ENERGY AND ECONOMIC ASSESSMENT OF USING TEMPERATURE CONTROLLER IN AIR-CONDITIONED ROOM

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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DECLARATION

I hereby, declared this report entitled “Energy and Economic Assessment of Using Temperature Controller in Air-Conditioned Room” is the result of my own research except as cited in references.

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Date : 26 June 2019

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Bachelor Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

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(Dr. Silah Hayati Binti Kamsani)

ABSTRAK

Kini, isu tenaga adalah penting kerana merupakan salah satu penyebab peningkatan pemanasan global. Penggunaan tenaga yang tinggi menyebabkan pelepasan gas rumah hijau yang lebih dan membawa kesan kepada alam sekitar global. Sistem penghawa dingin merupakan faktor terbesar dalam penggunaan tenaga di Malaysia disebabkan kapasiti elektriknya yang tinggi dan masa penggunaan yang tidak terkawal. Oleh yang demikian, projek ini bertujuan untuk membangunkan satu pengawal suhu automatik untuk penyaman udara di dalam bilik berhawa dingin supaya dapat mengawal dan mengekalkan suhu persekitaran secara automatik. Tambahan pula, pengawal suhu automatik akan mengurangkan penggunaan tenaga dan juga mengurangkan kos elektrik untuk pengguna. Selain itu, pengawal suhu ini dijangkakan mampu digunakan dengan penghawa dingin yang asas untuk memiliki fungsi kawalan suhu yang automatik. Projek ini akan menggunakan komponen elektrik termasuk mikropengawal dan penderia suhu untuk mengesan suhu persekitaran sebelum mengawal suhu penghawa dingin melalui sistem tersebut. Selepas pembangunan pengawal suhu automatik, eksperimen dijalankan dan data suhu persekitaran dikumpulkan. Dalam hasil eksperimen, dengan menggunakan pengawal suhu automatik ini menunjukkan bahawa penggunaan tenaga untuk penghawa dingin lebih efisien iaitu sejumlah 21597.46 Wh berbanding dengan 25904.00 Wh dari pengawal suhu manual. Kemudiannya, bil elektrik dikira antara jenis pengawal suhu yang berlainan menunjukkan kos pengurangan sejumlah RM 0.94 sehari dengan penggunaan pengawal suhu automatik tanpa toleransi suhu. Hasilnya, penggunaan tenaga yang paling rendah dan perbelanjaan yang paling berpatutan adalah penyaman udara dengan penggunaan pengawal suhu automatik tanpa toleransi suhu ini. Kesimpulannya, satu alat kawalan suhu automatik yang menunjukkan suhu persekitaran dan suhu penghawa dingin akan dibangunkan, dan sistem ini dijangkakan berkeupayaan untuk mengesan suhu dan memaklumkan kawalan suhu penghawa dingin dengan cekap kepada pengguna.

ABSTRACT

Nowadays, the energy issue is important as it is one of the reasons for the increase in global warming. High energy consumption results in greater greenhouse gas emissions and impacts on the global environment. The air conditioning system is the biggest factor in energy consumption in Malaysia due to its high electrical capacity and uncontrolled usage time. Thus, this project aimed to develop an automatic temperature controller for air conditioning in the air-conditioned room in order to control and maintain the ambient temperature automatically. Furthermore, this automatic temperature controller reduced energy consumption and decreased the cost of electricity for consumers. In addition, this temperature controller is used with a basic air conditioner to have an automatic temperature control function. This project used electrical components including microcontroller and temperature sensor to detect the ambient temperature before controlling the air conditioning temperature through the system. After the development of the controller, the experiments are conducted, and the data of the ambient temperature are collected. The result in the experiment of the automatic temperature controller without temperature error showed that the energy consumes for the air conditioner is more efficiency which is 21597.46 Wh as opposed to 25904.00 Wh for the manual temperature controller. The electric bills are then calculated among the different types of the controller and results showed that there is a reduced cost of RM 0.94 per day with using the automatic temperature controller without temperature error. In results, this automatic temperature controller without temperature error is the lowest energy consumption and the most economic assessment among the experiment. In conclusion, an automatic temperature control device that displayed the ambient temperature and air conditioning temperature is developed, and this system can detect and control the air-conditioning temperature for energy efficiency benefit to the consumers.

DEDICATION

Only

my beloved father, Ang Yu Kuang

my appreciated mother, Ooi Beng Chew

my adored brother, Ang Han Cin

for giving me moral support, encouragement and also understandings

Thank You So Much

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I would like to thank everyone who had contributed to the successful completion of this project. I would like to express my gratitude to my research supervisor, Dr. Silah Hayati Binti Kamsani for her invaluable advice, guidance and her enormous patience throughout the development of the research.

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LIST OF ABBREVIATIONS

AC	-	Air Conditioner
CAD/CAM	-	Computer Aided Design / Computer Aided Manufacturing
CFC	-	Chlorofluorocarbons
EER	-	Energy Efficiency Error
GND	-	Ground
HFC	-	Hydrofluorocarbons
HTST	-	High-Temperature Short Time
IoT	-	Internet of Things
IR	-	Infrared
LED	-	Light-Emitting Diode
OLED	-	Organic Light-Emitting Diode
OTTV	-	Overall Thermal Transfer Value
PID	-	Proportional-Integral-Derivative controller
PLC	-	Programmable Logic Controller
RM	-	Ringgit Malaysia
RTC	-	Real Time Clock
SDA	-	Serial Data
SCL	-	Serial Clock
SD	-	Storage Device
TSOP	-	The Sound of Philadelphia
Vcc	-	Voltage Common Collector

LIST OF SYMBOLS

°C	-	Degree Celsius
°F	-	Fahrenheit
%	-	Percentage
Btu	-	British Thermal Units
GB	-	Gigabyte
kWh	-	Kilo-Watthours
W	-	Watt
Wh	-	Watt-Hours

CHAPTER 1
INTRODUCTION

1.1 Background of Study

A control is a process of changing the performance of a system to the desired output. This is because a system usually does not behave the way of the desired result. A control system is a combination of components that interact with each other with the environment to operate a system from an input to the desired output. For a good control system, the stability of the system is important. The output signal must be bounded if the input signal is bounded. The system is a stable system if the input is zero, the output also is zero (MarinerDesk, 2017).

Control methods can differentiate between two modes which are manual control and automatic control as shown in Figure 1.1 (City University London, 2007). Manual control is controlled by the process operator to make the decision and changes for a system to control the output. The output from manual control will not feedback to affect the control system. In contrast, an automatic control is a system that controlled and performed correction for disturbance automatically without the attendance of process operator but process supervisor only. The output from the automatic control will feedback to the control system and adjust the output automatically (Weise, 2014).

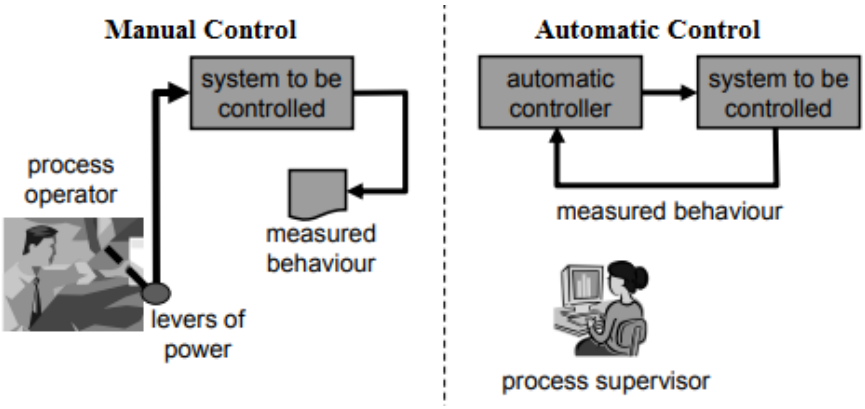

Figure 1.1: Comparison of manual and automatic control.

For example, driving a car is a manual control by a human. A driver steers a car to keep the car traveling in the lane on the road. When the driver turns the steering wheel, the direction of the car will change. The driver controls the steering wheel which is act as an input for the car system to control the output of the car system that will change the direction of the car (Suryadi and Widodo, 2007).

For this study, an example for the automatic controller had found which is the automatic cloth retriever system. For a working couple, they have no time to wait for the clothes dried before or after work, then the clothes are dried through from the morning until night. However, when the weather changes to rainy days, they will be facing the problem to lift the clothes. Hence, with the innovation of this system, they don't have to rush back home and keep the clothes or leaving the clothes under the rain. The automatic controller will retrieve-in and retrieve-out the clothes when detecting the climate change (Cutinha *et al.*, 2016).

For instance, automatic control such as machine vision is widely used in the industrial field such as automotive, electronics, food and beverage. The combination of software and hardware in the system perform high reliability, high mechanical and acceptable accuracy to determine the defect of a product. The machine vision is using the camera to capture and processing of images to replace human vision. The inspection system will allow the good product to pass through the level but not for the defected product. Since, the machine vision is the automated extraction of information of the product and suited to repetitive inspection task, hence it can work continuously to inspect hundreds or thousands of parts per minute (Cognex, 2016).

To sum up, the automatic controller that invented nowadays using intelligent and technology is replacing the manual task done by a human. This is not only saving time but also increasing the standard level of a human's daily life without affecting the environment and the ecosystem.

1.2 Problem Statement

Temperature control is a system that purposed for maintaining the ambient temperature and filter the air in an area at a certain range. This process commonly used in homes and especially in an industry that for certain areas such as clean rooms and research laboratories to provide fresh air and achieve the desired temperature to work successfully. In areas of the server rooms that have electronic activities and production plants that have machinery, are also need the temperature control to avoid the rise and fall of the temperature which would accelerate the wearing out of the system (Ogu, 2011). The used of the air conditioners give the benefit to control the comfortable temperature but at the same time, uncontrolled use of it will affect a human's daily life.

According to the survey of the national census Malaysia in 2000, the results concluded that in Malaysia, the total number of households with air conditioning has increased dramatically from 229,000 units in 1990 which is 6.5% to 775,000 units in 2000 which is 16.2% (Kubota *et al.*, 2011). The major factor that increases the electricity consumption in Malaysia is the using of air conditioners which occupy 50% of the total electricity as shown in Figure 1.2 (Fu E., 2012).

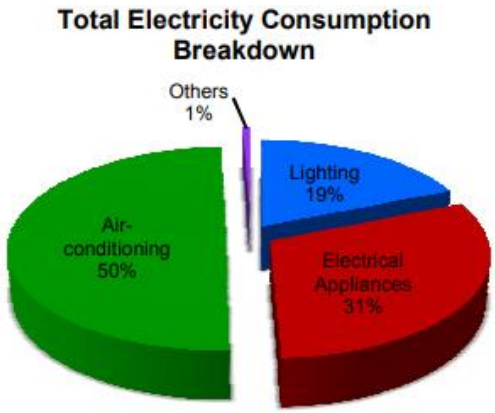

Figure 1.2: Total electricity consumption breakdown.

Besides that, the manually control temperature of the air conditioner is common in the market. It will function with the low temperature for a long time until the temperature adjusted by the users. Even the ambient temperature already achieved a low temperature, the air conditioner still works with the temperature set. In result, this will increase the power consumption of the air conditioner (Raj, 2017).

Other than that, during the operation of the air conditioner, the chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs) are emitted into the atmosphere. The Figure 1.3 (EPA *et al.*, 2016) shows that China is the top among the 5 countries in emitting the HFCs while the following countries are United States, South Korea, Russia and Japan. This day, the demand for the air conditioner is rising and causes the emission of the HFCs will grow continuously. The releasing of the HFCs directly affect the depletion of the ozone layer that protects the earth. The ultra-violet from the sun radiates to the earth affect human's health and environmental ((MACRA), 2013).

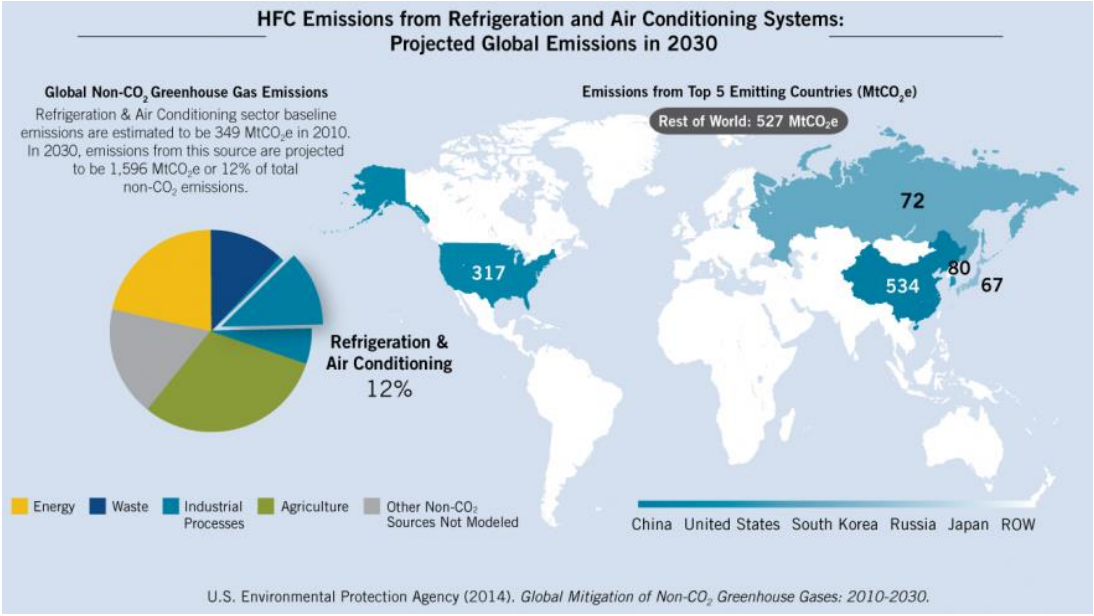

Figure 1.3: HFC Emissions from Refrigeration and Air Conditioning Systems.

To conclude, the main problems caused by the air conditioner are mentioned above. The uncontrolled use of the air conditioner by consumers will indirectly affect the environment and the nature of the earth. Therefore, in this report, the automatic temperature controller of the air conditioner is developed to detect the ambient temperature and feedback the signal to adjust the temperature of the air conditioner. So that the energy power can be reduced and the manual task by a human to control the temperature can be replaced.

1.3 Objective

The objectives of this report are as follows:

i. To develop an automatic temperature controller for the air conditioner.

ii. To minimize the energy consumption of the air conditioner.

iii. To maintain the ambient temperature by using the automatic temperature controller.

1.4 Scope

An automatic controller can be widely used by the consumers either in the company, factory or household. However, the controller will have its own limitation to function well under some condition.

This report mainly focuses on the split type air conditioner which has its own IR receiver to allow the setting of the temperature. The IR blaster in the circuit will transmit the signal to the IR receiver of the air conditioner by using the programming code in the microcontroller. Without the IR receiver like a central air conditioner, the air conditioner will not receive the signal that transmits from the IR blaster after detection.

Next, the IR blaster is an important component to transmit the signal to the receiver. The limitation of the IR blaster will only function within the range of 5-6 meters. As each of the room air conditioners will have its own signal receiver, the room air conditioner should be used rather than the central air conditioner. The distance should not be too far between the controller and IR receiver, the poor signal from the IR blaster will not reach the receiver and hence it will not have any changes to the temperature.

Besides that, this automatic controller should be developed in the close area rather than in the open area. The close area such as the bedroom, lecture room and the clean room in the industry are suitable to develop this automatic temperature controller due to the ambient temperature that will maintain in that area. If in the open area, the temperature sensor used will sense the temperature, but it will hard to achieve the desired temperature setting by the coding due to the loss of the temperature.

Hence, to develop an automatic temperature controller, a split type air conditioner with its IR receiver and the temperature sensor should be used and will conduct in the close area for better and accurate results.

1.5 Significant of Study

The significant study for this project is to study the importance of automatic control. Nowadays, it is common for consumers to set the temperature of the air conditioner manually by remote control. This project works to innovate using the knowledge of the technology and electrical with the aids of the microcontroller, sensor and IR blaster that connected in a circuit to replace the manual adjustment of the temperature.

In this project, the advantages and disadvantages of the automatic controller need to study to develop an effective and smart controller for the air conditioner. The purpose of this automatic controller is to adjust the temperature automatically after detecting the ambient temperature and hence, save the power used by the air conditioner. The control used of the air conditioner by this method will reduce the release of the greenhouse gases that harm the ozone layer.

However, there is some difficulty to develop the controller. The controller is quite complex and challenging to connect the electrical components with the sensor and the IR blaster. The understanding of the programming code also important to carry out the system successfully. The basic study of the microcontroller and the sensor are important to learn in this project to set the range of the sensitivity and control the system effectively.

1.6 Organization of the Report

For an introduction in Chapter 1, the background of the automatic controller is introduced using the concept of the loop system. There are few examples shown to prove the importance of the automatic controller. This chapter discusses the problems of uncontrol used of the air conditioner that faced by a human being and the objective to develop an automatic temperature controller. The scopes that limit the controller and that advanced study for the project are also discussed to understand the control system.