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(Material and Structure)"

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DESIGN A FEASIBLE CLOTH DRIER UTILIZING DOMESTIC WASTE-HEAT FOR HOUSEHOLD APPLICATION

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“I hereby declared this report is mine except summary and each quotation that I have mentioned the resources”

Signature:…………………………

Author’s Name:……………………………..

Date:……………………………..

To my beloved family for their encouragement and support especially, and for their understanding in the way I am.

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ABSTRACT

This paper is discussing about an experimental study on effectiveness of exhausted heat from a spilt type air condition for domestic cloth drying propose as a solution of global warming. This study will focus on utilizing domestic waste heat for drying purpose. A cabinet has been design using Solid Work 2003 according to it's criteria and the materials were chosen carefully for drying propose as well as some important formula that had stated inside. The materials were chosen by using engineering software CES EduPack 2005. The combination of acrylic, aluminum and polyvinyl chloride (PVC) was the cabinet materials. The effectives were shown in every experiment. This experiment is done in March where it's always rain in the evening. Three experiment were carried out and using a towel as a specimen. Each experiment has different duration; 2, 3 and 4 hour to show it's potential of drying.

ABSTRAK

Kertas kerja ini membincangkan tentang kajian experimen ke atas keberkesanan pengunaan semula haba yang terbuang dari penyaman udara untuk pengering baju domestik sebagai satu cara untuk mengurangkan kesan terhadap rumah hijau. Kajian ini memfokuskan tentang mengunakan semula haba terbuang untuk kegunaan domestik. Sebuah kabinet telah dicipta dengan mengunakan Solid Work 2003 dan telah dihasilkan mengikut kriteria. Bahan-bahan untuk membuat kabinet telah dipilih dengan mengunakan CES EduPack 2005. Kombinasi acrylic, aluminum dan polyvinyl cloride (PVC) adalah bahan-bahan untuk membuat kabinet tersebut. Keberkesanan kabinet tersebut telah dibuktikan melalui beberapa siri eksperimen. Tiga eksperimen telah dilakukan di bulan Mac dimana selalu hujan pada sebelah petang. Menggunakan tuala sebagai spesimen, eksperimen telah dijalankan mengikut masa pengeringan; 2, 3 dan 4 jam untuk menunjukkan potensinya.

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C_p	specific heat capacity (kJ/kg K)
E_s	energy-saving rate (%)
k	drying rate (%)
m_a	rate of process air (kg/h)
m_e	rate of evaporated water (kg/h)
m_{pi}	rate of product-input to dryer (kg)
m_{po}	rate of product-out from dryer (kg)
Q	actual heat-transfer (kJ)
Q_H	heater capacity (kJ/h)
Q_{max}	maximum possible heat-transfer (kJ)
Q_R	heat of recuperator (kJ/h)
Q_T	total heat rate (kJ/h)
t	drying time (h)
T_a	ambient-air temperature (^{0}C)
T_{di}	dryer-inlet air temperature (^{0}C)
T_{do}	dryer-outlet air temperature (^{0}C)
T_e	exhaust-air temperature (^{0}C)
T_{fi}	recuperator-inlet air (fresh-air) temperature (^{0}C)
T_{fo}	recuperator-outlet air (fresh-air) temperature (^{0}C)
X_1	dryer-inlet air_s moisture-content (kg_w/kg_a)
X_2	dryer-outlet air_s moisture-content (kg_w/kg_a)
ΔX	difference of dryer inlet–outlet moisture content (kg_w/kg_a)
ΔT	difference between Tdo and Te (^{0}C)
ε	effectiveness of heat recuperator (%)
φ	ambient-air_s relative humidity (%)
C_p	specific heat (kJ/kg K)
m_a	mass flow-rate of dry air (kg/s)

M_{BD}	bone-dry mass of clothes (kg)
Q	heat-flow rate (kW)
T_m	mean temperature of the clothes (^0C)
X	moisture content of clothes
ω	specific humidity

Subscripts

a	air
cold	cold fluid
hot	hot fluid
max	maximum
min	minimum
w	water
a	air
BD	bone-dry mass
cl	clothes
D	drum
evap	evaporation
0	ambient
w	water

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CHAPTER I

INTRODUCTION

In large densely populated cities, residential buildings are usually high-rise blocks. In order to maintain an acceptable appearance of building façade, clothes drying using natural means by hanging clothes outside windows or a balcony may not be allowed. Increasingly, a clothes drying has become confined to indoors, either at the expense of consuming energy through the use of clothes dryers or by natural ventilation. Clothes drying indoors using natural ventilation, versus by an electrical or a gas clothes dryer, can take days, depending on textile type, weather conditions, and the location of a residential flat in a high-rise residential block (e.g., prevailing flat orientation and floor level). In places where air humidity is high (wet seasons or during rainy days), clothes drying indoors by natural ventilation can take a long time and still yield unsatisfactory results. In addition, drying clothes indoors by natural ventilation has an effect on the indoor thermal environment, as the moisture contained in wet clothes is transferred to internal ventilation during drying, by evaporation and diffusion. This additional excess moisture must be dealt with through either mechanical or natural ventilation means. Besides using cloth dryer and air condition leads to global warming.

Global warming is the increase in the average measured temperature of the Earth's near-surface air and oceans since the mid-20th century, and its projected continuation. This phenomenon is also because the average global air temperature near the Earth's surface increased 0.74 ± 0.18 °C (1.33 ± 0.32 °F) during the 100 years ending in 2005. The Intergovernmental Panel on Climate Change (IPCC) state that most of the observed increase in globally averaged temperatures since the mid-twentieth century is very likely due to the observed increase in anthropogenic (man-made) greenhouse gas concentrations via an enhanced greenhouse effect. Natural phenomena such as solar variation combined with volcanoes probably had a small warming effect from pre-industrial times to 1950 and a small cooling effect from 1950 onward.

Climate model projections summarized by the IPCC indicate that average global surface temperature will likely rise a further 1.1 to 6.4 °C (2.0 to 11.5 °F) during the twenty-first century. This range of values results from the use of differing scenarios of future greenhouse gas emissions as well as models with differing climate sensitivity. Although most studies focus on the period up to 2100, warming and sea level rise are expected to continue for more than a thousand years even if greenhouse gas levels are stabilized. The delay in reaching equilibrium is a result of the large heat capacity of the oceans.

Increasing global temperature is expected to cause sea levels to rise, an increase in the intensity of extreme weather events, and significant changes to the amount and pattern of precipitation, likely leading to an expanse of tropical areas and increased pace of desertification. Other expected effects of global warming include changes in agricultural yields, modifications of trade routes, glacier retreat, mass species extinctions and increases in the ranges of disease vectors.

Some of the disasters are sea level increasing, extreme weather, agricultural yields and most worst, species extinction. Therefore, we must avoid it before its getting worse. To avoid it, we must know the cause of the global warming.

The cause of global warming is divided by two, nature cause and man-made cause. Man-made causes probably do the most damage and the causes are burning fossil fuel, mining coal and oil or petroleum and also the human population that uses of air condition and air condition. We can save this world from disaster if we can reuse or at least reduce the dangerous element from “eating up” the ozone.

This is the main idea for this study of utilize waste heat from air condition that reuses the heat that been rejected to use for another activity. For this current study, it is to make the idea feasible of drying cloth using the heat exhausted from the air condition.

With using back the waste heat, it can make some benefits. For some example that relate to this study, RAC air condition is one of home applicant that we never turn off. Thus, its better we use the heat that exhausted to dry washed cloth over time rather let the waste heat being wasted. On the same time we can save time and also money rather buying cloth dryer that cost so much.

The concept of the RAC system for clothes drying had been pioneered by R. Tugrul Ogulata in 2004 and patented by Shiming Deng in 2004 with the wooden prototype but in this study focuses on an experimental study on the effectiveness of clothes drying using rejected heat (CDURH) with a split-type RAC which will make some improvisations based on mechanical formula hopefully to be a successful method.

1.1 Problem Statement

Almost all air condition release heat to surroundings air and take a small part to the process of global warming. The main idea of this study is to utilize the waste heat for reproduce energy to generate power for other home applicant, cloth dryer. By utilizing the waste heat, it is possible to save our only and the only one home, the earth.

1.2 Objective

To design a system that can utilize waste heat from an air condition to a feasible cloth drying apparatus for house hold application utilizing waste heat. Also, it is to analyze the performance or efficiency of the design.

1.3 Scope

This study include about utilize only domestic waste heat from an air condition. The most of all, it is about initial study for a feasible design of cost effective cloth dryer.

CHAPTER II

LITERATURE REVIEW

Drying is one of thousand activities that we done daily. The drying process were normally using sun ray to reduce the cloth humidity. But in the area is humid which is limited sun rays and restrict air flow, using a tumble dryer is the right choice (A. Ameen et. Al 2004). Another method is heat pump dryer which is not so well known to people.

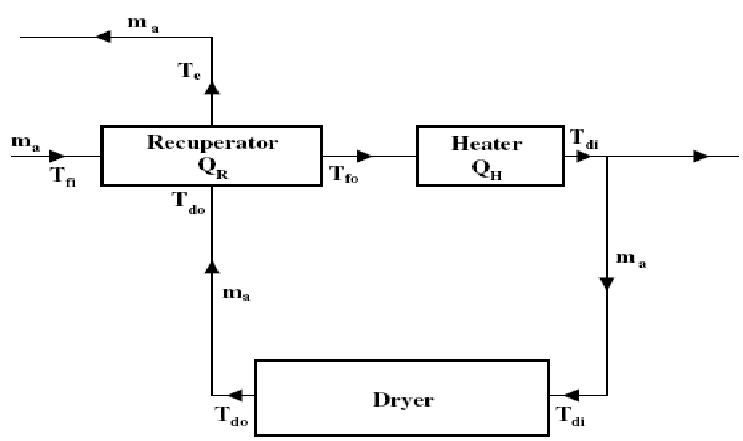

Fig 2.1: Diagram of a textile drying system with waste-heat recovery.
(Source: R. Tugrul Ogulata, 2004)

As for tumble dryer, that the most of the population in humid tropic used, has an energy issue that vary of each type of tumble dryer. An electrical or gass powered dryer is fast drying, but it is pollute and use more energy. (Ogulata R. Tugrul 2004). About 9%

of residential using electricity in the US is from cloth dryers. (V. Yadav et. Al 2007). Another type of tumble dryer is evaporative tumble dryer that generates hot air steam up to 50^{o}-$70^{o}C$ used to dry clothes and discharged into outdoors as air pollution and local heat.

To solve this problem, people try to use a heat pump tumble dryer which use waste heat to remove moister. For this kind of tumble dryer, there no are commercial efforts yet because it's under research. There are many designs that use different way. The following figure shows that a drying systems that studied by R.Tugral Ogulata 2004. The figure shows that the humid and dirty waste air is sent to heat exchanger. The fresh air from environment and the waste air were realized by heat transfer via pale type heat exchanger (cross flow) the waste air passes through the abutting channel. This make the fresh air temperature is raised and cooled waste air and sent to ambient environment. The temperature of the preheated fresh air is future raised in air heater. (R.Tugral Ogulata 2004)

To make a dryer design, we have to know a bit about a drying process. As Manuel R Conde reported in his report, he stated that a simple model of the drying process in the drum may be considered in order to demonstrate that the use of any fraction of humid air

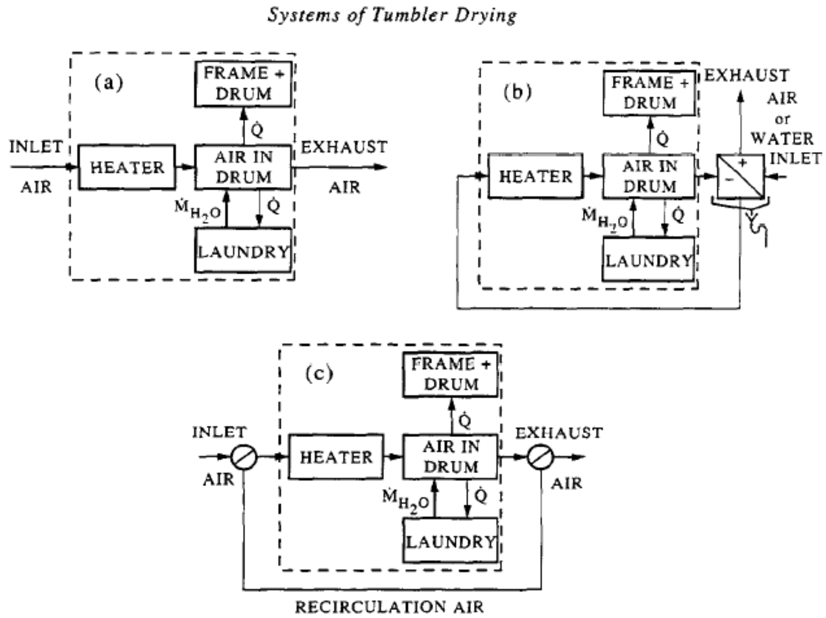

Fig 2.2: The various systems of air circulation currently used in tumbler dryers (S.S. Elsayeda, et al. 2006)

recirculation lowers the driving force for the evaporation of the water from the textile. This also applies to condensation tumblers as in Fig. 2(b), where the exhaust air is cooled by ambient air. (Manuel R Conde et. Al, 1997)

$$\left[\frac{\dot{M}_{da}}{M_L}\right] \times (\omega_{ao} - \omega_{ai}) = \left[\frac{A_L}{M_L}\right] \times \frac{[\beta]}{R_v \bar{T}_L} \times \left\{a(X, \bar{T}_L) \times p_s(\bar{T}_L) - p_{p,a}\right\} \tag{1}$$

$$\left[\frac{\dot{M}_{da}}{M_L}\right] \times (h_{ao} - h_{ai}) = \left[\frac{A_L}{M_L}\right] \times \frac{[\beta]}{R_v \bar{T}_L} \times \left\{a(X, \bar{T}_L) \times p_s(\bar{T}_L) - p_{p,a}\right\}$$
$$\times \left\{I_{fg}(\bar{T}_L) + Cp_V \times (T_{ao} - \bar{T}_L)\right\} + (Cp_L + Cp_{H_2O} \times X) \times \frac{d\bar{T}_L}{dt} + \left[\frac{\dot{Q}_L}{M_L}\right] \tag{2}$$

The equations 1 and 2 show, all other conditions being equal, that the lower the partial pressure of water vapour in the drying air $p_{p.a}$, the faster the drying process will be. The partial pressure of the water vapour in the drying air may be lowered by either of two methods: Heating, or decreasing the air humidity content. Since in order not to degrade the textiles to be dried the temperature of the drying air must be limited, the humidity content of the air should be kept as low as possible. This is not the case both in the system with recirculation and in that with humidity condensation by cooling with ambient air. It is eventually possible by condensing with cold water or by forcing the humid air across the evaporator of a heat pump. Figure 2.3 shows schematically the solutions proposed for open and closeloop systems. For household applications, where the disposal of humidity inside the laundry room may create problems with the building structure, the close-loop system seems the logical response, though the potential for energy recovery should still be interesting with a system as that depicted in Fig. 2.3(b).

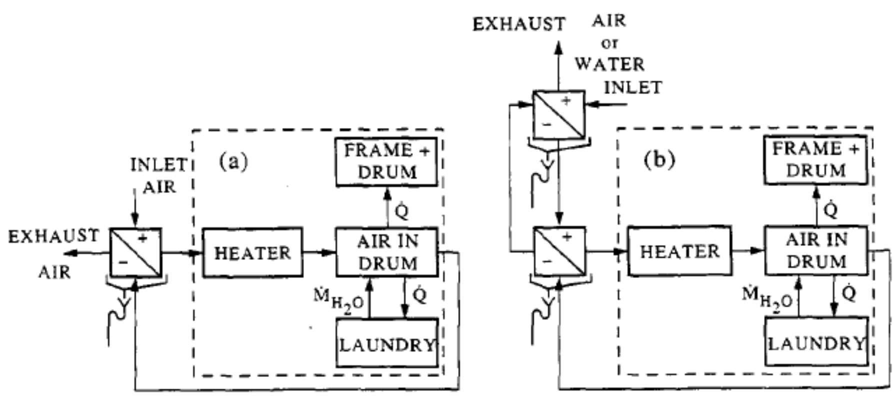

Fig 2.3: Schematic representation of the systems proposed for heat recovery in tumbler dryers: (a) Openloop system; (b) Closed-loop system.
(S.S. Elsayeda, et al. 2006)

Another system was design by V. Yadav and C.G Moon in their study about fabric drying process in domestic dryers. According to the report, they were use waste heat from an air condition as a heater to generate power for dehumidification process of a drying system. Diagram bellow shows how the drying system operated. (V. Yadav, et. Al 2007)