UNIVERSITI TEKNIKAL MALAYSIA MELAKA

NEW DESIGN FOR CLOTHES DRYING APPLICATION BY USING GAS STOVE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Refrigeration and Air- Conditioning System) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Refrigeration and Air Conditioning System) (Hons.). The member of the supervisory is as follow:

……

(Dr. Ahmed Salem Saeed Bin Ghooth)

ABSTRAK

Proses pengeringan merupakan satu proses yang melibatkan pemindahan jisim yang terdiri daripada penyingkiran air atau larutan lain melalui proses penyejatan. Pengeringan pakaian merupakan sesuatu kerja yang mudah dan boleh dilakukan dimana-mana tempat yang tededah secara semulajadi kepada cahaya matahari. Walaubagaimanapun, pengeringan pakaian secara semulajadi menggunakan matahari sukar dilakukan bagi sesetengah tempat yang mengalami cuaca hujan bermusim dan bagi mereka yang tinggal di bangunan yang tinggi. Objektif projek ini adalah untuk menyiasat penggunaan almari pengering tulen bagi tujuan proses pengeringan pakaian dan untuk memepertimbangkan kos kesuluruhan projek, penggunaan tenaga dan membandingkan dengan pengering pakaian konvensional yang sedia ada di pasaran pada hari ini. Projek ini melibatkan proses merekabentuk projek, fabrikasi dan kerja eksperimen bagi penjaan haba di dalam almari pakaian. Struktur badan almari ini terdiri daripada logam Galvanized yang berukuran 1m × 0.5m × 2m dengan bantuan dapur gas bagi membekalkan haba ke dalam almari dan penimbang berat bagi menimbang berat pakaian sebelum dan selepas proses pengeringan. Ruang yang digunakan bagi menjalakan eksperimen adalah ruang yang tertutup bagi satu tempoh masa yang ditetapkan. Kadar pengeringan sesuatu pakaian dinilai melalui masa yang diambil untuk mengeringkan pakaian, suhu dan berat pakaian didalam almari metallic. Keputusan yang telah dicapai adalah bahawa model pengering tulen berjaya mengeringkan baju cotton dalam tempoh masa 20 minit dengan kadar aliran maksimum gas iaitu sebanyak 0.000096kg/s. Manakala, bagi seluar jeans pula hanya mengambil masa selama 1 jam 05 minit dengan kadar maksimum aliran gas. Data yang telah diperoleh daripada projek ini telah membuktikan bahawa projek ini sesuai digunakan bagi mengeringkan pakaian dalam masa yang singkat tanpa merosakkan bahan fabric pakaian tersebut, menjimatkan kos berbanding pengering konvensional yang terdapat pada hari ini dan baju yang dikeringkan boleh digunakan serta merta.

ABSTRACT

Drying is a mass transfer process consisting of the removal of water or another solvent by evaporation from solid, semi-solid or liquid. Clothes drying are an easy and daily work can be done in open places naturally where the sun is available. However, naturally drying is difficult to achieve by certain places where seasonal rains continuing profusely and for a high level commendation in high building. The objectives for the current project are to investigate the possibility of using original dryer cupboard for drying process and to consider the overall cost, energy consumption and compare with others conventional dryer that are available today. The current project consisting the designing process, fabrication and experimental work related to heat generation inside metallic cupboard. The structure of the current project consisting Galvanized metal which is 1m × 0.5m × 2m with aid of gas stove to generate heat inside the cupboard, and a weight balance to determine the weight of clothes before and after drying process. Area that are use to conduct the experiment is a closed space for a specified time period. A clothes drying rate is measured through the time it takes to dry the clothes, clothes weight and temperature inside metallic cupboard. The results achieved in this study have shown that the original dryer model can dry a cotton clothes in only 20 minutes with a maximum gas flow rate of 0.000096kg /s. Meanwhile, the jeans were only takes 1 hour 05 minutes with a maximum rate of gas flow. Data have been obtained from this project has shown that the project is suitable for drying clothes in a short time without damaging the fabric of the clothing, cost-effective compared to other conventional dryers that are available today and the clothes has been dried can be use immidiately.

DEDICATION

I dedicate my dissertation work to my beloved parents, Syed Ghazali Jalalulin Bin Syed Hassan and Roslinah Binti Mohd Idris and also to my beloved wife Siti Nur Shahirah Binti Abd Rahim.I am very lucky to have them as my family, who supports me through thick and thin till that make me able to stand where I am today.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND NOMENCLATURE

$\dot{m}$	-	Gas mass flow rate
ΔT air	-	Air temperature difference
°C	-	Celcius
Cp	-	Air constant pressure (1.6794kJ/kg)
Dr	-	Drying rate
g	-	Gram
Gc	-	Gas cost
HTF	-	Heat Transfer Fluid
IEA	-	International Energy Agency
kg	-	kilogram
kJ	-	kilojoule
kW	-	Kilowatt
Max	-	Maximum flow rate
Med	-	Medium flow rate
MEPS	-	Minimum Energy Performance Standards
min	-	Minutes
Min	-	Minimum flow rate

Q_{gas}	-	Energy input from gas
s	-	Second
T_{avg}	-	Average air temperature
T_i	-	Initial temperature
W	-	Watt
W_i	-	Initial weight (clothes, jeans and propane gas)
W_o	-	Final weight (clothes, jeans and propane gas)

CHAPTER 1
INTRODUCTION

In this chapter, introduction of the most important topics that involves background, problems statement, objectives, scope of the project is provided and the thesis organization of overall chapters is provided within the chapter.

1.1 Background

Drying is a mass transfer process consisting of the removal of water or another solvent by evaporation from solid, semi-solid or liquid. This process is often used as a final production step before selling or packaging products (http://en.wikipedia.org/wiki/Drying cited on 12 April 2015). There are two basic mechanisms involved in the drying process; the migration of moisture from the interior of an individual substance to the surface, and the evaporation of moisture from the surface to the surrounding air. The rate of drying is determined by the moisture content and the temperature of the substance, the (relative) humidity and the velocity of the air in contact with the substance. A source of heat and an agent to remove the vapour produced by the process are often involved. Desiccant may be used for extreme drying application to absorb moisture. In past few decades there a several type of clothes dryer generally used in residential which is tumbler dryer, microwave dryer and ventless dryer. The ventless dryer can be divided into six type which is spin dryer, condenser dryer, heat pump dryer, mechanical steam compression dryer, and convectant drying and solar clothes dryer. (http://en.wikipedia.org/wiki/Clothes_dryer cited on 1 may 2015).

Clothes drying are an easy and daily work can be done in open places naturally where the sun is available but it consumes more time for clothes to dry. In some areas where seasonal rains continuing profusely and for a high level commendation in high building are not suitable for naturally drying. Drying of clothes implies the removal of the water from the clothes. In clothes drying process, drying is accomplished by vaporizing the water that is contained at the clothes, and to do this latent heat of vaporization is supplied. There are, thus, two important process controlling factors that enter into the unit operation of drying which is; transfer of heat to provide the necessary latent heat of vaporization and movement of heat through the clothes and then away from it to effect separation of water from the clothes (http://www.nzifst.org. nz/unitoperations/ drying1.htm cited on 1 may 2015).

Conventional tumbler dryer has been used for 30-40 years ago by using electricity as a source of energy to generate a heat to dry the clothes inside a drum. Limitations associated with conventional tumbler dryer encourage researchers to investigate new ideas that enable to overcome this dilemmas such as high cost, environmental effects (fossil fuel at power plant) and dangerous. The current project will consider as an alternative way which be able to provide same function without using electrical heater. The current project is done by conducting a designing process, fabricating and experimental work. The design are considered the heat generation inside a cupboard by setting up inside a closed space with some hole at the side of cupboard to allow air to force the heat rise. The cupboard are made up from 6 pieces of galvanized metal. Gas stove is apply to generate heat inside the cupboard to dry the clothes. The temperature, weight of the clothes before and after drying process, and time taken to dry the clothes will be recorded.

1.2 Problem Statements

Conventional tumbler dryer is associated with some limitations such as high energy consumption to generate heat and to run the system itself, environmental effect due to tumbler dryer is still rely on fossil fuel as internal combustion at power plant to generate an electricity and dangerous. Hence, it is always desirable to consider about

energy saving generating heat for the future with more safety. The current project is considered as an alternative solution, which is able to provide same function of drying process with avoiding using electrical heater. However the problem statement is to design a new application to perform the drying process by using gas stove.

1.3 Objectives

The study sets out to investigate the possibility of using original dryer model for drying process and to consider the economic analysis to compare with conventional dryer.

Specific objectives:

1. Design and develop the gas stove clothes dryer.
2. Measurement of temperature, clothes weight and record the time to dry a clothes and calculate the drying rate.
3. To establish economic analysis via comparing the cost of drying between the current original model and conventional laundry clothes dryer.

1.4 Scope

Consider the venue to implement this project are the important factor. Metal Fabrication Laboratory at (FTK) UTeM is used to design and fabricate the current project. Experimental work, is implemented at Air Distribution Laboratory (FTK), UTeM due to a lot of measuring parameters equipment are available. The area under consideration is to focus on energy consumption for original dryer model that will be used as an alternative way to dry the clothes. Besides, recording data related to drying process which is temperature, clothes weight and time taken for clothes to dry to calculate the drying rate and make an economic analysis.

1.5 Organization of the thesis

This report compromises of five chapters. Chapter 1 is the introduction of the project including the background, problem statements, objectives, and research limitations as well as work scope of the study. Chapter 2 is written to review the theories, experimental works and findings that have been done in the past research with respect to the current project. In chapter 3, the methodology used to achieve the objectives that have been set for this study will be explained clearly. Besides, all materials and equipment, procedures, and experimental work used for this study are described. In Chapter 4, the results and findings of the study are presented. The data of temperature collected in interval time and time taken for the drying process using the generated heat will be tabulated in graphs and figures. Discussions on the results are also provided in the same chapter. Chapter 5 summarizes the outcomes of this research according to the objectives. Conclusion will be made and some recommendations will be stated as suggestions for future research.

CHAPTER 2
LITERATURE REVIEW

In this chapter, some literature researches on previous studies which are in the line with the conducted current project are reviewed. The major sources of the gained information are from open-sourced published articles in books and journals and internet websites Some important information are presented in the chapter which include introduction of drying process, conventional clothes dryer, conventional electric drier system description, air flow, and related work for this studies.

2.1 Introduction of drying process

The process of removing either the water or water vapour from the solid material or another solvent is known as drying process (http://en.wikipedia.org/wiki/Drying cited on 12/04/2015). The overall drying process consist of three parts which is warm up period, first drying period and lastly the second drying period. The drying process of material or solvent begins with warm up period where the heat is supply to material and the moisture start to evaporate from the surface. After warm up process is done, the drying process will proceed to next period which is constant rate period of drying or also known as first drying period. During this period, the water contained in the material is evaporated due to the air flow by external diffusion. The drying rate of this period is depending on temperature, moisture content (humidity) and mass flow of air. The second period of drying process begins when the formation of moisture gradient inside the material is accomplished. During this period, the water contained inside the material is transferred to the surface by internal diffusion (http://uchi.vscht.cz/uploads

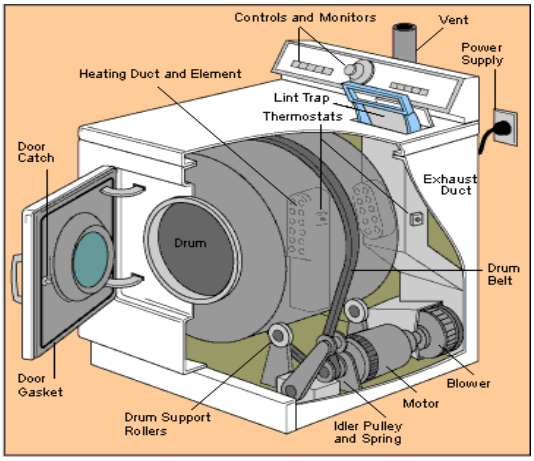
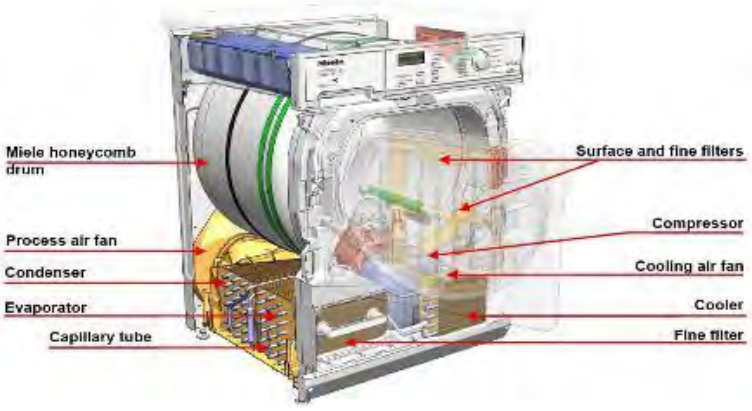
/pedagogika/labchi-en/lab.chi.s.eng.pdf, cited on 5/2015). Basically, there a three basic methods of drying are used today which is by exposed the material to the direct sunlight or also known as sun drying, hot air drying where the material are exposed to a blast of hot air and freeze drying change the phase of material directly from a solid state to gaseous state by placing the material below its triple point (www.nptel.ac.in/courses/103103027/pdf/mod4.pdf cited on 1 may 2015)

2.2 Conventional clothes dryer

Today, tumble dryers are frequently used in ordinary households to dry clothes. They require little space and they dry clothes rapidly independent of weather conditions. Electricity is the one of the fundamentals in designing air heating system. The traditional technology involves the use of electric heaters to warm up the air which operates the clothes drying process. However, high levels of electricity, which is the one disadvantage of using, tumble dryers. According to the International Energy Agency (2003) approximately 77 TW h (or 3.3% of the residential electricity consumption) were used in 2000 for the drying of textiles in 22 IEA member. Household tumble-dryers can be considered as insufficient devices, which are based on a sixty-year old technology. Their energy consumption has attracted attention due to the establishment of minimum energy-performance standards (MEPS) and various utility objectives to encourage consumers to use more efficient units. Tumbler dryers generally can be divided into two categories which is air vented dryers and condensing dryers. According to Bansal et al. (2001) they state that an open-cycle condensing dryer, with heat recovery, is more efficient than a standard air-vented dryer. This is because in an open cycle condensing dryer, the air stream coming from the drum is cooled and dehumidified inside an air to air heat exchanger where the external air is pre-heated. If no external ducting provided, this solution makes it possible to add less moisture to the room. Meanwhile, in air vented dryers, the drying process occurs when the air stream from the outside will be heated to the suitable temperature before entering the drum. Close-cycle condensing dryer consists of two heat exchanger which is first heat exchanger will heat the air stream coming from outside by using electric heaters. The purpose of second heat exchanger is to removes the moisture from the

clothes and then is cooled and dehumidified where the cooling fluid can be external air or tap water. Actually, the heat and mass transfer between the humid air and the tap water occurs by exposing the air stream to direct contact with water. The third type of dryer is equipped with a heat pump. According to J.E. Braun et al (2002) the air cycle heat pump dryer was found to be significantly more efficient than the traditional tumbler dryer. The cost if the dryer, however, is considerably higher than the cost of a traditional tumbler dryer. Conde M.R (1997) used a computer model in combination with experiments concluded, that the optimum rate of exhaust re-circulation was almost 79%, through tumbler-dryer modelling. Krokida and Bisharat (2004) reported that 25% and 100% could be recirculated by using a heat exchanger and a heat pump, respectively. Conde (1997) and D. Hekmat and W.J. Fisk (1984), state that the condensing tumbler dryer has an increased energy use compared with the venting tumbler dryer based on measurements which is computer modelling and experiment methods. M. Cochran et al. (2009) found a significant improvement in the energy efficiency of the condensing tumbler by incorporating surface tension elements instead of the traditional air-to-air heat exchanger.

The Figure 2.1 below shows a type of tumbler dryer that currently used in ordinary households to dry clothes

Tumbler dryer types	Diagram
Air vented dryer	 (http://www.nwu.ac.za/faculty-engineering-energy-saving-home-tumble-dryer cited on 16 may 2015)
Heat pump dryer	 (http://www.reuk.co.uk/Heat-Pump-Tumble-Dryer.htm cited on 16 may 2015)