UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF HVAC VIRTUAL LABORATORY (HV-LAB); RECIRCULATION AIR CONDITIONING SYSTEM TRAINING UNIT USING MATLAB/SIMULINK SOFTWARE

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Refrigeration and Air-Conditioning Systems) with Honours.

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FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

2019

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Development of HVAC Virtual Laboratory (HV-Lab); Recirculation Air Conditioning System Training Unit using MATLAB/Simulink Software**

SESI PENGAJIAN: **2019/20 Semester 1**

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of UTeM as a partial fulfillment of the requirements for the Bachelor of Mechanical Engineering Technology (Refrigeration and Air-Conditioning Systems) with Honours. The member of the supervisory is as follow:

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ABSTRACT

Laboratory-based play a crucial assessment to institution of higher learning especially engineering technology programme. Simulated laboratories changing the nature of laboratory activities, and there is a long-running debate about the value of hands-on versus simulated laboratories. Hands-on advocates emphasize design skills, while simulated laboratories advocates focus on conceptual understanding. Interest in simulated laboratories versus hands-on has increased based on two factors; advance in technology and cost pressure. Educational goals of hands-on laboratories activities focus in conceptual understanding, professional skills, design skills and social skills, but not all the equipment give the professional skill to the students. Many of equipment has design and build to explain the conceptual understanding only, because of that this paper present Development of HVAC Virtual Laboratory (HV-Lab); Recirculation Air Conditioning System Training Unit (RACSTU) using MATLAB/Simulink. RACSTU located at Fundamental HVAC Laboratories, Department of Mechanical Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM). The HV-Lab system was design as the laboratory experimental setup. General equations were defined separately for each state of air properties in RACSTU then experimental were conducted based on fifteen (15) different cases. Using these equations and experimental data MATLAB/Simulink models for every state of air properties were created. The MATLAB/Simulink models were combined and verified with experimental results. The simulation results show that the experimental results are compatible with experimental results for each state.

ABSTRAK

Berasaskan makmal merupakan penilaian penting kepada institusi pengajian tinggi terutama program teknologi kejuruteraan. Makmal simulasi mengubah sifat aktiviti makmal, dan terdapat perdebatan yang panjang mengenai nilai pembelajaran secara langsung berbanding dengan menggunakan simulasi. Pembelajaran secara langsung menyokong menekankan kemahiran reka bentuk, manakala makmal simulasi menyokong fokus pada pemahaman konsep. Penarikan dalam makmal simulasi berbanding pembelajaran secara langsung telah meningkat berdasarkan dua faktor; kemajuan dalam teknologi dan tekanan kos. Matlamat pendidikan aktiviti makmal dengan pembelajaran secara langsung bergantung kepada pemahaman konsep, kemahiran profesional, kemahiran reka bentuk dan kemahiran sosial, tetapi tidak semua peralatan memberikan kemahiran profesional kepada pelajar. Banyak peralatan mempunyai reka bentuk dan dibina untuk menjelaskan pemahaman konsep sahaja, maka dengan inilah membentangkan Pembangunan Makmal Maya HVAC (HV-Lab); Unit Latihan Pengedaran Sistem Pendingin Udara (RACSTU) menggunakan MATLAB / Simulink. RACSTU terletak di Makmal Asas HVAC, Jabatan Teknologi Kejuruteraan Mekanikal, Universiti Teknikal Malaysia Melaka (UTeM). Sistem HV-Lab direka bentuk sebagai persediaan eksperimen makmal. Persamaan umum ditakrifkan secara berasingan untuk setiap keadaan udara pada RACSTU, kemudian eksperimen dilakukan berdasarkan lima belas (15) kes yang berbeza. Dengan menggunakan persamaan dan data eksperimen MATLAB / Simulink, model untuk setiap keadaan sifat udara dicipta. Model MATLAB / Simulink digabungkan dan disahkan dengan hasil eksperimen. Hasil percubaan menunjukkan bahawa keputusan simulasi serasi dengan hasil eksperimen untuk setiap keadaan.

DEDICATION

Alhamdulillah, be grateful to Allah S.W.T because keeps me level head up throughout this project. I would like to dedicated this project to my beloved family especially my mother Pn Nurida Bte Daem, who encourage me mentally, physically and spiritually to keep moving forward throughout this project and inspire me to break border of true limitation and reach the definite of purpose. In additional, I would like to give huge credit to my siblings through financial support and extra push of encouragement. And I would like to give such a special thanks to my supervisor Ts. Mohd Faez Bin Zainol who is guide and help me from early stage until complete this project. Thank you for everything.

ACKNOWLEDGEMENT

First and foremost, I would like to take this opportunity to express my special gratitude and sincere acknowledgement to my one and only supervisor Ts. Mohd Faez Bin Zainol for guiding me to complete this project. He had taught me a lot of knowledge that relate to this project with essential supervision, patience quality feedback, moral support and encouragement towards completion of this project.

I also would like to give my thanks who was give their generous expertise and precious time. Special thanks to my mother and brother for their seed motivation to complete this bachelor's degree. I would like give my deepest appreciation to Universiti Teknikal Malaysia Melaka (UTeM) for bringing out the true potential of me during my studies.

Finally, thanks for those that assisted me throughout this project especially to the lecturer and assistant engineer. Their persistence and willingness to provide good feedback made the completion of this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

BDP	-	Bachelor Degree Project
RACSTU	-	Recirculation Air Conditioning System Training Unit
GUI	-	Graphical User Interface
MATLAB	-	Matrix Laboratory
UTeM	-	Universiti Teknikal Malaysia Melaka
HVAC	-	Heating , Ventilating and Air Conditioning
AHU	-	Air Handling Unit
HV-Lab	-	HVAC Virtual Laboratory
IAQ	-	Indoor Air Quality
API	-	Application Program Interface
VLE	-	Virtual Laboratory for Electronic Engineering Education
HAMLab	-	Heat, Air and Moisture Laboratory

CHAPTER 1

INTRODUCTION

1.0 Introduction

In this chapter of introduction for Bachelor Degree Project (BDP) that consist of the problem statements, objectives and the scope of project. In this chapter provide the purpose of the report and the reason of research.

1.1 Problem Statement

Laboratories are the necessary part of any engineering course fields. From the laboratories, there is equipment or training unit that are provided for the students to learn and studies that are related with their course. But, despite of the advantages of laboratories, perhaps there is disadvantage from that such as cost of setting-up the equipment itself, maintenancing cost, and in fact of limited for student ratio in the class using the equipment. Regarding to this problem, the use of simulation tool were introduced that were interactive for teaching and learning process. For the lab equipment Recirculation Air Conditioning System Training Unit (RACSTU) is to change the state of entering air to a desired state by manually control the temperature and humidity of the specified space. The value of the temperature and humidity were controlled by indicator given on the equipment.. There is previous development simulation tool by using Graphical User Interface (GUI) and mathematical equations generated by using MATLAB/Simulink software. This research purposed were to continuous previous development simulation tool to conduct the experiment without using lab equipment.

1.2 Objectives

The objectives of this project have been identified and should be achieved to produce a successful simulation system for RACSTU. The objectives of this project are as follow :

i. To design Graphical User Interface (GUI) for the simulation tool software.
ii. To develop air properties mathematical models using MATLAB/Simulink for RACSTU.
iii. To measure air properties using RACSTU.
iv. To validate air properties mathematical models against an experimental value.

1.3 Scope of the Research

In producing a successful work, the scope is required to assist and set the directions of the project development. These scope should be identified and planned appropriately. The scope of this project are listed as follow :

i. Collect necessary data for the laboratories equipment to develop the mathematical equations.
ii. Build Graphical User Interface (GUI) for the simulation tool.
iii. Develop air properties mathematical models by using a MATLAB/Simulink.

1.4 Significance of the Study

This part will explains the scope of the research which also provide the limitation of the research. Based on the objectives, this project will be operated by using the MATLAB/Simulink software. The parameter is design to find the enthalpy and humidity ratio in the various state of the temperature and humidity. There is also had various case that can be made in this study such as cooling process, humidifying process, heating process and others. All the detail about the cases were described at methodology. This project also to observe the comparison data between experimental and by using software.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, there is consists of some of the topics from the journals, web pages, the research paper and also from the HVAC books such as Thermodynamics. This chapter also provide a few topics that have relation to the topic of the studies.

2.1 Air Conditioning System

Air conditioning system is define as treatment of air in order to maintain the temperature, moisture content (humidity),and movement of air in the enclosed space to achieve human comfort level or for industrial process that involves with air conditioning process (SystemAir, 2007).In the air conditioning process involves with four basic component which is compressor, condenser, expansion valve and also evaporator. Figure 2.1 show the basic cycle of refrigeration system.

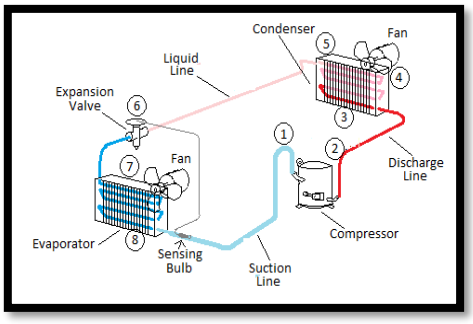

Figure 2.1 : Basic Cycle of Refrigeration System ("Basic Refrigeration Cycle", n.d.)

2.1.1 Laboratory Equipment Recirculation Air Conditioning System

The laboratory equipment of recirculation Air Conditioning system is used as training unit for students as well technical staff in investigated the study of properties of air in the Air conditioning system (Koçyiğit & Şahin, 2017). In this laboratory equipment, it consists of four basic equipment of Air Conditioning system which is compressor, condenser, expansion valve and the evaporator. The laboratory equipment used a ventilating system that consists of part such as evaporator(cooling coil), heater, humidifier, and fan. The cycle of the air is start from the outdoor (fresh air) and supply through cooling coil and performed the cooling and dehumidifying process. The air also pass through the humidifier to humidify the air before it go through the heater for the reheating process. By usage of fan, the air can be blow to the outdoor or by closing the damper in the system, it can recirculate back. As mention before, in this laboratory equipment, basically the process involves is psychrometric process which is cooling, heating, humidifying and also dehumidifying process (Koçyiğit & Şahin, 2017).

Figure 2.2 : Recirculation Air Conditioning Equipment

2.2 Similar Equipment in Actual Condition

Air handling units used as circulation unit which is used to cooled the air by a few process which is involves of heating, cooling, humidifying and dehumidifying functions. Up until the 1970's air handling units were determined to provide comfort temperature or suitable humidity level in the area (SystemAir, 2007). Air handling unit used in the building that distributed the air by using ducting or ventilating system. Figure 2.3 show the schematic diagram of air handling units (AHU).

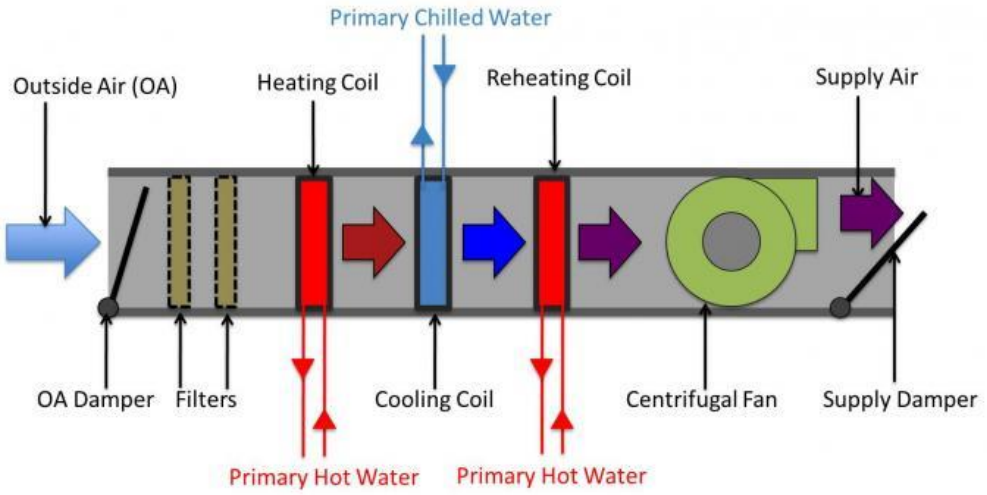

Figure 2.3 : Air Handling Unit

The general purpose of air handling units is treating the air by circulate the air to achieved the thermal comfort situation. For the laboratory equipment, it has similarity design but used in small scale for the study purpose. There is various of situation or problem that can be used to achieved the actual situation. Such as, some of ventilating system application does not recirculate back the air such as chemical laboratory, medical operation theatre room and the other. This is to prevent the fumes or small particles and bacteria to circulate back into the space. It will cause of dangerous and harm for occupants if the bacteria or bad fumes circulate back into the space. It can be achieved by control the damper. Altough some of application of air handling unit use separate unit to achieve different requirements.

2.2.1 Component in Air Circulation Unit

From the process of heating, cooling, humidifying and dehumidifying process in the air handling units, there is consist of few component which is heating coil, cooling coil, humidifiers, dehumidifiers and others. Each component has their own function in treatment of air in the air handling units.

i. Cooling Coils

The purpose of cooling coil is to cool the air and also had dehumidify process of air, Cooling coils in the air handling unit has cold water that have been cool by a refrigerant in the evaporator. Cooling coil consists of cooper tube or aluminium tube and fin. Figure 2.4 show the cooling coils. But for the laboratory equipment of recirculation air, it use only evaporator and refrigerant cycle and not used water as medium of heat transfer.

Figure 2.4 : Cooling Coil

ii. Heating coil

The purpose of heating coil is to increase the temperature or dehumidify the air to bringing up the set point of thermal comfort. Figure 2.5 show the example of heating coil that contain of hot water. There is similar equipment that contain is laboratory equipment but use heater plate by apply the heat sources to the plate.

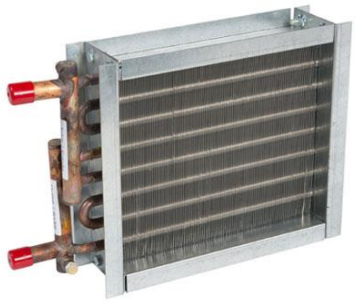

Figure 2.5 : Heating Coil

iii. Fan

In the air handling unit, there is fan that drive by a fan motor for the purpose of move the air and supply the air through ducting system. Some of fan speed are static and some of them offer varies set of speed. Figure 2.6 show the normal centrifugal fan. In the equipment of recirculation air, it use axial and propeller fan and it has fix speed of velocity.

Figure 2.6 : Fan

iv. Humidifier

General purpose of humidifier is to increase the moisture content in the air and prevent of dryness situation. Humidifier also prevents from uncomfortable air quality. Figure 2.7 show example of humidifier in air handling unit. For the recirculate air laboratory equipment, it only use of water and generate the same function as humidifier by apply the heat to the tank of water.

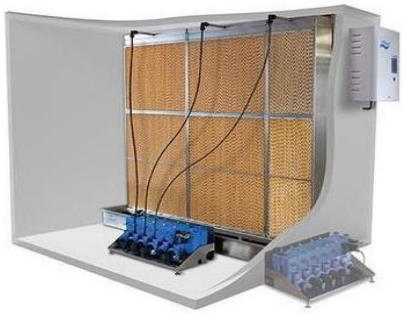

Figure 2.7 : Humidifier

2.3 Psychrometric Air Conditioning Process

In the recirculation air conditioning process, the moist air is treated and then supplied to the enclosed space. The treatment of moist air involve the process of heat and mass transfer between the moist air and the cooling coils (evaporator). There is also other equipment that affected the changes of properties air such as heater and humidifier. The common process include of sensible cooling and heating process, dehumidification process and also humidification process by adding the water vapour to the air. The different stages of air properties can be determined in the psychrometric charts. Figure 2.8 show the psychrometric chart.

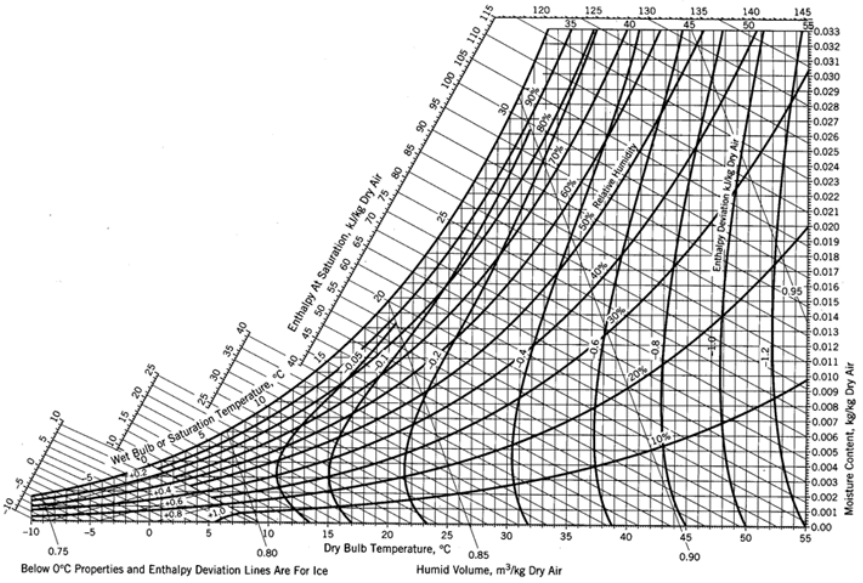

Figure 2.8 : Psychrometric Chart

2.3.1 Uses of Psychrometric Chart

The psychrometric chart explains that by raising the surface temperature or by lowering the moisture content of the air or employ some combination of both can avoid surface condensation. A psychrometric chart also helps in calculating and analyzing the work and energy transfer of various air-conditioning processes.

i. Cooling and Dehumidifying

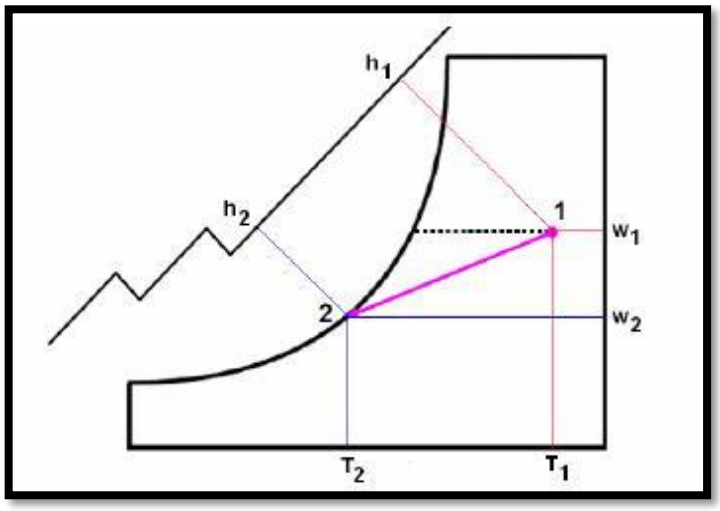

Figure 2.9 : Cooling and dehumidifying(Bhatia, n.d.)

On psychrometric chart, this process is represented as line sloping downward and to the left. This process is assumed to occur as simple cooling first and then condensation.