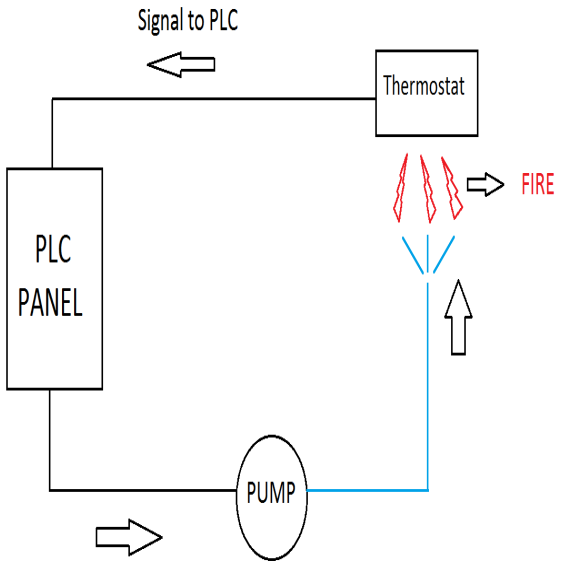

Fig.5. Prototype model of Fire Fighting system

VII. CONCLUSION

It has been observed that PLC is more convenient and efficient in controlling the parameters of diesel engine than the conventional control panel .By using PLC into the automatic diesel engine control panel we can control the parameters of the diesel engine. It is easy to handle and modify the logic .It requires less space and reduces errors in manufacturing of control panel. Hence it can be seen that PLC and its related circuits provide the logic diagnostic and options so as to provide a safe, reliable Fire Fighting system. The system is cost competitive and is applicable for industrial applications. Hence, it can be concluded that the system designed and developed works satisfactorily.

REFERENCES

[1] IEEE Automated fire fighting system with smoke and temperature detection, Khan, M.J.A. ; Dept. of Mech. Eng., Bangladesh Univ. of Eng. & Technology

[2]John W. Webb, Ronald A. Reis, Programmable Logic Controllers: Principles and Applications.

[3] www.**matherplatt**.com

[4] Mark Bromann, The Design and Layout of Fire Sprinkler Systems, Second edition.

[5]ab.rockwellautomation.com/programmable-controllers/micro830.

[6] Dr. P.S. Bhimbra, Power Electronics, Khanna Publication.