A PROJECT REPORT

ON

"DESIGN OF AUTOMATED FIRE AND SAFETY SYSTEM IN TANKS AND VESSELS"

Submitted by

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In partial fulfilment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. AfaqAhmed Jamadar

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

NAVI MUMBAI – 410206

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CERTIFICATE

This is to certify that the project entitled

"DESIGN OF AUTOMATED FIRE AND SAFETY SYSTEM IN TANKS AND VESSELS"

Submitted by,

RAWOOT ALTAF

SHAIKH ATEEF

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MULLA SAAHIL

To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfilment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University of Mumbai**, is approved.

Internal Examiner	**External Examiner**
(Prof. AfaqAhmed Jamadar)	**(__________________________)**
Head of Department	**Director**
(Prof. Zakir Ansari)	(Dr. Abdul Razzak Honnutagi)

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APPROVAL OF DISSERTATION

This is to certify that the thesis entitled,

"**DESIGN OF AUTOMATED FIRE AND SAFETY SYSTEM IN TANKS AND VESSELS**"

Submitted by,

RAWOOT ALTAF

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ISAF DANISH

MULLA SAAHIL

In partial fulfilment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering, as prescribed by University of Mumbai approved.

(Internal Examiner) **(External Examiner)**

Date: ___________

Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

--- (Signature)

---(Name of student and Roll No.)

Date:

PROJECT COMPLETION LETTER

Gayatri
Tanks & Vessels Private Limited

Ref No. GTV/2018/16 Date: 25.03.2018

TO WHOM SO EVER IT MAY CONCERN

This is to certify that the following group of students of ANJUMAN–I-ISLAM'S KALSEKAR TECHNICAL CAMPUS, NEW PANVEL, have successfully completed their project titled "DESIGN OF AUTOMATED FIRE SAFETY SYSTEM IN TANKS AND VESSELS" in our company GAYATRI TANKS AND VESSELS PVT. LTD, NEW PANVEL, with the reference to the partial fulfilment of the requirements of the Bachelors in Mechanical Engineering Course of Mumbai University. The name of the group of students are as follows:

1. ISAF DANISH A KADIR
2. RAWOOT ALTAF ADAM
3. SHAIKH ATEEF SHABBIR
4. MULLA SAAHIL SHAKEEL

All necessary details were provided from our side for the successful completion of the project. In the span of the project duration their candidature was found to be very sincere & hardworking.

We wish them the very best in all their future endeavours.

For Gayatri Tanks & Vessels Private Limited

Rambujh S. Sharma
(Managing Director)

GAYATRI TANKS & VESSELS PVT. LTD.

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Last but not the least we would also like to thank all the staffs of Kalsekar Technical Campus (Mechanical Engineering Department) for their valuable guidance with their interest and valuable suggestions brightened us.

ABSTRACT

A literature review has been conducted to gather information related to the extinguishment of actual tank fires and relevant large-scale fire extinguishing tests. The aim was to search for data that could be used for validation of foam spread models. In total, 480 tank fire incidents have been identified worldwide since the 1950s and the information collected has been compiled into a database. A list of the incidents with some data is provided in this report. Out of the 480 fire incidents, only about 30 fires have provided relevant information for model validation. A more detailed summary of the existing data from these fires is also provided in this report. Looking to this history it was very necessary to timely trigger the fire system so that it is never too late and the situations are not out of control. Keeping this in mind Gayatri Tanks & Vessels gave us a project on this particular topic of fire and safety simple automation in tanks and vessels. This report consists a brief about the system using PIC controller as the brain of the system. Different foams are explained so as to give an overview of which type of foam is to be used according to particular situation. The system is supposed to detect a fire inside the tank as well as to the vicinity of the vessel and activate the valve so that the system starts to function.

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LIST OF FIGURES

ABBREVIATIONS

Sr. No.	Abbreviation Or Notation	Full Form
1.	PIC	Peripheral Interface Controller
2.	BUS	Bidirectional Universal Switch
3.	A/D	Analog to Digital
4.	USART	Universal synchronous and asynchronous receiver and transmitted
5.	SPI	Serial peripheral interface
6.	EEPROMS	Electrically erasable programmable read only memory
7.	CCP	Capture compare PWM
8.	PWM	Pulse width modulation
9.	ICSP	In-circuit serial programming
10.	LCD	Liquid crystal display
11.	LED	Light emitting diode
12.	UART	Universal asynchronous receiver and transmitted
13.	RTD	Resistance Temperature Detector
14.	AFFF	Aqueous film forming foam
15.	NFPA	National Fire Protection Association
16.	AR	Alcohol Resistance
17.	UEF	Universal Extinguishing Foam
18.	PFOA	Perfluorooctanesulphonic Acid
19.	PFOS	Perfluorooctanaic
20.	FFFP	Film forming fluoroprotein
21.	ARFFFP	Alcohol resistance - Film forming fluoroprotein
22.	SF	Solenoid operated flow control valve

CHAPTER 1

INTRODUCTION

1.1. PROBLEM IDENTIFICATION

In total, 480 tank fire incidents have been identified worldwide since 1950. As the burn out procedure will result in a fire that is likely to last several days, complete loss of the stored product, environmental problems, large cooling operations to protect fire spread to adjacent tanks and in some cases potential for a boil-over, this is often not an acceptable alternative.

Extinguishment of a tank fire can only be obtained by using firefighting foams. However, historically the chances of successful fire control and extinguishment have been low, especially for larger tanks. Even tanks exceeding 20 m diameter have caused problems in many cases, and for many years, there had been no successful extinguishment of tanks larger than 45 m in diameter.

1.2. AIM OR OBJECTIVE

Looking to this history it was very necessary to timely trigger the fire system so that it is never too late and the situations are not out of control. Keeping this in mind a project was undertaken on this particular topic of fire and safety automation in tanks and vessels. This report consists a brief about the system using PIC controller as the brain of the system. An overview of which type of foam is to be used is explained. The system is designed to detect a fire inside the tank as well as in the vicinity of the vessel and activate the respective valve so that the system starts to function. This entire system is designed keeping in mind the overall cost of the system so that automation is economical. This makes the application of this system feasible and economical in large as well as small tanks. Further exclusion of human intervention ensures the safety of human life and also ensures the safety from human errors. The system consists of thermocouple, solenoid operated flow control valves, foam proportionate, and Peripheral Interface Controller

CHAPTER 2

LITERATURE REVIEW

TANK FIRES
REVIEW OF FIRE INCIDENTS (1951–2003)

The Orion Tank Fire in 2001, world record in tank fire fighting.
Photo courtesy of Industrial Fire World

2.1. BRIEF

Although large-scale tank fires are very rare, they present a huge challenge to fire fighters, oil companies and the environment. There are only two alternatives for combating such a fire, either to let it burn out and thereby self-extinguish or, alternatively, to actively extinguish the fire, using firefighting foams.
As the burn out procedure will result in a fire that is likely to last several days, complete loss of the stored product, environmental problems, large cooling operations to protect fire spread to adjacent tanks and in some cases potential for a boil-over, this is often not an acceptable alternative.
Extinguishment of a tank fire can only be obtained by using firefighting foams. However, historically the chances of successful fire control and extinguishment have been low, especially for larger tanks. Even tanks exceeding 20 m diameter have caused problems in many cases, and for many years, there had been no successful extinguishment of tanks larger than 45 m in diameter. Presently, the largest tank fire ever extinguished occurred in June 2001 and had a diameter of 82,4 m (270 ft). However, tanks that exceed 100 m in diameter exist and there are some debate concerning whether it would be possible to extinguish a fire in the largest tanks at all.
Standards, such as the highly influential USA standard NFPA 11 [1], provide very limited guidance on how to extrapolate fire protection guidelines from smaller tanks to the huge fire risks of today. Even assuming that extinction is possible, it is not fully known what type of equipment, type of foam, application rate and tactics should be used.
One of the reasons for this lack of guidance is that there has not been any fundamental understanding of the extinguishing process. In order to improve this understanding, a large research project, FOAMSPEX [2], was undertaken several years ago. Through comprehensive theoretical and experimental work, engineering models to predict foam spread and fire extinction under large-scale fire conditions were developed.

Some of the conclusions from the FOAMSPEX project were that:

- The results support the existing recommendations according to NFPA 11 referring to the number of fixed foam discharge outlets and the limitation of maximum foam flow length.
- The model indicates that tanks up to 120 m in diameter can be extinguished provided the application rate is sufficiently increased above the recommended value of 6,5 L/m2 /min.
- The model has been compared to a number of actual, large-scale tank fires, ranging in diameters from 40 m to 80 m. The difference between the predicted time to cover the whole burning surface and the observed time to knock down is in the range of 10 to 20 minutes.
- The models are based on friction data from laboratory experiments with cold foam flow. A remaining uncertainty in the models is how to scale the friction data when increasing the length scale by orders of magnitude (e.g. from about 10 m to tank diameters of 100 m to 120 m). More work is needed to improve the accuracy of the friction data for larger tanks and for various types of foam.
- Further work is needed to incorporate the breakdown of foam at the foam front and to quantify the initial delay of the extinguishment phase caused by foam break down. This

will call for additional large-scale experiments and more detailed observations from large-scale tank fires.

The benefits of being able to predict the foam spread is clearly shown by the FOAMSPEX project. For the first time, it is possible to study the influence of various parameters such as the viscosity of the fuel, the foam quality and the influence of the application tank fire incidents rate versus tank diameter. However, there are uncertainties in the models when applied to large-scale conditions, as all test data has been obtained in small and medium size tests. There were few data available from large-scale tank fires, which could be used for comparing to the model calculations, and there is therefore a need for further validation to estimate the uncertainty of the model.

The project reported here was therefore initiated in order to establish a database by collecting as much information as possible from actual tank fires and large-scale foam tests. Even if tank fires are rare, a significant number of fires occur annually on a worldwide basis. On a local basis, every single tank fire is a very expensive event and it has therefore been our hope that a lot of information and experience collected in e.g. fire investigation reports, would be available and could be very valuable for the future.

Although the search for information is focused on the extinguishing part of the fire, it was also recognised that information about tank fire incidents could be a valuable source of knowledge, both for the oil industry and fire protection community. Thus, even data on incidents where only limited information was available concerning the extinguishment tactics, have been included in this search and compilation.

2.2. SOURCES

2.2.1 The LASTFIRE project

The LASTFIRE project is one of the most comprehensive studies on the fire hazards associated with large diameter (greater than 40 m), open top floating roof storage tanks. Resource Protection International (RPI) carried out the study on behalf of 16 oil companies and the report was issued in 1997. One part of the study was a review of the cause of fires and the escalation mechanisms. As a part of this, a survey of major tank fire incidents was made. The information was collected by the distribution of a questionnaire to all the participating oil companies, asking for details about tank fire incidents within their facilities. Parts of the information were confidential and in the LASTFIRE report [3], full details (e.g. oil company, location specific date) are not given. According to the LASTFIRE project group, it was also difficult to obtain detailed technical data from the fires even though the oil companies participated in the study. Besides collecting the information from the oil companies, a literature review was also made and in total about 80 fires were identified and reported. Some were rim seal fires, other full surface fires also involving other types and sizes of tanks actually outside the scope of the LASTFIRE project. Being the perhaps most important study, the LASTFIRE project group was contacted and asked to review their material to analyse if they could contribute to our project with more detailed information, in particular on the extinguishment of the tanks. Very limited new information could be gained beyond what was already presented in the LASTFIRE report.

2.2.2 The Technica report

As a consequence of a major tank fire in 1988 in Singapore, which started in a floating roof tank that escalated to two nearby tanks, a study escalation mechanisms was made by Technica Ltd [4]. The study was made on behalf of a number of oil companies located in Singapore and one aim was to develop an engineering model in order to predict fire spread from one tank to another. The model allowed Technica to study the influence of a variety of parameters such as the effect of wind, cooling water sprays, type of floating roof, tank diameter, tank spacing, etc. As a part of this study, a literature review was made, both regarding full surface tank fires and large spill/bund fires and some brief information is given for about 120 fires. As the information in the report is very limited, it did not contribute to the collection of detailed information but a significant number of additional tank fires were identified. The API report In 1995, Loss Control Associates, Inc prepared a report for the American Petroleum Industry (API), "Prevention and suppression of fires in large aboveground storage tanks" The study applied to storage of flammable and combustible liquids in vertical atmospheric tanks having a diameter of 30,5 m (100 feet) or larger and/or storage capacities of 80 000 barrels or greater. In this particular study, an analysis was made of past fires and a brief summary of case histories is given for 128 fires.

2.2.3 The Sedwick report

On behalf of the LASTFIRE project group, a search for tank fires was made 1996 by the company Sedgwick Energy & Marine Limited in their database. This study identified 141 incidents and contributed with many new tank fires, especially outside the USA. As the information in the report is very limited it did not contribute to the collection of detailed information.

2.2.4 The NFPA Special Data Information Package

On request, NFPA provides various forms of statistics and a specific search was made of tank fire incidents [5]. Parts of the report provide statistical data from 1980 to 1998. However, the statistics cover fires in flammable or combustible liquid storage tank facilities in general and not only tank fires specifically. The statistics are therefore presented in various forms, e.g. related to incident type, by year, ignition factor, etc. This does not provide specific information but in an annex to the report, some technical information was given specifically related to some few tank fires.

2.3.0 SUMMARY OF TANK FIRES

No.	Fire	Dia (m)	Fuel	Foam	Appl. rate (L/m²/min)	Knock-down	Ext	Comments
0	Czechowice	33	Crude	Protein	8,4	No	No	Boilover
1	Collegedale-72	21,4	Gasoline	XL-3	2,45	?	1:30h	SSI Vent-fire
2	Romeoville-77	58	Diesel	FP	3,9	10-15 min	30 min (99%)	SSI 1st attempt
3	Rialto-78	?	Gasoline	AFFF	?	?	10-15 min ?	Over-top + SSI
4	Chevron-80	?	Gasoline	?	?	?	?	Video
5A	Navajo-82	24,4	Gasoline	FP+AFFF	7,7	?	65	
5B	Navajo-82	24,4	Gasoline	ATC	7,7	?	11	
6	Milford Haven-83	78	Crude	FP	2,2 3,0	3 h ?	No 7 h	1st attempt 2nd attempt
7	Tenneco-83	45,7	Gasoline	ATC	6,5	22-23 min	45min	
8	Chemischen Werke-84	29	IPA	(Det foam) water	?	25 h	27 h	Extinguished by dilution
9	Peninsula-85	36,6	Aviation gasoline	AFFF AFFF	4,3 7,9	15-20 10-15 min	No 20-25 min	2nd attempt 3rd attempt
10	Newport-86	29	Crude	ATC	3,95	20 min	40min	
11	Newport-87	29	Crude	ATC	6,9	10 min	15 min	
12	Ashland-88	36,6	Cracking tower slurry	ATC	5,4	1,5 min	10 min	
13	MAPCO-88	34,2		ATC	6,2	20 min	< 1h	Estimated ext.time
14	Neste-89	52	Isohexane	Various	7,2 5,2	30 min No	43 min No	1st fire 2nd fire
15A	Exxon-89	41	Heating oil	ATC	4,5	20 min	65 min	
15B	Exxon-89	41	Heating oil	ATC	5,4	?	?	
16	Jacksonville-93	30,5	Gasoline	?	7,9 (max 51)	55 min	1:57 h	SSI+over-top "Fishmouth"
17	France	36	Platformate	?	?	?	About 1 h	
18	Ultramar-95	47,6	Heated fuel	ATC 1%	?	?	About 2 days	
19	Amoco-96	41	MTBE	AFFF-AR	11,4	20-30 min	2,5 h	
20	Woodbridge-96	42,7	Gasoline	AFFF	10,6	?	2-2:30 h	
21	Sunoco-96	42,7	Raffinate	AFFF+ATC	10,6	10-12 min	3:10 h	
22	Nedalco-98	?	Ethanol	Alcoseal	?	20 min	2 h	
23	Conoco-99	60,4	Gas-oil	CNF UnivP	7,94	19-25 min	1:18 h	
24	Orion-01	82,4	Gasoline	ATC	8,55	20-25 min	1:05 h	Record in size!
25	Granite City-01	?	Heated asphalt	?	?	?	1:10 h	
26	Granite City-01	?	Heated asphalt	?	?	?	1:00 h	

?=Information missing

CHAPTER 3

METHODOLOGY

Fire is the result of a chemical reaction called combustion, which requires a combination of fuel and oxygen as well as a source of ignition. Different methods can be used to extinguish fires. The methods often involve the removal of heat by cooling the burning material, the cutting of fuel or air source or the adding of chemical substances.

3.1.1 Cooling the Burning Material

Cooling the burning material is the most common method used to extinguish fire. Water is widely available and the best cooling agent to use specially in fires involving solid materials. By evaporating in contact with fire, water also blankets the fire, cutting off the oxygen supply. However, you should never apply water to fires involving hot cooking oil or fat; water can cause the fire to spread.

3.1.2 Excluding Oxygen from the Fire

Smothering agents are substances used to extinguish a fire by cutting off the oxygen supply. Foam, which is the content of some fire extinguishers, can help to cool down and isolate the fuel surface from the air, eliminating combustion and being able to resist wind and draught disruption. However, never use foam on energized electrical equipment, because it is an electrical conductor. Other smothering agents include carbon dioxide, which is found in some fire extinguishers and is ideally used in electric equipment and sand, which is effective only on small burning areas.

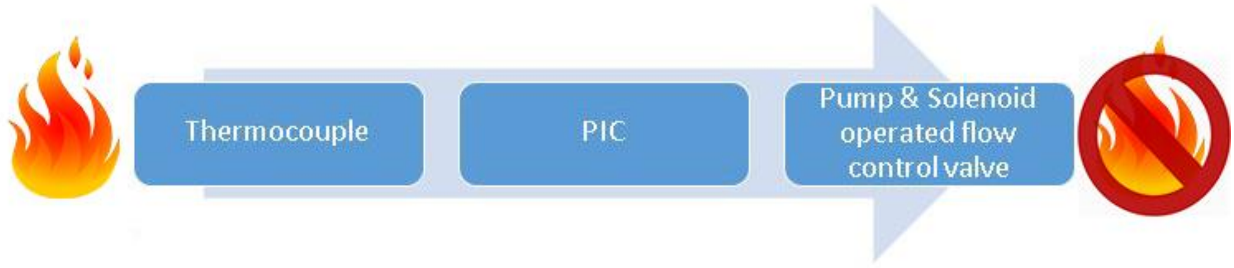
3.1.3 Removing Fuel from the Fire

Another method of extinguishing a fire is to remove the fuel supply by switching off the electrical power, isolating the flow of flammable liquids or removing the solid fuel, such as wood or textiles. In woodland fires, a firebreak cut around the fire helps to isolated further fuel. In the case of gas fire, closing the main valve and cutting off the gas supply is the best way of extinguishing the fire.

3.1.4 Using a Flame Inhibitor

Flame inhibitors are substances that chemically react with the burning material, thus extinguishing the flames. Dry-chemical fire extinguishers work in this way, and can contain mono ammonium phosphate, sodium and potassium bicarbonate and potassium chloride. Vaporizing liquids, such as Halon, also have a flame inhibiting action. However, most of these substances have been phased out due to high levels of toxicity.

3.2. OUR APPROACH

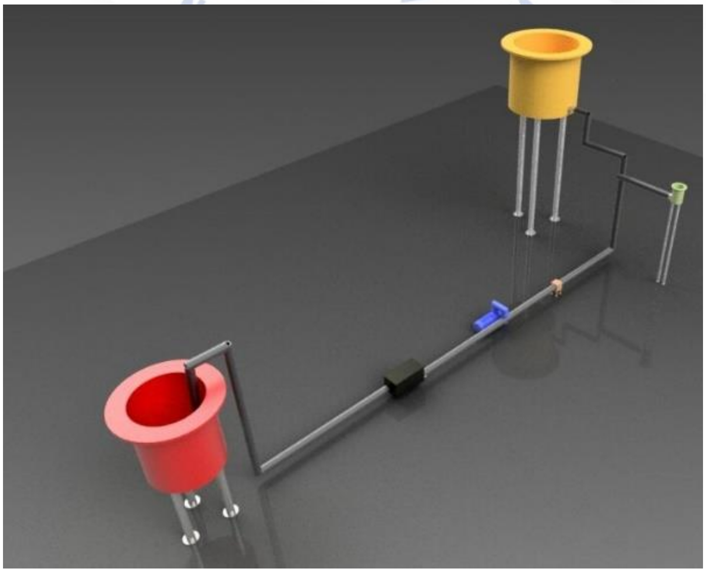


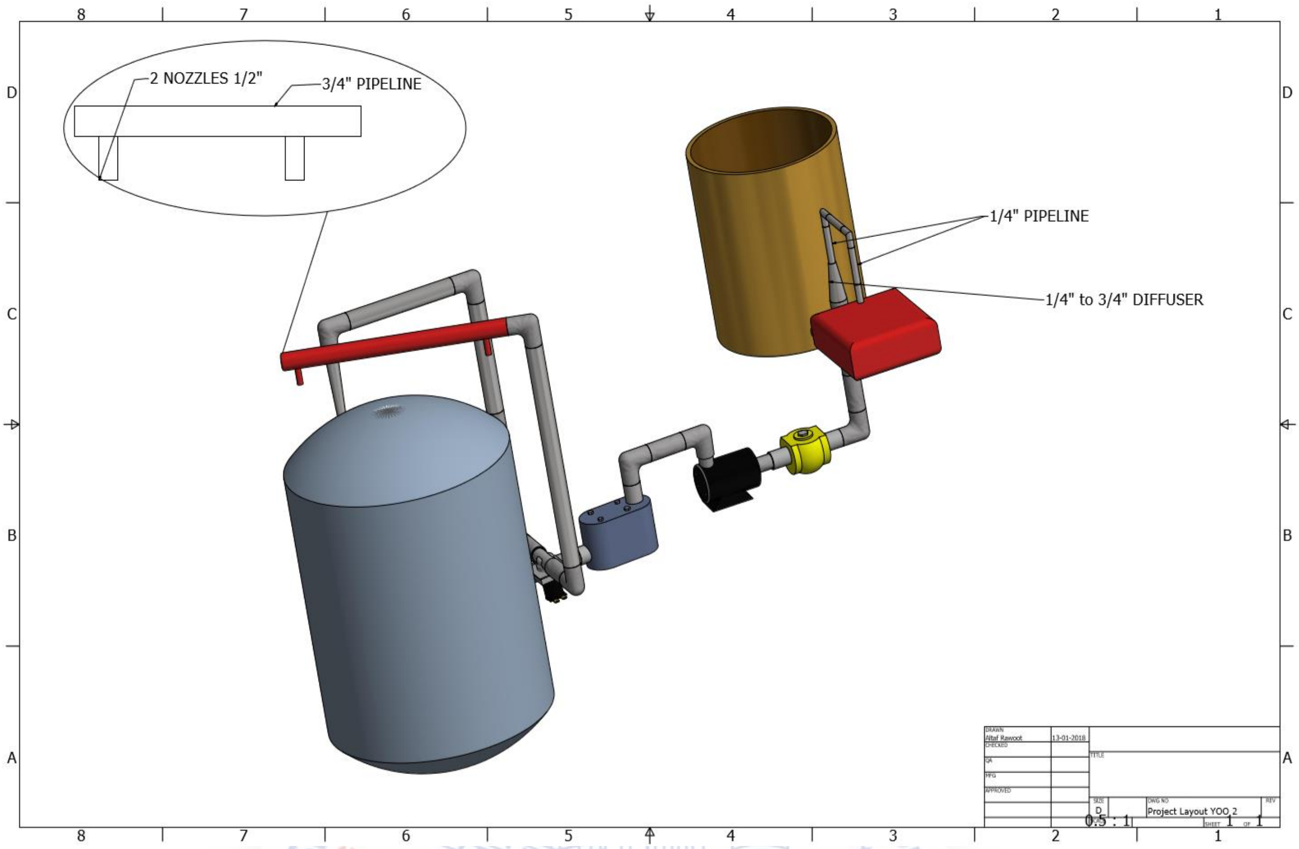
Fire means flames and flames means temperature. In this method, we are using a thermocouple to detect the elevated temperature of the flames as an input and give an equivalent electrical output, which is then interpreted by PIC. PIC then control the switching of pump and solenoid operated flow control valve as per the electrical input. When the pump is switched ON, the water flows from the water storage and mixed with the AFFF concentrate in Foam proportioner to form a foam. This foam is then admitted into the vessel, where the fire is to be extinguished via solenoid operated flow control valve, which is in ON position.

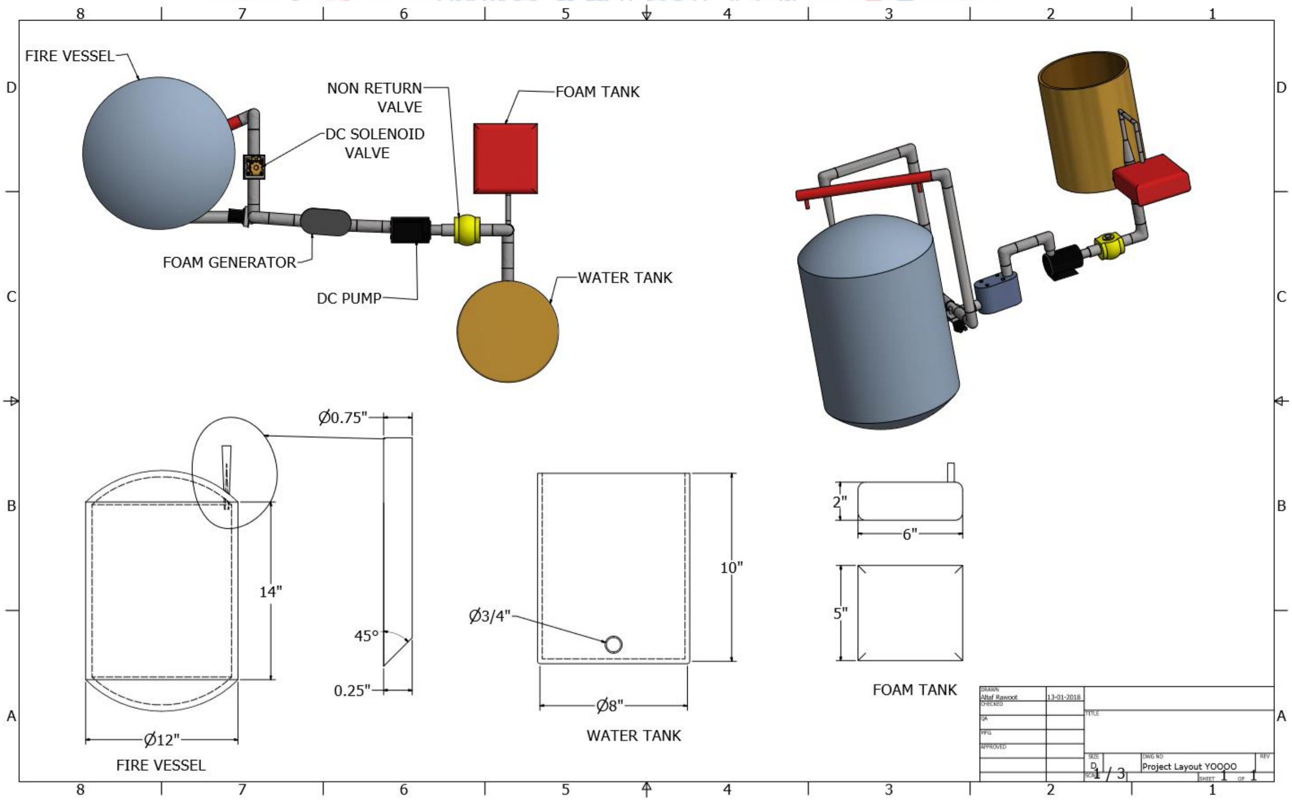
3.2.1 Our Method v/s Others

Traditional methods of fire extinguishing are laborious, less economical, time-consuming and their application in small to moderate capacity tanks and vessel are futile. Our method is fully automated i.e. no human intervention is needed. Due to this, human error is also limited. Actual time of the process is reduced since all the action is automated. The components used are less costly which means, this method is far more superior, economical and impeccable for fire safety in small tanks and vessels.

3.3. ROUGH DESIGN OF SYSTEM INTENDED




2 NOZZLES 1/2"
3/4" PIPELINE
1/4" PIPELINE
1/4" to 3/4" DIFFUSER

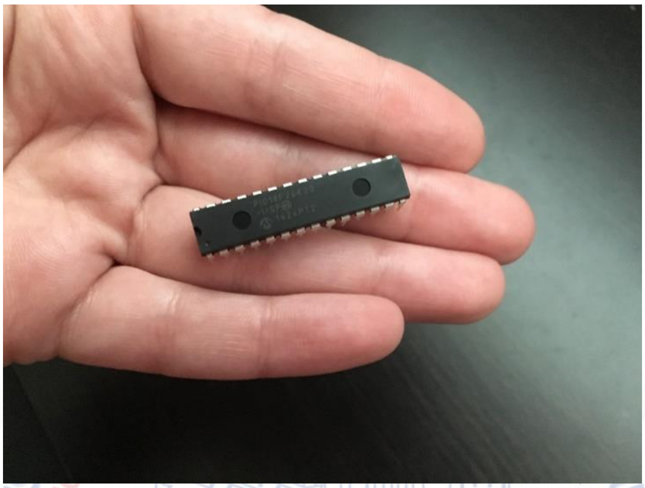

FIRE VESSEL
NON RETURN VALVE
DC SOLENOID VALVE
FOAM TANK
FOAM GENERATOR
DC PUMP
WATER TANK
Ø0.75"
14"
45°
0.25"
Ø12"
FIRE VESSEL
Ø3/4"
10"
Ø8"
WATER TANK
2"
6"
5"
FOAM TANK

CHAPTER 4

COMPONENTS

4.1. PIC (PERIHERAL INTERFACE CONTROLLER)

The term PIC stands for Peripheral Interface Controller. Initially this was developed for supporting PDP computers to control its peripheral devices, and therefore, named as a peripheral interface device. These microcontrollers are very fast and easy to execute a program compared with other microcontrollers. PIC Microcontroller architecture is based on Harvard architecture. PIC microcontrollers are very popular due to their ease of programming, wide availability, easy to interfacing with other peripherals, low cost, large user base and serial programming capability (reprogramming with flash memory), etc.



We know that the microcontroller is an integrated chip which consists of CPU, RAM, ROM, timers, and counters, etc. In the same way, PIC microcontroller architecture consists of RAM, ROM, CPU, timers, counters and supports the protocols such as SPI, CAN, and UART for interfacing with other peripherals. At present PIC microcontrollers are extensively used for industrial purpose due to low power consumption, high performance ability and easy of availability of its supporting hardware and software tools like compilers, debuggers and simulators.

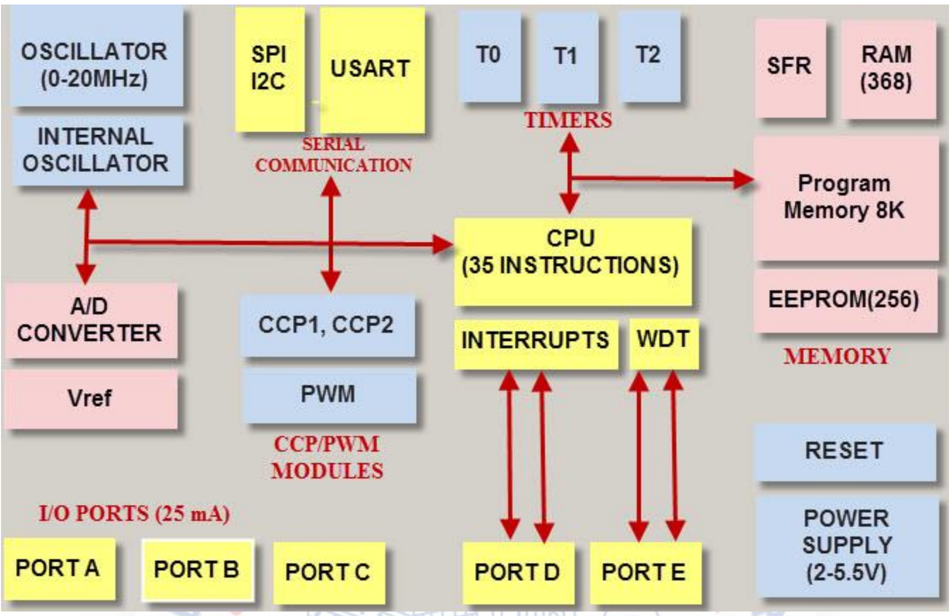
4.1.1 What is a PIC Microcontroller?

PIC (Programmable Interface Controllers) microcontrollers are the world's smallest microcontrollers that can be programmed to carry out a huge range of tasks. These microcontrollers are found in many electronic devices such as phones, computer control systems, alarm systems, embedded systems, etc. Various types of microcontrollers exist, even though the best are found in the GENIE range of programmable microcontrollers. These microcontrollers are programmed and simulated by a circuit-wizard software.

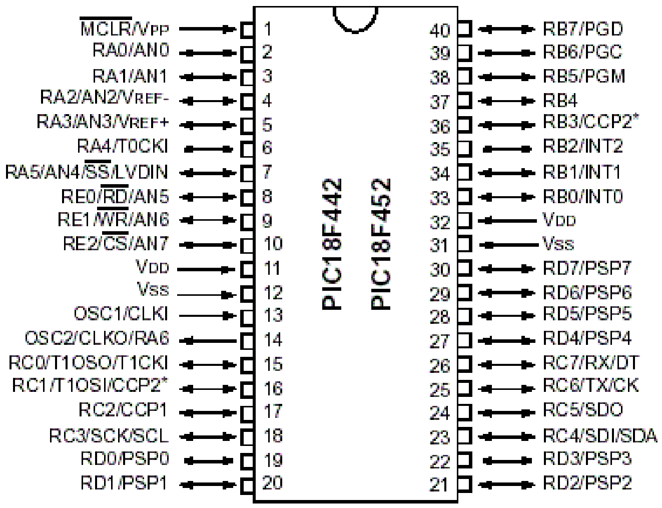
Every PIC microcontroller architecture consists of some registers and stack where registers function as Random Access Memory (RAM) and stack saves the return addresses. The main features of PIC microcontrollers are RAM, flash memory, Timers/Counters, EEPROM, I/O Ports, USART, CCP (Capture/Compare/PWM module), SSP, Comparator, ADC (analog to digital converter), PSP (parallel slave port), LCD and ICSP (in circuit serial programming) The 8-bit PIC microcontroller is classified into four types on the basis of internal architecture such as Base Line PIC, Mid-Range PIC, Enhanced Mid-Range PIC and PIC18.

4.1.2 Architecture of PIC Microcontroller

The PIC microcontroller architecture comprises of CPU, I/O ports, memory organization, A/D converter, timers/counters, interrupts, serial communication, oscillator and CCP module which are discussed in detailed below.



4.1.3 Pin Diagram of PIC18F4520



4.1.4 Why are we using PIC18F4520 over microcontrollers like Arduino and PLC (Programmable Logic Computer)?

- PIC microcontrollers are consistent and faulty of PIC percentage is very less. The performance of the PIC microcontroller is very fast because of using RISC architecture.
- When comparing to other microcontrollers, power consumption is very less and programming is also very easy.
- Interfacing of an analog device is easy without any extra circuitry.

4.2. PIC DEVELOPMENT BOARD

The PIC development board offers RS232 (Receiver, Transmitter including RTS, CTS), USB port, a switch, LED modules, ICSP devices, a reset and power monitoring buttons, I2C device, external / USB power supply, to stabilize the system's power, connector for alternate power battery and power switch and an expansion bus.

The board is a powerful development platform based on PIC18F452 microcontroller, PIC18F252 microcontroller, PIC16F877A microcontroller and PIC16F84 microcontroller. PIC 32 USB based data logging, application in real time data monitoring and control process, interactive control panel systems, etc.

On-chip USB controller provides a direct high speed interface to a PC/ laptop with speeds up to 12Mb/s speed. The UART boot loader eliminates need of an additional programmer and allows you to program using serial port interface. The on board peripherals include a USB interface port, ULN2003 current sinking driver interface, L293D DC motor controller for devices, 16X2 character LCD.

The on chip peripherals and the external hardware on the development board are interconnected using pin headers and jumpers in a board. The I/O pins on the microcontroller can be accessed easily. The board is made from double sided PTH PCB board to provide extra strength to the connector joints for increased reliability application. PIC development board supports the operating supply voltage between 5V DC and 12 V AC and has built-in reverse polarity protection.

A PIC development board is ideal for developing embedded applications involving high speed wireless communication process, the USB based data logging instructions, real time data monitoring and control of devices, interactive control panels, etc. USB controller provides a direct high speed interface to a PC/ laptop with speeds up to 12Mb/s speed. The UART (universal asynchronous receiver/transmitter) boot loader eliminates need of an additional programmer and allows you to program using serial port on board.

The I/O pins on the microcontroller can be accessed easily. The board is made from double sided PTH PCB board to provide extra strength to the connector joints for increased reliability while connecting. PIC32 supports the operating supply voltage in the range of 5V DC to 12V DC and has built-in reverse polarity protection.

This low-cost and reliable component constitutes a smooth transition to the co-design of universal boards. The board in testing program phase it can be simulated in any embedded environment called as a development system.

4.3. PIC PROGRAMMER KIT

A pic programmer is a circuit which interfaces the PC to the microcontroller using the PC's parallel, serial or USB port. It can write data to the microcontroller and read it back for verification.

The pic programmer translates digital logic levels from the PC to suitable logic levels for the microcontroller - most levels are ok as they are, but for 'normal' (or high volt) programming of a pic microcontroller the following voltage at the MCLR pin is needed:

The 13.5-volt level complicates the interface circuit since the voltages from the parallel port or USB port are not that high. Typical digital logic levels are nominally 5v so usually these programmers require use of an external power supply to generate the higher voltage.

The serial port generates higher voltages and this fact is used by programmers such as a JDM pic programmers. The programmer should isolate the microcontroller so you can test the microcontroller program while the programmer is still attached.

4.3.1 PICkit 3 Programmer/Debugger Defined

The PICkit 3 programmer/debugger is a simple, low-cost in-circuit debugger that is controlled by a PC running MPLAB IDE (v8.20 or greater) software on a Windows platform. The PICkit 3 programmer/debugger is an integral part of the development engineer's tool suite. The application usage can vary from software development to hardware integration. The PICkit 3 programmer/debugger is a debugger system used for hardware and software development of Microchip PIC microcontrollers (MCUs) and dsPIC.

Digital Signal Controllers (DSCs) that are based on In-Circuit Serial Programming™ (ICSP™) and Enhanced In-Circuit Serial Programming 2-wire serial interfaces. In addition to debugger functions, the PICkit 3 programmer/debugger system also may be used as a development programmer. The PICkit 3 programmer/debugger is not intended to be used as a production programmer.
The debugger system executes code like an actual device because it uses a device with built-in emulation circuitry, instead of a special debugger chip, for emulation. All available features of a given device are accessible interactively, and can be set and modified by the MPLAB IDE interface.
The PICkit 3 debugger was developed for emulating embedded processors with debug facilities. The PICkit 3 features include:
• Full-speed USB support using Windows standard drivers
• Real-time execution
• Processors run at maximum speeds
• Built-in over-voltage/short circuit monitor
• Low voltage to 5V (1.8-5V range)
• Diagnostic LEDs (power, active, status)
• Read/write program and data memory of microcontroller
• Erase of all memory types (EEPROM, ID, configuration and program) with verification
• Peripheral freeze at breakpoint

4.4. Shysky Tech DC30A-1230 4.2W Brushless DC Water Pump

The main advantage of DC (direct current) pumps over AC (alternating current) pumps is that they can operate directly from a battery, making them more convenient and portable. They are easier to operate and control, since AC systems typically require a controller to manage speed. DC pumps also tend to be more efficient. However, AC pumps usually are designed for higher speeds and larger bursts of power. They also have a longer working lifespan than DC pumps. DC pumps come in many different design types, each with its own method of operation, advantages, and preferred applications.

As with most pumps, the primary specifications to consider when discerning DC powered pump performance are flowrate, pump head, pressure, horsepower, and operating temperature. DC powered pumps can also be distinguished based on the features they provide, such as adjustable speed, run-dry capability, and corrosion resistance.

Specifications

Dimension and weight: 51mmx34mmx42.7mm; 90g
External diameter of outlet: 8mm
External diameter of inlet: 8mm
Driving mechanism: Brushless, magnetic separation
Condition of use: Can continuously work, submersible or land use (not self-priming)
Suitable medium: Water, oil, or other non-corrosive liquids
Max working temperature: 60°C
Power consumption: 4.5W @12VDC
Max load current: 0.35A @12Vdc
Max horizontal flow rate: 240L/H
Max static lift: approx. 2.5~3.3m
Noise class: <40dB
Waterproof class: IP68(suitable for submersible installation)
Power supply: Suitable for solar panel, batteries, adapter or other power module

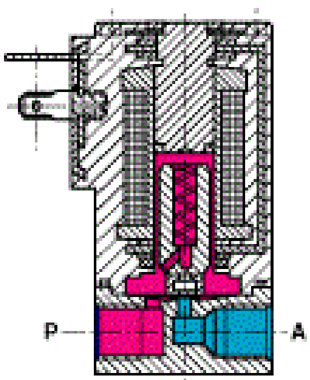
4.5. 12V DC SOLENOID VALVE

A Solenoid valve is used wherever fluid flow has to be controlled automatically. They are being used to an increasing degree in the most varied types of plants and equipment. The variety of different designs which are available enables a valve to be selected to specifically suit the application.

Solenoid valve is a control unit which, when electrically energized or de-energized, either shut off or allow fluid flow. The actuator takes the form of an electromagnet. When energized, a magnetic field builds up which pulls a plunger or pivoted armature against the action of a spring. When de-energized, the plunger or pivoted armature is returned to its original position by the spring action.

To the mode of actuation, a distinction is made between direct- valves, internally piloted valves, and externally piloted valves. A further distinguishing feature is the number of port connections or the number of flow paths ("ways"). With a direct-acting solenoid valve, the seat seal is attached to the solenoid core. In the de-energized condition, a seat orifice is closed, which opens when the valve is energized.

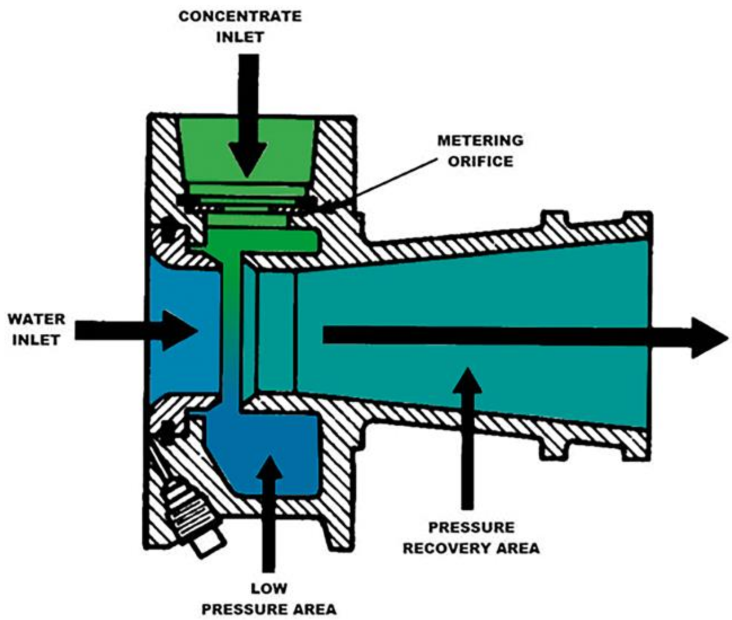
4.5.1 Direct-acting 2-way solenoid valve



Two-way solenoid operated valves are shut-off valves with one inlet port and one outlet port. In the de-energized condition, the core spring, assisted by the fluid pressure, holds the valve seal on the valve seat to shut off the flow. When energized, the core and seal are pulled into the solenoid coil and the valve opens. The electro-magnetic force is greater than the combined spur and the static and dynamic pressure forces of the medium.

4.6. FOAM PROPORTIONER

Common to all fixed foam firefighting systems is the need for a suitable induction/proportioning system to mix a pre-determined amount of foam concentrate with the fire mains water to produce a foam solution. The proportioning system is an essential element of any foam firefighting system as it ensures the correct mix ratio of foam concentrate to water. These systems can include pumps, bladder tanks or atmospheric tanks for foam concentrate storage as well as the proportioners and foam inductors themselves. Foam Proportioners utilize the water flowing through them to produce a venturi effect that induces foam concentrate into the water stream. The different types of foam proportioners are line proportioners, ratio controllers, injection foam proportioner, inline mixer. We are using line proportioners also called as inline inductors.



Line Proportioners
Line Proportioners are venturi devices that introduce foam concentrate into a flowing stream of water at a controlled proportioning rate. The line proportioner (also known as an inductor) is a simple, inexpensive method of proportioning when the water supply pressure is reasonably high. It has no moving parts and requires minimal maintenance. These proportioners mixer the foam properly with water so that a suitable foam solution is formed in a proper foam to water ratio. We are using the foam proportioner as an inline inductor. It eliminates the need of a separate metering device for the foam concentrate. It saves unnecessary excess mixing of foam with water.

4.7. THERMOCOUPLE

A Thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals. The wires legs are welded together at one end, creating a junction. This junction is where the temperature is measured. When the junction experiences a change in temperature, a voltage is created. The voltage can then be interpreted using thermocouple reference tables to calculate the temperature.

There are many types of thermocouples, each with its own unique characteristics in terms of temperature range, durability, vibration resistance, chemical resistance, and application compatibility. Type J, K, T, & E are “Base Metal” thermocouples, the most common types of thermocouples. Type R, S, and B thermocouples are “Noble Metal” thermocouples, which are used in high temperature applications (see thermocouple temperature ranges for details).

Thermocouples are used in many industrial, scientific, and OEM applications. They can be found in nearly all industrial markets: Power Generation, Oil/Gas, Pharmaceutical, Bio Tech, Cement, Paper & Pulp, etc. Thermocouples are also used in everyday appliances like stoves, furnaces, and toasters.

Thermocouples are typically selected because of their low cost, high temperature limits, wide temperature ranges, and durable nature.

4.7.1 Type K Thermocouple (Nickel-Chromium / Nickel-Alumel)

The type K is the most common type of thermocouple. It’s inexpensive, accurate, reliable, and has a wide temperature range.

Temperature Range:
- Thermocouple grade wire, –454 to 2,300F (–270 to 1260C)
- Extension wire, 32 to 392F (0 to 200C)

Accuracy (whichever is greater):

- Standard: +/- 2.2C or +/- .75%
- Special Limits of Error: +/- 1.1C or 0.4%

4.7.2 Why We Are Using Thermocouple Over RTD?

Temperature range
First, consider the difference in temperature ranges. Noble Metal Thermocouples can reach 3,100 F, while standard RTDs have a limit of 600 F and extended range RTDs have a limit of 1,100 F.

Cost
A plain stem thermocouple is 2 to 3 times less expensive than a plain stem RTD. A thermocouple head assembly is roughly 50% less expensive than an equivalent RTD head assembly.

Accuracy, Linearity, & Stability
As a general rule, RTDs are more accurate than thermocouples. This is especially true at lower temperature ranges. RTDs are also more stable and have better linearity than thermocouples. If accuracy, linearity, and stability are your primary concerns and your application is within an RTD's temperature limits, go with the RTD.

Durability
In the sensors industry, RTDs are widely regarded as a less durable sensor when compared to thermocouples. However, REOTEMP has developed manufacturing techniques that have greatly improved the durability of our RTD sensors. These techniques make REOTEMP's RTDs nearly equivalent to thermocouples in terms of durability.

Response Time
RTDs cannot be grounded. For this reason, they have a slower response time than grounded thermocouples. Also, thermocouples can be placed inside a smaller diameter sheath than RTDs. A smaller sheath diameter will increase response time. For example, a grounded thermocouple inside a 1/16" dia. sheath will have a faster response time than a RTD inside a ¼" dia. sheath.

CHAPTER 5

FOAMS

5.1. INTRODUCTION TO FOAM

The National Fire Protection Association (NFPA) 11 – Standard for Low, Medium and High Expansion Foam defines firefighting foam as "...an aggregate of air-filled bubbles formed from n aqueous solution which is lower in density than flammable liquids. It is used principally to form a cohesive floating blanket on flammable and combustible liquids, and prevents or extinguishes fire by excluding air and cooling the fuel. It also prevents reignition by suppressing formation of flammable vapours. It has the property of adhering to surfaces, which provides a degree of exposure protection from adjacent fires." Or put more simply... foam is used for the suppression of fire and can extinguish flammable liquid or combustible liquid fires in four different ways:

- separates the flames from the fuel surface
- retards vapour release from the fuel surface
- cools the fuel surface and any surrounding metal surfaces
- excludes oxygen from the flammable vapours

5.2. Synthetic Foams

Synthetic foams are based on synthetic surfactants. They provide better flow and spreading over the surface of hydrocarbon-based liquids, for faster knockdown of flames. They have limited post-fire security and are toxic groundwater contaminants. This type of foam concentrate is based on a mixture of surfactants and solvents, both fluorinated and fluorosurfactant/ fluoropolymer-free. These types of foam concentrates may or may not form films or membranes on the fuel surface, depending on the foam concentrate and the fuel being protected.

- Aqueous film forming foams (AFFF) are water-based and frequently contain hydrocarbon-based surfactant such as sodium alkyl sulphate, and fluorosurfactant, such as fluorotelomers, perfluorooctanoic acid (PFOA), or perfluorooctanesulfonic acid (PFOS).
- Alcohol-resistant aqueous film-forming foams (AR-AFFF) are foams resistant to the action of alcohols and can form a protective film.

5.3 WHY USE FOAM?

Class B fires consist of flammable or combustible gases, and liquids. Extinguishment is normally accomplished by excluding (eliminating) oxygen, interrupting the combustion of the chain reaction, or stopping the release of the combustible vapours. The type of Class B hazards is either water soluble (meaning they mix with water) e.g. polar solvents or water insoluble (meaning they will not mix with water) e.g. hydrocarbons. For water soluble fuels, special alcohol resistant foam agents that will not mix with the fuel are required. Many different extinguishing agents are effective on flammable or combustible liquids. However, foam is the only extinguishing agent capable of suppressing vapours and providing visible proof of securement. Reasons to use firefighting foam include:

■fire prevention– application of a foam blanket on an unignited spill
■vapour suppression– prevention of vapours from finding an ignition source
■odour control– suppression of hazardous or noxious vapours
■personnel exposure– protection of fire and/or rescue personnel during emergency operations

Class B foam is not effective on all types of fires. It is critical to know the type of fire and fuel involved.

Firefighting foam is not effective on:

- Class C Fires (energized electrical equipment) as water conducts electricity and foam contains 90% plus water. Class C fires can be extinguished by either de-energizing the equipment or using alternative extinguishing media such as dry chemical, carbon dioxide or a clean agent;

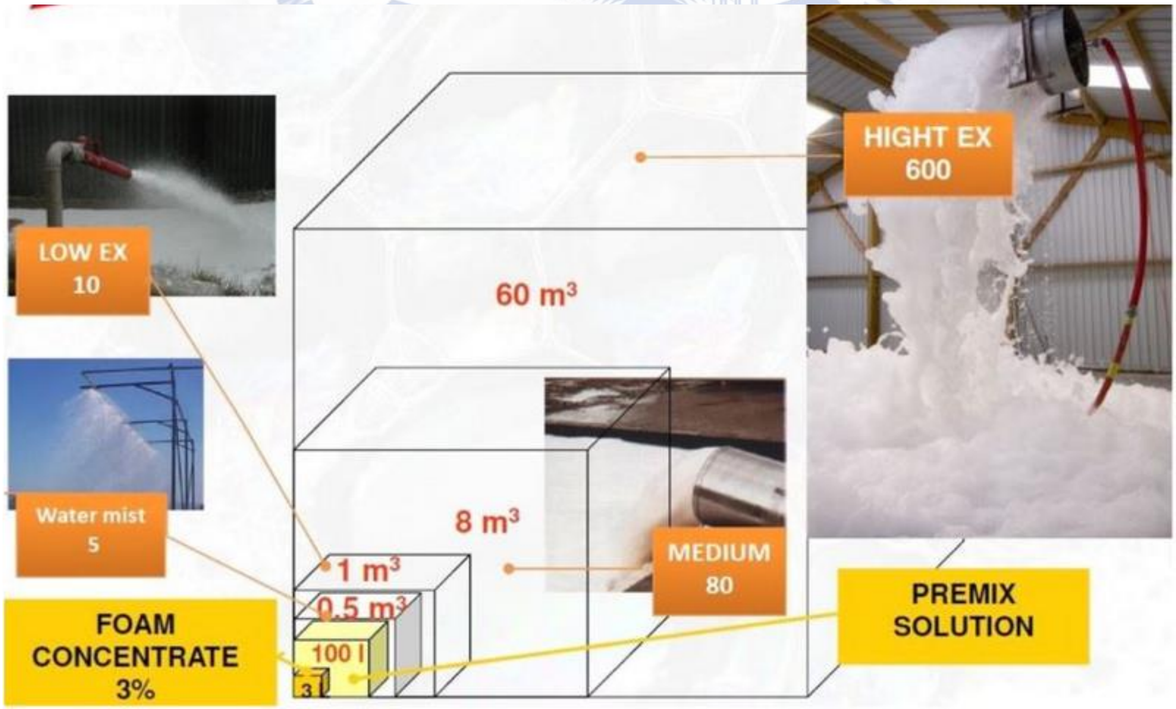
- Pressurized Gases– materials stored as liquids but are vaporous at ambient temperature. The vapour pressure for these type fuels is too high for foam to be effective;

- Three-dimensional Fires– in which the flammable liquid is being discharged from an elevated source creating a pool fire on a lower surface area;
- Class D Fires– combustible metals such as aluminium, magnesium, potassium, sodium and titanium alloys. The extinguishment of Class D metals requires the use of specialised dry powder agents.

5.4 CATEGORIES OF FOAM SYTEMS

Expansion is the ratio between the Foam Volume obtained and the Volume of Foaming Solution used to produce it. For example: 100 litres of water + foam concentrate pre-mix give 1000 litres of foam. Expansion is therefore 1000/100 = 10.

The more air is introduced the higher the expansion. There are 3 types of expansion depending on the equipment used. Expansion closely depends on the type of foam concentrate and the type of hose used. Thus, protein foam concentrates are usually suitable for Low and Medium expansion. Synthetic foam concentrates are suitable for Low, Medium and High Expansion.



5.4.1 Low Expansion Foam

Its higher density allows the use of long range jets using hoses or monitors. Low Expansion foam is little sensitive to atmospheric conditions, wind or rain: it is stable and provides a strong cover. Its high water content guarantees significant additional cooling. Its Expansion ratio of 12:1 when mixed with air. It is Effective in controlling and extinguishing most flammable liquid (Class “B”) fires. It usually used on widespread hydrocarbon fires (storage tanks, holding tanks).

5.4.2 Medium Expansion Foam

Medium Expansion foam can be sprayed up to about ten metres. Its low density makes it sensitive to wind and bad weather. Its expansion ratio of between about 20:1 to 100:1. It is truly three dimensional; it is measured in length, width, height, and cubic feet. It is used for smaller surfaces (solvent storage, cellars) as a rule in closed or partially closed areas of which the walls limit the spread

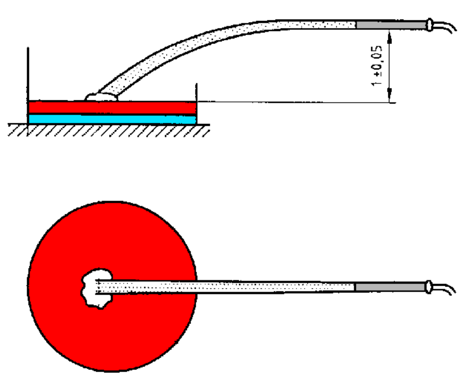
5.4.3 High Expansion Foam

It is designed for fires in confined spaces. It is heavier than air but lighter than oil or water. It is preferably used on dry product fires or on premises on which there are mixed risks (stores, warehouses).

5.5 DIFFERENT WAYS OF APPLYING FOAM

There are **2 application modes,** recognised by the European (EN1568) and international (ISO7203) standards.

5.5.1 Direct application



This is the direct spraying of the foam into the heart of the liquid. The firefighting teams use a hose or a monitor in the "solid jet" position. This makes it possible for them to fight the origin of the fire from a distance and thus be less exposed to intense heat. Static installations are concerned in the case of long distance static monitors, or classic headed sprinklers. The jet of spray strikes the liquid directly. This type of spray can only be applied to class B fires of the hydrocarbon type (water-immiscible liquids), using AFFF foam concentrates (Aqueous Film Forming Foam).

5.5.2 Indirect application

It is imperative for all polar solvent liquid fires (miscible with water). The foam is sprayed onto a vertical surface and then runs onto the burning liquid to spread evenly on its surface without contaminating it. The foaming agent therefore strikes a surface before coming into contact with the polar product. This is the case for most fire brigade interventions and for mobile resource operating tactics.

The sprayed foam can also be applied directly onto the liquid but using Medium or High expansion. This is the case for almost all static installations (crown with ME foam box on a holding tank, HE flooding, foam head sprinkler...). This process is mandatory so that the foam is not directly absorbed by the polar solvent. This method of application also allows to extinguish hydrocarbon type fires (water-immiscible liquid).

CHAPTER 6

CALCULATION

6.1.0 PIPE DIMENSIONS

Diameter = ¾" ......(Available Standards)
Length = 3 m ....(Constraint)

6.2.0 VESSEL DIMENSIONS

Diameter = 12" = 0.304 m

Height = 14" = 0.355 m

Area of Vessel = $\frac{\pi}{4} \times 0.304^2$
= $0.072\ m^2$

Volume of vessel = 0.072 x 0.355
= $0.025\ m^3$

Available time to completely fill the vessel (t) = 1 min = 60 sec

6.3.0 PUMP CALCULATIONS

Discharge (Q) = $\frac{\text{Volume}}{t}$
= $\frac{0.025}{60}$
= $4.166 \times 10^{-4}\ m^3/sec$
= 24.996 lit/min

Head (H) = 1 m

Density of water (ρ) = $1000\ kg/m^3$

Acceleration due to gravity (g) = 9.81 m/s

Water Power = $\frac{\rho \times g \times Q \times H}{6000} = \frac{1000 \times 9.81 \times 0.0004166 \times 1}{60000}$
= 11.352×10^{-6} KW
Water Power = 1.52×10^{-5} HP

Since Pumping Power and Discharge is too low, Hence, selecting Small Capacity DC pump.

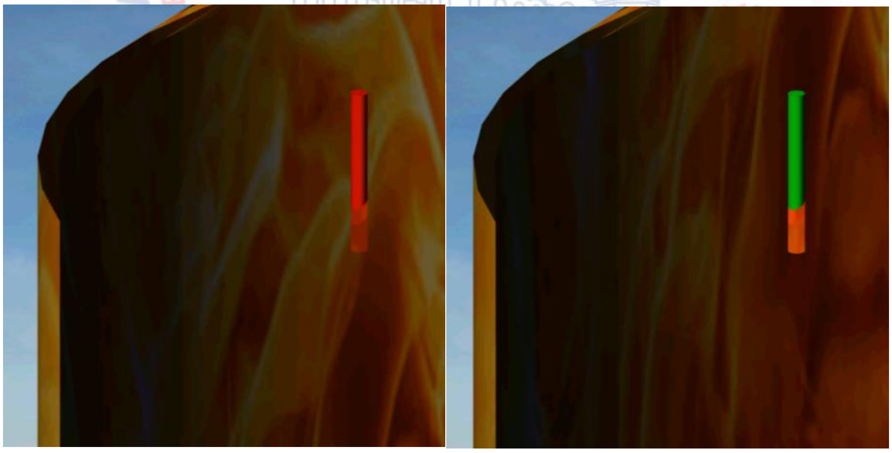
CHAPTER 7

ACTUAL EXECUTION

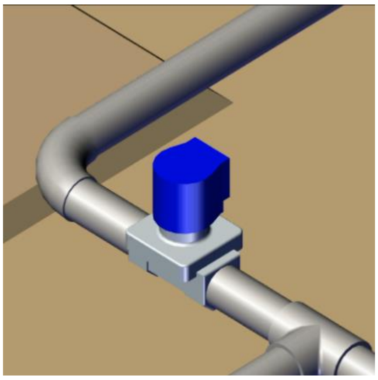
7.1. CASE-1

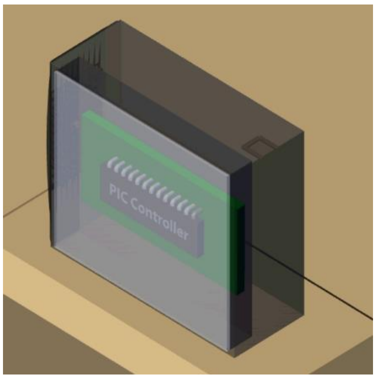
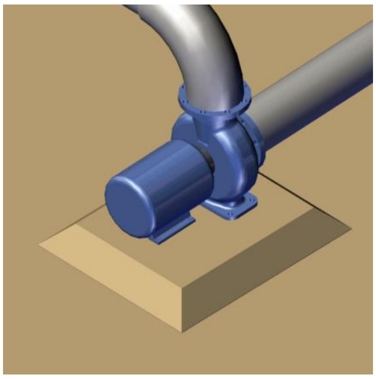
When the fire breaks out inside the vessel due to lightning, human error or some other external reason.

Thermocouple 1 fabricated inside the vessel detects the rise is in temperature, this rise in temperature is taken as an input. Thermocouple 1 then produces an electrical signal equivalent to the rise in temperature as an output. This output electrical signal is then sent to the PIC

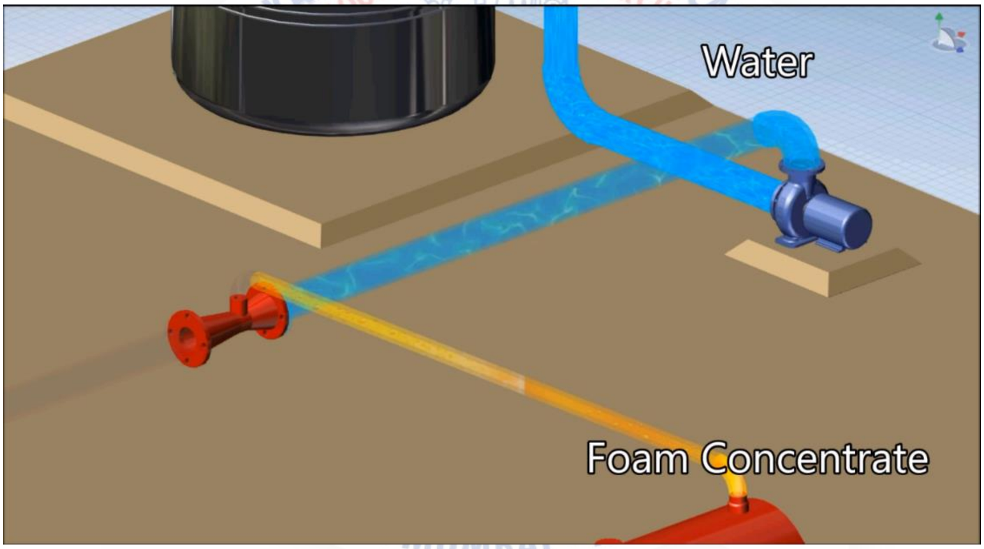


As soon as PIC receive an electrical signal from the thermocouple 1, it starts processing and generates another electrical signal, which is then sent to the SF-1 and pump. This electrical signal is used to switch ON the pump and trigger the SF-1.

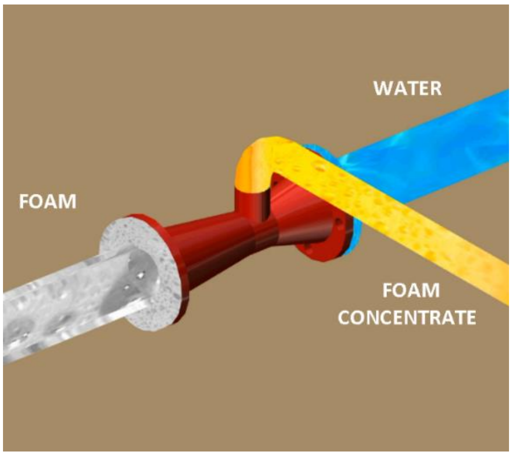


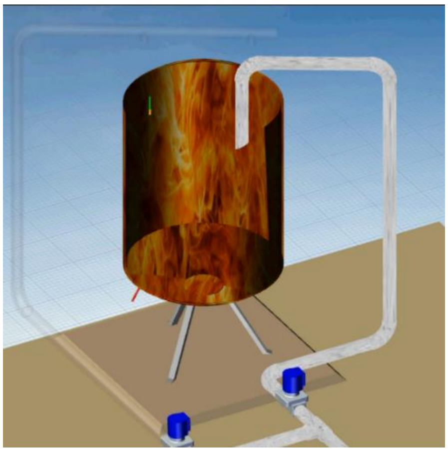



Water from the storage tank is pumped in the pipelines. Water flows into the foam proportioner. Foam proportioner is a venturi-like structure having convergence, divergence and throat section. When water flows through the throat section pressure in this section decreases. This decrease in pressure allows foam concentrate to flow into the foam proportioner in small quantity from foam storage tank.

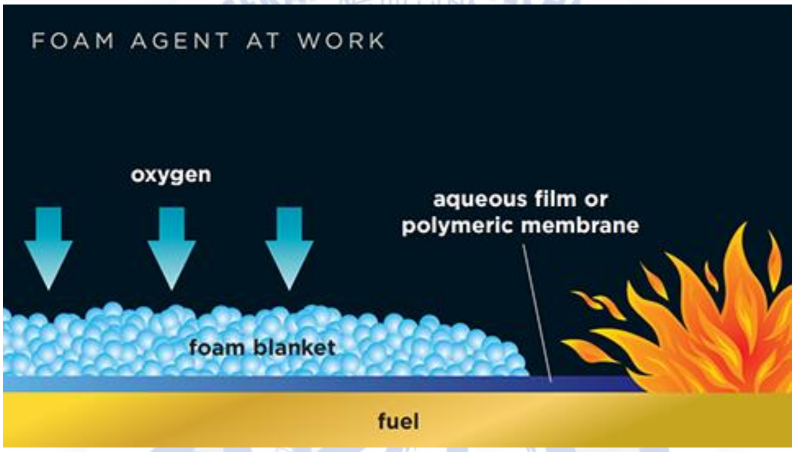


Inside foam proportioner, water enter from convergence section and foam concentrate enter from throat section and get mixed. Resultant Foam having appropriate properties is then come out from the divergence section. This foam is admitted inside the vessel through the SF-1.



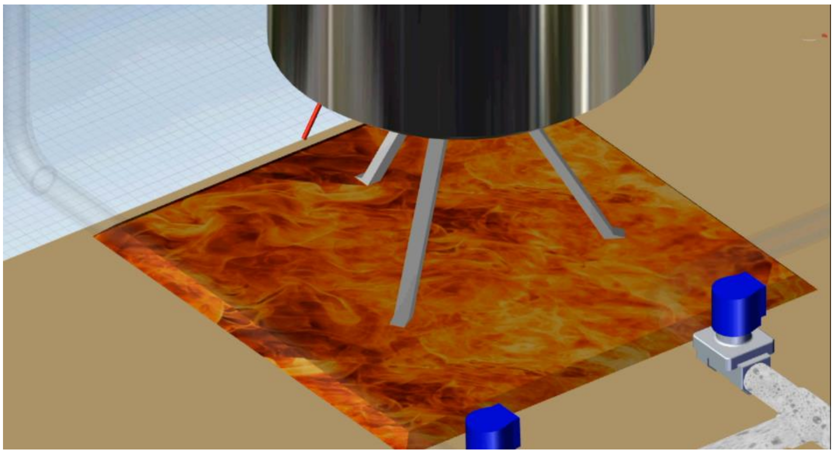


Foam after admitting into the vessel get settle at the bottom of the vessel and create a blanket over the burning substance, preventing oxygen supply to it and cools down the burning substance. This act of forming blanket extinguishes the fire

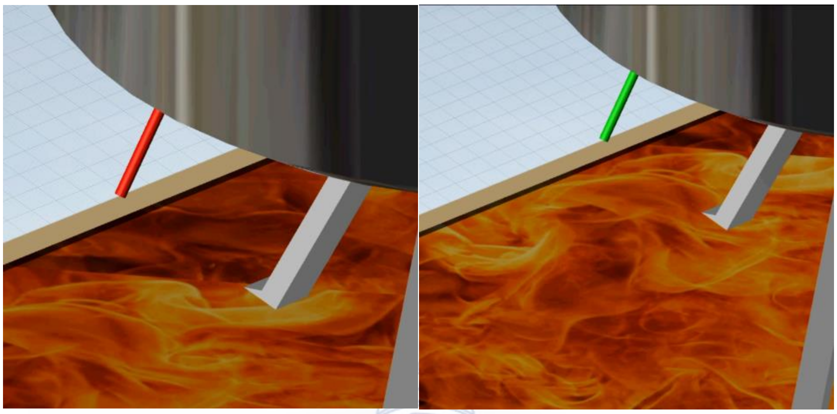


7.2. CASE-2

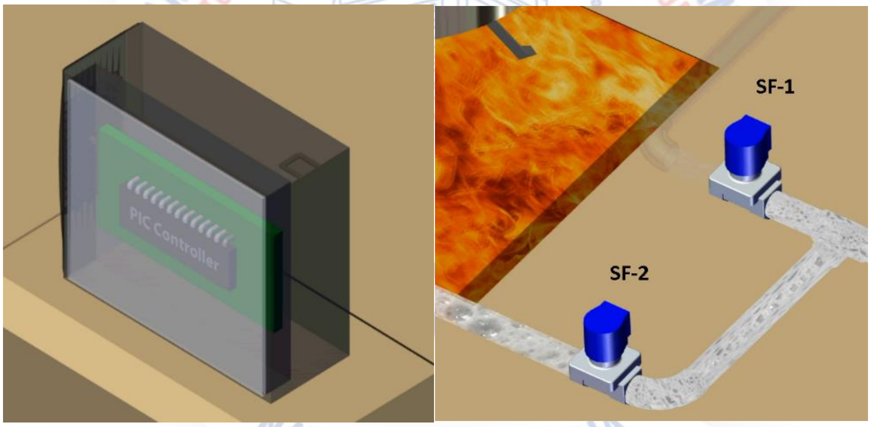
When the fire breaks out in the vicinity of a vessel due to lightning, human error or some other external reason.



Thermocouple 2 fabricated outside the vessel detects the rise is in temperature, this rise in temperature is taken as an input. Thermocouple 2 then produces an electrical signal equivalent to the rise in temperature as an output. This output electrical signal is then sent to the PIC



As soon as PIC receive an electrical signal from the thermocouple 2, it starts processing and generates another electrical signal, which is then sent to the SF-2 and pump. This electrical signal is used to switch ON the pump and trigger the SF-2.



SF-2 allows the passage of foam into further pipelines. Foam through pipelines enters the manifold located above the vessel. While exiting the manifold foam velocity increases. Foam settle above the vessel and slowly drip on the ground thereby creating a foam blanket over the burning substance and extinguishing the fire.

CHAPTER 8

FUTURE SCOPE

Flammable liquids, particularly crude oil, with high vapour pressure, poses difficulties for fire protection and fire safety. AFFF foam is effective under the best condition i.e. when the temperature of the surrounding is -10 degrees Celsius and above, but typical AFFF based fire safety system is ineffective in extremely cold conditions in which either water is scarce or frozen. This can pose extraordinary problems when active water-based fire protection system fails to perform. This problem is encountered in extremely cold climates where temperature of -40 degrees Celsius is common.

This problem can be overcome by using Engineered composite beads, which were developed to address the need for a non-water based fire protection solution for flammable liquids, particularly high vapour pressure crude oil stored in a place having a temperature -44 degrees Celsius or less. This technology also proves to be beneficial in all climates and can be used for different flammables like liquefied petroleum gas (LPG) and liquefied natural gas (LNG). This technology also shows potential to bring new paradigm on how to deal with flammable liquid storage tank fires.

Engineered composite beads are an evolution of synthetic foams that are commonly used for buoyancy, thermal protection and in other application. Beads are made up of hollow sphere combined with a resin. Once cured, this combination produces a useful shape having good rigidity, stability and lightweight. The final bead can tolerate continuous, long-term exposure to hydrocarbons of many sorts including crude oils, diesel, acetone, gasoline and ethanol. when beads are exposed to high temperature during tank fire, they intumesce, by creating a thermal barrier. The beads exposed to fire expand and trap with adjacent beads creating a crust that form a tighter vapour barrier between fire and flammables.

Engineered beads create a potential new method of fighting tank fires. Using existing pumps, piping and infrastructure, the new method would deliver the beads directly to a target tank fire without deploying firefighting personnel to the tank or tanks.

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