UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A NEW STRATEGY OF WATER TEMPERATURE CONTROL BASED ON TEMPERATURE RATE MONITORING

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical and Electronic Engineering Technology (Industrial Automation and Robotic) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electric and Electronic Engineering Technology (Industrial Automation and Robotic) with Honours. The member of the supervisory is as follow:

Signature: .....

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ABSTRAK

Cerek elektrik adalah peranti elektronik yang digunakan untuk menyediakan air mendidih, satu-satunya tugas yang boleh dilakukan oleh cerek elektrik. Oleh itu, cerek elektrik tidak dapat memanaskan air kepada suhu tertentu yang dikehendaki oleh pengguna. Selain itu, cerek elektrik tidak mempunyai sebarang pengantaramuka untuk menunjukkan suhu air. Oleh itu, untuk mengatasi semua masalah ini, satu peranti direka untuk suhu air. Pengawal suhu air dilakukan oleh algoritma baru yang dibangunkan berdasarkan kadar perubahan suhu air. Satu prototaip dibangunkan untuk menguji kecekapan algoritma. Peranti ini juga mempunyai antaramuka untuk menunjukkan suhu air. Analisa dibuat pada suhu 50°C, 65°C dan 85°C. Adalah didapati bahawa pengawal algoritma baru akan mengurangkan turun-naik suhu pada suhu yang dikehendaki, seterusnya menyediakan prestasi pengawal yang lebih baik berbanding pengawal turun naik minimum berbanding dengan pengawal hidup-mati. Prestasi kedua-dua pengawal adalah dibandingkan dengan kaedah grafik.

ABSTRACT

Electric kettle is an electronic device that used for provides boiled water, the only task that can perform by electric kettle. Thus, electric kettle is unable to boil water to a specific temperature that wanted by user. Besides, electric kettle does not have any interface to show temperature of water. So, to overcome all these problems, a device is designed with water temperature control. Water temperature controller perform by a new algorithm that derived from temperature rate response of water. A prototype is developed to test the efficiency of the algorithm. This device is also having an interface to show water temperature. The analysis is tested with set temperature 50ºC, 65ºC and 85ºC. It is found out that the new algorithm controller can reduce the temperature fluctuation along desired temperature, thus provide improve performance as compared to on-off controller. The performance of both controllers is compared in graphical method.

DEDICATION

To my beloved parents, they taught me there is nothing impossible as long as having a lot of passion and patient. A lot of appreciation and thankful to my supervisor, Dr. Mohd Badril Bin Nor Shah for his endless patience in helping and teaching me throughout the entire process. Lastly, I would like to thank all my friends who giving me support along the way of doing this thesis.

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^oC	-	Degree Celsius
θ_s	-	Water temperature once kettle is stopped
θ_r	-	Point where temperature starts to drop after kettle stopped for θ_s
θ_n	-	Point where kettle stopped for temperature rise to desired temperature
t_1	-	Time taken to reached θ_s
t_2	-	Time once the water temperature dropped from desired temperature
t_3	-	Time taken for heating process of second algorithm
m	-	Gradient of graph Temperature versus Time

LIST OF ABBREVIATIONS

PID	Proportional, Integral and Derivative
CPU	Central Processing Unit
RAM	Random Access Memory
ROM	Read Only Memory
PIC	Peripheral Interface Controller
RISC	Reduced Instruction Set Computer
PWM	Pulse Width Modulation
USB	Universal Serial Bus
SMC	Sliding Mode Controller
LCD	Liquid Crystal Display
SSR	Solid State Relay

CHAPTER 1

INTRODUCTION

1.1 Background

Water temperature controller is a device to control temperature at the desired level. This water temperature controller can be widely used in electric kettle. As electric kettle can only perform one purpose, that is boil water to 100^{o}C, a kettle also does not have any display devices to show current water temperature

Electric kettle is widely used nowadays but with this simple feature obviously it is not enough to satisfy user that wish to boil water to certain level of temperature. With the aid of water temperature controller, the disadvantages that having by electric kettle, that is cannot control the level of temperature and without temperature display can be overcomed.

Water temperature controller is a usually perform by using on-off or PID controller. However, on-of controller will induce large fluctuation of along desired temperature. PID controller can regulated water temperature precisely, but to tune PID gain to obtain such performance is not an easy task.

Therefore, in this work, a new algorithm of water temperature control will be developed for precise temperature regulation. The algorithm will perform the water temperature control based on temperature rate monitoring.

1.2 Problem Statement

Water is one of the most important things in daily life. Besides, water temperature also taking a big role as different level of water temperature has its own usage. For example, to

produce a coffee, the best water temperature is about 88^{o}C to 93^{o}C (Brown, 2014). For powdered milk, it is recommended to use water in temperature above 70^{o}C but not boiling (Llewellyn et al, 2018).

Due to electric kettle do not have the features of water temperature control and temperature display, we have to use expensive water heater is needed to buy so that it can fulfil the requirements. With the aid of the proposed device, user can also obtain the features that only exist in an expensive water heater with just using a normal electric kettle.

On-off controller is a controller that widely used nowadays (Sarkar, 2014). On-off controller also known as two position controller or bang bang controller as the output is just involved two outcomes, that is 'on' when it is not in desired set point and 'off' when it reached above or nearly desired set point (Sonal, 2015). This controller is having a significant disadvantage, that is this type of controller will induce a large fluctuation that shown in Figure 1.1.

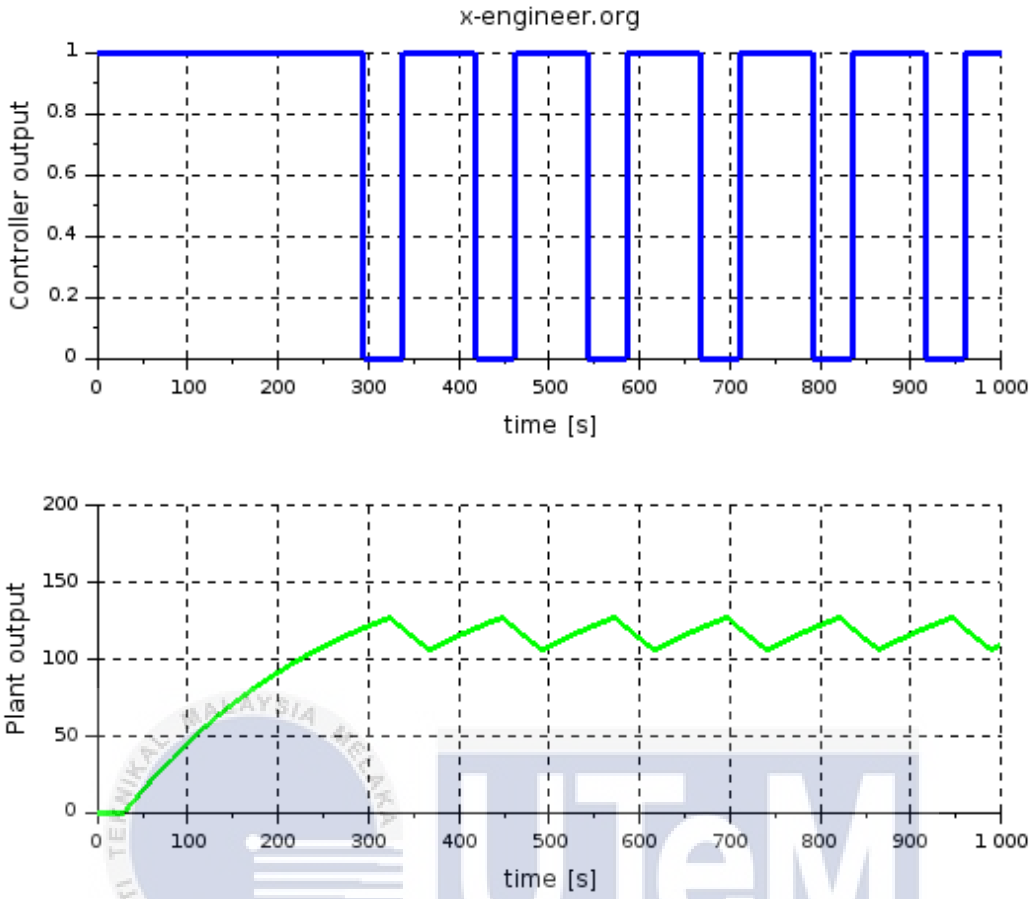

Figure 1.1 Output results for ON-OFF controller (Anonymous, (n.d.))

Nowadays, PID (Proportional-Integral-Derivative) controller is the most well-known controller that being used in industrial application. PID controller is used to improve the performance and stability of a control system. By setting in derivative mode to allow the changes in proportional gain, integral gain as well as speed of the controller response, the stability of system will be improved. By tuning PID controller, the desired water temperature that set by user can be achieved. However, tuning the PID gain is tedious work, and may require many sets of gains to cater different desired temperature control, as shown in work done by Nayan (2018).

1.3 Objective

The objectives of this project are:

a) To design a water temperature control device, complete with temperature display and control input.

b) To design a new algorithm controller to regulate water temperature at the level that desired by user.

1.4 Work Scope

This project concentrates about water temperature control that able to control desire level of temperature that set by user. There are few elements that need to complete in order the achieve the aim of this project:

a) Circuit Design

A microcontroller-based circuit is designed for this project combined with temperature sensor

b) Controller Design

A new controller will be designed based on water temperature rate to provide precise temperature control.

c) Hardware Prototype

A hardware is developed to show that the efficiency of the designed controller.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review is article to provide reader the historical and present background information that related to a project or research from time to time. The information can be obtained through some thesis, reference books, journal article as well as project papers. This information can be used as a guideline by provided a correct path to make the process easier in develop this project. The literature review about microcontroller, PID controller, temperature sensor and previous research about this project will be provide in this chapter.

2.2 Microcontroller

Microcontroller is a microprocessor with combination of memory and input/ output ports (Ying Bai, 2016). A microcontroller basically contains of Central Processing Unit (CPU), Random Access Memory (RAM), Read Only Memory (ROM), input/ output ports, timer and counter, interrupts control, analog to digital converter, digital to analog converter, serial interface ports and oscillatory circuits.