Automated Boiler Water Cascade Tank Filling With Temperature Control

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ABSTRACT

Boilers are one of the essential machinery onboard a ships. Its purpose is to provide steam heating for the fuel bunker tanks and service tanks, heating of the sea water to produce fresh water through freshwater generator, cleaning purpose and etc. Cascade tank or hot well is a part of boiler feed water system. This tank is very important in boiler system because its a reservoir for for the fresh water that had to be supply into boiler for heating and produce steam. The important things that we need to maintain in this reservoir is the level of water and also the temperature that had to be maintained. This is because unstable water level with improperly heated feed water will cause lower boiler efficiency. This paper will focus on how to control the water level with set value with a proper temperature regulated to give optimum output for the boiler.

KEY WORDS: *PIC Microcontroller, Tank Level Controller, Temperature Regulator*

NOMENCLATURE

PIC *Peripheral Interface Controller*
MCU *Microcontrollers*
LM35 *Temperature Sensor*
LCD *Liquid-Crsytal Display*
$L_{0\%}$ *Level at 0%*
$L_{50\%}$ *Level at 50%*
$L_{75\%}$ *Level at 75%*
POR *Power On Reset*
PWRT *Power Up Timer*
PCB *Printed Circuit Board*

1.0 Introduction

Water is a main substance for a marine boiler to work efficiently to produce high quality of steam. To maintain the quality of the steam, cascade tanks are used to feed water in boiler drum for steam generation. Cascade tank is used to control the level and regulate the temperature of feed water entering the boiler drum. This system is to ensure that adequate feed water is supplied to the boiler drum in a correct range of temperature, so the boiler steam generation produce at most efficiently..

1.1 Current System

Several upgrade has been done for the water level control system in cascade tank but it didn't proportionally controlled the temperature of the water which is the main element for the boiler system. They had two independent sensor and control. For the level, they use level sensor and float valve to detect and topup the water whereas for the temperature, they use temperature sensor and temperature regulator.

1.2 Proposed System

The system that this paper proposed is the combination of this two sensors and the action to be taken by the level controller and the temperature regulator in order to maintain both value in correct range for better performance of the boiler. By this we can save cost and time to maintain the boiler feed water in the tank at optimum temperature at required level.

2.0 Methodology

Microcontroler will continuously detect the temperature inside the tank together with the level. This is done by the level sensor which detects the water level, as in this project using the switches to represent level sensor and also using the temperature sensor (LM35) to detect the water temperature as per the set value. When the temperature drops below the set point (75'C — 85'C), the heater (Steam supply) will switch on to heat and switch off when reaches the set value. The motor will run to top up water in the cascade tank if the level drop below 50% and stop when reaches 75%. Both heater and motor are controlled by MCU through relay.

2.1 Components

The device components consist of PIC18F452, a microcontroller with 40 pins fit. Do it as the brain of the machine. Relays are switches that are designed to close and open circuits electronically as well as electromechanically. 10WATT10R is resistor which a passive electrical component with the primary function of limiting the flow of electrical current. The crystal oscillator is an electronic oscillator circuit that use the mechanical character of a vibrating crystal of piezoelectric material to produce a determined frequency electrical signal. The motor will be activated when needed. LCDs used to display data such as sensor values or indications. A 16x2 LCD means it can display there are 2 such lines and 16 characters per line .The 16 x 2 intelligent alphanumeric dot matrix display is capable of displaying 224 different characters and symbols. This LCD has two registers, namely which is Command and Data. Command register stores several instructions given to the display. The phone keypad in Proteus has three columns and four rows. The software code shown above is working well and serves the function. It's called the Polling type of programming. It is possible for systems that have to perform basic tasks like this. Push button is the output of this function that is stored in another variable that can be used to execute other functions depending on the application. LM35 is known as Precision Centigrade Temperature Sensors are precision integrated-circuit temperature devices with an output voltage linearly relative to the Centigrade temperature. POT-HG also known as potentiometer, commonly referred to as a "pot", is a 3-terminal mechanically operated rotary analogue device which can be found and used in a large variability of electrical and electronic circuits. They are passive devices, which mean to say they do not need a power supply or additional circuitry in order to accomplish their basic linear or rotary position function.

2.2 Operations

- When the level inside the tank drops below 50% by activating switch 50%, it will send signal to MCU and MCU will send signal to the motor via relay to start and top up.
- Level of the water will slowly increase until 75% and the motor will be stopped by MCU.
- At this point,while the level of water increase, LM35 will detect the dropped of temperature
- When the temperature drops below 75'C, the MCU will send signal to relay of heater to be switch on and heat gradually to reach at set point of 85'C and switch off.
- MCU will control both the heater and motor as per the set value that been set to prevent any damage to the heater or motor.
- LCD will display the reference reading and the actual reading of the temperature.

Table 1: Truth Table

Input Ports				Output Ports	
Tank Level			Temperature		
RD1	RD2	RD3	RA0	Motor	Heater
1	0	0	LOW	OFF	ON
1	1	0	NORMAL	OFF	OFF
0	1	1	NORMAL	OFF	OFF
0	0	1	HIGH	ON	OFF

2.3 Microcontrollers

PIC18F452 (Figure 1), has been used for this system. This microcontroller is used as the brain of the system. Total 40 pins are included PIC18F452 microcontroller. Widely used in engineering projects. This microcontroller has an 8-bit with 10 MIPS, followed by CMPS, and a FLASH-based microcontroller that has 34 Input/Output(I/O) pins out of 40 pin package. It is a dominant microcontroller with one 8-bit. Three 16-bit timers, I2C, 8-channel 10-bit analog-digital converters, USART peripherals, and SPI. It is a low power consumed microcontroller unit that consumes lesser than 0.2 uA standby current and 1.6mA normal current during 5V and 4 Mhz operations. It has other features such as Programming code protection, Power-on Reset (POR), Power-up Timer (PWRT), Oscillator Start-up timer with power saving sleep mode.

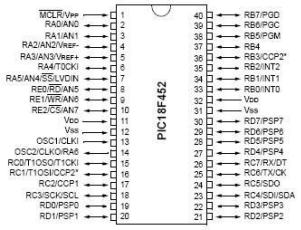

Figure 1 : PIC18f452 Microcontroller .

2.4 Software

Proteus is a program for the simulation of microprocessor, schematic capture and printed circuit board (PCB) design. Built by Labcenter Electronics. PROTEUS incorporates advanced schematic capture, mixed mode SPICE emulation, PCB layout and auto routing to construct a full electronic design system. PROTEUS product line also includes our groundbreaking VSM technology, which allows you to simulate a microcontroller-based interface, along with all the electronics surrounding it.

2.5 Programming Description

C is a programming language of operation. It was developed mainly as a system programming language for the writing of an operating system. The main features of the C-language include low-level access to memory, a simple collection of keywords, and a clean style, which make the C-language suitable for system programming such as operating system or compiler development. In this project, we use this C language to monitor the entire process of the PIC18F452 microcontroller by compiling and testing it using CCS compilers.

2.6 System Flow

This system works with sensing the temperature of the water inside the cascade tank to be proportional to the level of tank to be maintained. The temperature sensor will detect the temperature as an input from water inside the tank and send the signal to Microcontroller. Together with this, the level sensor will sense the level of water inside the tank as an input and send the signal to MCU. In microcontroller, both input will be checked and verified with the set value. If one of this value is out of range, the MCU will send signal to the responsible regulator for example temperature regulator or the water pump to regulate the input and re-send again the value to be verified with the set value. Once the value is verified and its in tolerance within the set value, the output will send the signal to maintain this value for continuously operation. (Figure 2).

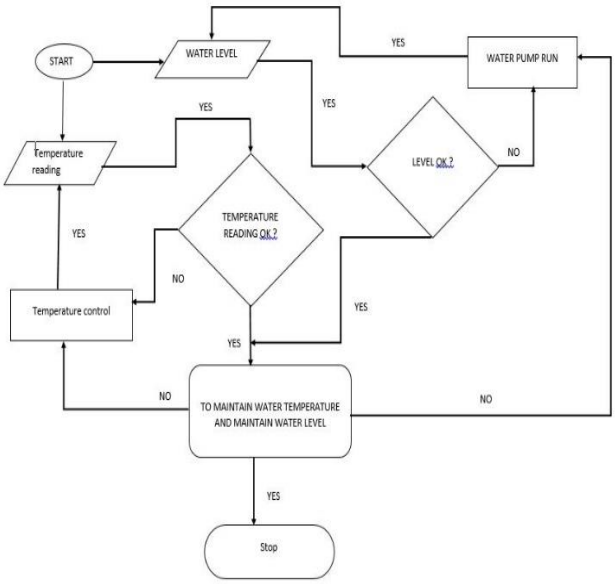

Figure 2 : Automated Boiler Water Cascade Tank Filling With Temperature Control.

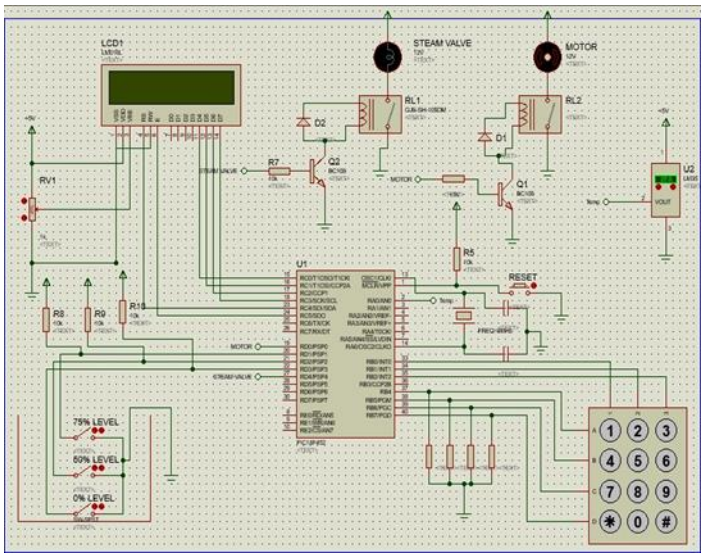

Figure 3 : The complete circuit.

This is the complete over view of the circuit which consists of Level Sensor, heater, motor, LCD display, LM35, PIC18F452 and keypad. All the system are connected to the microcontroller which consists of input and output. From this circuit, we can conclude there are 3 important sections which are water level, heater & motor, and also the keypad with LCD display.

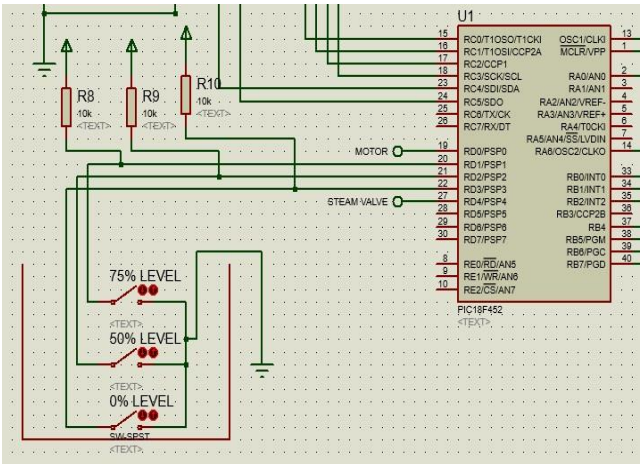

Figure 4 : Water level switches.

To detect the water level we have 3 input which consists of level switches at range of 0%, 50% and 75%. This switch will be activate to simulate the water level high or low in the tank to send the signal to the microcontroller and processed output signal.

2.7 Circuit

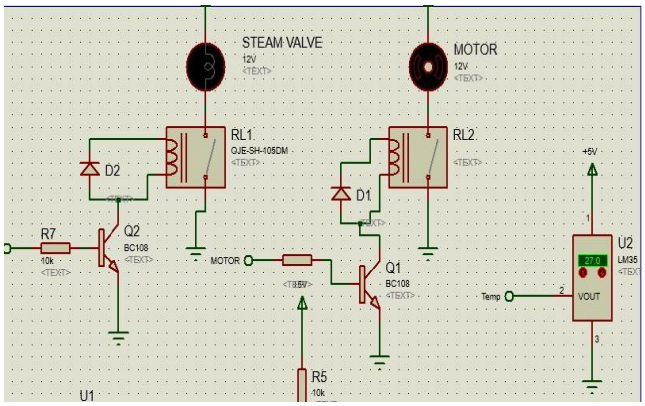

Figure 5 : Output signal to motor.

The output signal which comes from MCU will send signal to the motor and activated according to the requirement of the level. If level below 50% the motor start and when reach level 75%, the motor stop. At this point the LM35 (Temperature sensor) will detect the changes in temperature due to this increase of level and will switch on/off the heater.

3.0 CIRCUIT DESIGN SIMULATION

The circuit was designed in the software Proteus v7.6. Using this particular software, all the components of the circuit which is important were carefully selected from the software library and the connections were done by lines. The program has been compiled using CCS C compiler. The output, hex file of the program is loaded into PIC microcontroller using the PicKit2. Lastly, the simulation is tested for all the circumstances. The circuit used for simulation is given in Figure. 3. The connection to the microcontroller separated into several parts. To detect the water level we have 3 input which consists of level switches at range of 0%, 50% and 75%. The input RD1 is used for 75% , input RD2 is used for 50% , input RD3 is used for 0% of the microcontroller while the output signal which comes from MCU will send signal to the motor and activated according to the requirement of the level. RD0 is connected to the AC Motor (figure 5). The system were connected RC0 through RC5 for the display units (LEDs).

4.0 RECOMMENDATIONS & CONCLUSION

This system has reached its purpose by monitoring the level and temperature of the feed water via sensors and pumps. Automation achieved by introducing a MCU capable in controlling all the process required to maintain the boiler efficiency. This gives the ship crew ease of operation during unmanned condition of machinery space. Further improvement can be made by introducing salinity and oil detection sensors in monitoring the feed water quality, this will make the system to detect any fault or malfunction occurs to be detected easily. The system also can be implemented additional standby pump for redundancy, when a single operating pump malfunction. This will ensure the safety system and operation of the boiler is efficient and uninterruptable.

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