I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the Bachelor of Mechanical Engineering (Thermal-Fluids)

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Date : 17TH APRIL 2007

ANALYSIS AND DUCT SIMULATION USING AIR CONDITIONING LABORATORY UNIT

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A report submitted in partial fulfillment of the requirement for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids)

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I declare that this report entitled "ANALYSIS AND DUCT SIMULATION USING AIR CONDITIONING LABORATORY UNIT" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	: ....
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ABSTRACT

This project (PSM) is carried out with the purpose to analysis and do duct simulation, by air conditioning laboratory unit. The objective of this study is to conduct experiment, develop simulation of air flow and compare the result between experiment and simulation model. The basic component air conditioning is consist four part, which called compressor, condenser, expansion valve and evaporator. The simulation of duct circulation will be use simulation CFX software. This simulation showed air flow through duct (velocity), pressure and temperature contour were performed base on circulation before and after chamber. Experiment conducted is divided to three parts; humidification, dehumidification and comfort temperature. Psychrometric chart is used to calculate the properties of moist air for each process. For experiment part comfort temperature result is prefer to compare with simulation result. The analysis conducted from both results will perceive.

ABSTRAK

Projek (PSM) ini dijalankan adalah bertujuan untuk menganalisa dan membuat simulasi saluran dengan menggunakan unit penghawa dingin yang terdapat di UTeM. Objektif bagi projek ini adalah untuk mengendalikan eksperimen, membangunkan simulasi saluran aliran udara dan membandingkan keputusan antara eksperimen dengan model simulasi saluran. Komponen asas bagi penghawa dingin terdiri daripada empat bahagian, iaitu pemampat, pemeluwapan, injap pengembang dan penyejat. Simulasi saluran dibangunkan dengan mengguna perisian CFX. Simulasi yang dibangunkan akan menunjukkan pergerakan udara (halaju), tekanan dan suhu kontur daripada sebelum dan selepas peredaran dalam kebuk iklim. Ujikaji yang dijalankan terbahagi kepada tiga bahagian, iaitu; perlembapan, penyahlembapan, dan suhu selesa. Carta psikrometrik digunakan untuk mengira kandungan kelembapan dalam udara bagi setiap bahagian ujikaji yang dijalankan. Bagi keputusan ujikaji suhu selesa, perbandingan akan dilakukan dengan keputusan simulasi. Analisis kedua-dua kaedah akan di kaji.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

LIST OF SYMBOL

SYMBOL	DEFINITION
RH	Relative humidity
Ω	Humidity ratio
h	Enthalpy
υ_D	Specific volume
Z	Duct Differential Pressure
Q_r	Heater power
m_a	Air mass flow rate
$C_{p\ air}$	Specific heat of air
SFEE	Steady Flow Energy Equation
m_w	Conservation of mass,
Q_B	Boiler total power input,
h_w	Boiler feed water,
h_g	Enthalpy of the water vapor,
D	Dry bulb temperature
W	Wet bulb temperature
VF	Fan supply voltage

CHAPTER 1

INTRODUCTION

1.0 Background

Air conditioning is mechanical process for controlling the humidity, temperature, cleanliness, and circulation of air in buildings and rooms. Indoor air is conditioned and regulated to maintain the temperature-humidity ratio that is most comfortable and healthful. In the process, dust, soot, and pollen are filtered out, and the air may be sterilized, as is sometimes done in hospitals and public places.

Refrigeration is the process removing heat from an enclosed space or from a substance and rejecting it for the lowering the temperature of the enclosed space or substance and then maintaining that lower temperature.

Most air-conditioning units operate by ducting air across the colder, heat-absorbing side of a refrigeration apparatus and directing it back into the air-conditioned space. The refrigeration apparatus is controlled by some form of thermostat. Air conditioning laboratory unit is used to demonstrate and evaluate energy and mass balances in most of the processes found in practical air conditioning plant.

1.1 Objective of the research

The objectives of this study are:

a) To observations involving humidification, dehumidification and energy transfer using the available air-conditioning laboratory unit.
b) To develop a simulation model of duct circulation by using CFX simulation software.
c) Comparing the result experiment and simulation model.

1.2 Problem statement

As we know, human beings have an inherent weakness-they want to feel comfortable. They want to live in an environment that is neither hot nor cold, neither humid nor dry. However, comfort does not come easily since the desires of the human body and the weather usually are not quite compatible.

The comfort of the human body depends primarily on three factors: the (dry bulb) temperature, relative humidity, and air motion. The temperature of the environment is the single most important index of comfort. Most people feel comfortable when the environment temperature is between 22 and 27°C (72 and 80°F) *'thermodynamics 4th edition page 675'*.

Now, Air Conditioning Laboratory Unit allow demonstrated and investigated systems to heat, cool, humidify, dehumidify, clean, and deodorize the air, in other words, *condition* the air to peoples' desire. Air conditioning systems are designed to *satisfy* the needs of the human; therefore, it is essential that we understand the thermodynamic aspect of the body. Then, also from experiment air conditioning laboratory unit, it allow to investigated and measured of all the thermodynamic process involved in the heating, cooling, humidification and dehumidification of air.

1.3 Scopes of the Study

The scopes of this study are:

a) To review and evaluate ventilation load calculations through air conditioner approach.
b) To conduct practical experimental involving humidification, dehumidification and energy transfer.
c) To develop airflow simulation inside duct.
d) To propose guidelines of procedures for experimental air conditioning laboratory unit based on the study.

1.4 Expected Outcomes

During project researching and analyzing, the expected outcomes value is:-

a) Energy transfer between parts of duct.
b) Specific heat capacity of air by any convenient steady flow process.
c) Comparison experimental data or results of calculation and simulation model.
d) Data and Calculation analyzed.

CHAPTER 2

THEORY

2.0 Introduction

The Hilton Air conditioning Laboratory Unit A660 allows the process governing air conditioning to be demonstrated and investigated. Then it allow student to investigate the measurement and calculation of all the thermodynamic processes involved in the heating, cooling, humidification and dehumidification of air. And it is optional extra components are a valuable teaching aid for student in a wide range of courses from technician to graduate level.

2.1 Description of Air Conditioning Laboratory Unit

Air conditioning laboratory unit has been designed to demonstrate and to evaluate the energy transfer occurring in all the process which required. The unit is mounted on a mobile frame which houses the refrigeration unit and steam generator.

Local relative humidity is close to saturation, injection of steam can simply result in the duct running with water as the air cannot absorb more vapor than that required to saturate it at the given dry bulb temperature.

Addition of sensible heat as well as the steam raise the dry bulb temperature and take the air away from the saturated condition to a lower relative humidity. For demonstrate the dehumidification and mass transfer process, steam is inject before the evaporator/cooling coil. Then the relative humidity of incoming air can be raised close to saturation.

Data can be obtained;

a) The condition of the air before and after the various processes (via wet and dry bulb sensor)
b) The energy transfer rate at each heater, fan and refrigeration unit.
c) Air mass flow rate.
d) Pressure and temperature of refrigerant.

2.2 Component of Air-Conditioning Laboratory Unit

2.2.1 Compressor

Compressors are used to increase or decrease the mass of a gas in an enclosed system so that its pressure becomes significantly higher or lower than that of the outside air. The largest energy use of the air conditioner is the compressor.

2.2.2 Condenser

Air-cooled condensers in residential air conditioning (AC) systems commonly employ finned-tube construction to transfer heat from the refrigerant to the outdoor air. As hot refrigerant passes through the condenser coil, heat in the compressed refrigerant is transferred through the tubes to the attached fins. The air conditioner condenser fan is one energy using component of a residential air conditioning system.

2.2.3 Evaporator

It is the source of cooling as air passes through the furnace or air handler. They are constructed of aluminum finned copper tubing. All evaporator coils must have a drain pan to collect the water that condenses as the air flowing across the coil cools. The water can drain away by gravity or be pumped away.

2.2.4 Fan

It is required to cause the air movement and to make good the pressure drop due to the duct and system resistances.

2.2.5 Heat Exchangers

Heat exchangers usually are finned on the air side, are needed to increase or decrease the air temperature.

a) Heater – may use steam, hot water or electric as the heating medium.
b) Coolers – may be supplied with chilled water or may be of the direct expansion type which liquid refrigerant boils at a low temperature within the heat exchanger.

2.2.6 Humidifier

Humidifier is used to increase the moisture content of the air. Such as, water may be sprayed directly into the air, may be evaporated from the moist surface, or steam may be injected into the air.

2.2.7 Dehumidifier

Dehumidifier is used to reduce the moisture content of the air. It is usually achieved by cooling the air below its dew point so that surplus moisture is precipitated.

2.3 The Psychrometric Chart

The atmosphere is a mixture of air (oxygen and nitrogen) and water vapour. *Psychrometric* is the study of moist air and of the changes in its conditions. The psychrometric chart graphically represents the interrelation of air temperature and moisture content and is a basic design tool for building engineers and designers. Several terms must be explained before the charts can be fully appreciated.

a) Absolute humidity (AH) is the vapour content of air, given in grammes or kg of water vapour per kg of air, i.e. g/kg or kg/kg. It is also known as moisture content or humidity ratio. Air at a given temperature can support only a certain amount of moisture and no more. This is referred to as the saturation humidity.

b) Relative humidity (RH) is an expression of the moisture content of a given atmosphere as a percentage of the saturation humidity at the same temperature.

c) Wet-bulb temperature (WBT) is measured by a hygrometer or a sling psychrometric and is shown as sloping lines on the psychrometric chart. A status point on the psychrometric chart can be indicated by a pair of dry-bulb temperature (DBT) and WBT.

d) Specific volume (Spv) , in m^3/kg, is the reciprocal of density and is indicated by a set of slightly sloping lines on the psychrometric chart.

e) Enthalpy (H) is the heat content of unit mass of the atmosphere, in kJ/kg, relative to the heat content of 0 deg ?C dry air. It is indicated on the psychrometric chart by a third set of sloping lines, near to, but not quite the same as the web-bulb lines. In order to avoid confusion, there are no lines shown, but external scales are given on two sides.

f) Sensible heat is the heat content causing an increase in dry-bulb temperature. Latent heat is the heat content due to the presence of water vapour in the atmosphere. It is the heat which was required to evaporate the given amount of moisture.

Psychrometric processes Figure 2.1 shows any changes in the condition of the atmosphere can be represented by the movement of the state point on the psychrometric chart. Common processes include:

a) Sensible cooling / sensible heating
b) Cooling and dehumidification / heating and humidification
c) Humidification / dehumidification
d) Evaporative cooling / chemical dehydration

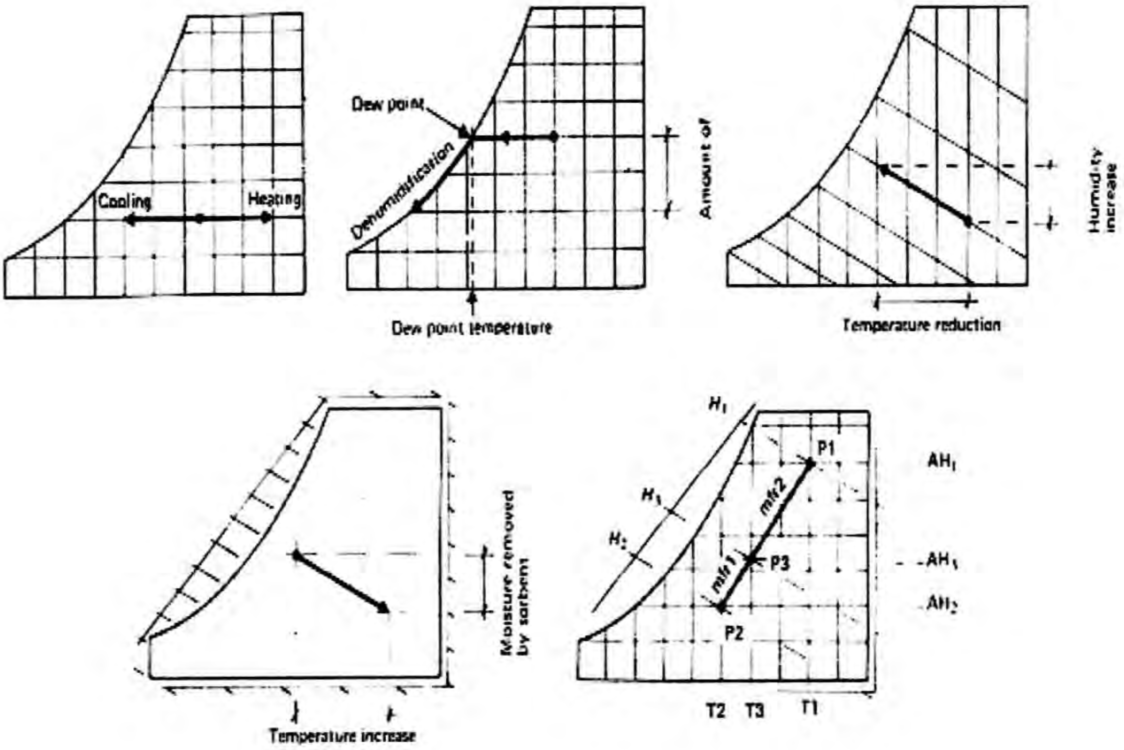

Figure 2.1 Psychrometric processes

2.4 Duct

The conditioned air (cooled and heating) from the air-conditioning equipment must be properly distributed to rooms or spaces to be conditioned in order to provide comfort conditions. When the conditioned air cannot be supplied directly from air conditioning equipment to the spaces to be conditioned, then the ducts are installed. The duct systems convey the conditioned air from the air conditioning equipment to the proper air distribution points or air supply outlets in the room and carry the return air from the room back to the air conditioning equipment for reconditioning and recirculation.

2.4.1 Classification of Ducts

The ducts may be classified such as;

a) Supply air duct – the duct which supplies the conditioned air from the air conditioning equipment to the space to be conditioned, is called supply air duct.
b) Return air duct – the duct which carries the recirculation air from the conditioned space back to the air conditioning equipment is called return air back.
c) Fresh air duct – the duct which carries the outside air is called fresh air duct.
d) Low pressure duct – when the static pressure in the duct is less than 50mm of water gauge, the duct is said to be a low pressure duct.
e) Medium pressure duct – when the static pressure in the duct is up to 150mm of water gauge, the duct said to be medium pressure duct.
f) High pressure duct – when the static pressure in the duct is from 150mm to 250mm of water gauge, the duct is said to be high pressure duct.
g) Low velocity duct – when the velocity of air in the duct is up to 600m/min, the duct is said to be low velocity duct.
h) High velocity duct – when the velocity of air in the duct is more than 600 m/min, the duct is said to be a high velocity duct.

2.4.2 Duct material

The ducts are usually made from galvanized iron sheet metal, aluminum sheet metal or black steel. The most commonly used duct material in air conditioning system is galvanized sheet metal, because the zinc coating of this metal prevents rusting and avoids the cost of painting.