PROTOTYPING OF NEW ROOF COOLING SYSTEM THROUGH THERMOFLUID CONCEPT FOR ENERGY OPTIMIZATION AND ENVIRONMENTAL CONSERVATIONS

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A thesis submitted
in fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Product Design) with Honours

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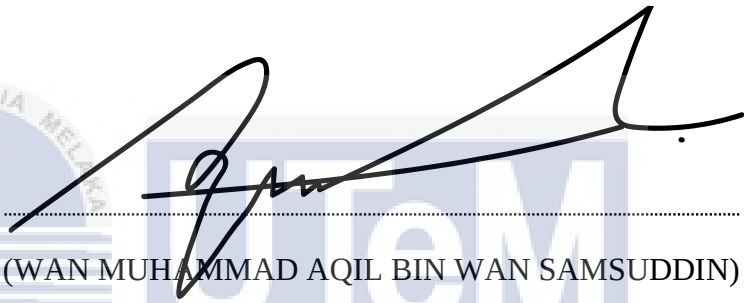
DECLARATION

I declare that this project “Prototyping of New Roof Cooling System Through Thermofluid Concept for Energy Optimization and Environmental Conservations” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : (WAN MUHAMMAD AQIL BIN WAN SAMSUDDIN)

Date : 11th January 2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical and Manufacturing Engineering Technology (Product Design) with Honours.

Signature : .....

Supervisor Name : (TS. DR. KAMARUL BIN AMIR MOHAMED)

Date : 11th January 2023

DEDICATION

Dedicated to

My honorable father, Wan Samsuddin bin Wan Bakar

My lovely mother, Hasliza binti Husin

My supportive sister, Wan Nur Afiqah binti Wan Samsuddin

My brother Wan Muhammad Ahnaf bin Wan Samsuddin

Lastly for my youngest sister, Wan Nur Aqilah binti Wan Samsuddin and

Wan Nur Anis Fatini binti Wan Samsuddin

ABSTRACT

This cooling roof refers to the roof to be built into a closed system. The new roof cooling system is designed to help homeowners to obtain a moderate temperature inside the house space. In hot and humid areas, air conditioning is increasingly being used to achieve thermal comfort. The air conditioner is very intensive in terms of energy, and it is desirable to develop low energy alternatives to achieve comfort. This roof cooling system is designed to help reduce the temperature of the heat in the house to get a modest temperature. This cooling system has been built with a gable roof design as the main design for this system because of the frequently used designs in terraced houses due to low development costs. However, the purpose of this study is to help every homeowner able to have an appropriate roof-cooling system at an affordable price compared to the appropriate market price is no longer expensive. In addition, the roof is designed with a thermo-fluid concept that heat will be transferred through the water moving over the roofing material and the hot water will continue to be transferred to the cooling system. Water will be continued to recycle on the roof of the house. Heat transfer is a movement of a fluid such as water when it has been heated it will cause the heat or energy to move away and carry it to another place. The temperature change in the double roof is caused by the water flow in and out supported by a water pump that pushes the water to the roof. The system on reducing temperature is proven on the results experimented and this double roof is effectively changing the temperature from outside that enter to the house space. The water in that flow inside the double roof will bring out the heat from the roof to the water out. In this experiment, temperature change (± 6.7 °C) or 17.8 % heat has been reduced.

ABSTRAK

Bumbung sejuk ini merujuk kepada bumbung yang akan dibina untuk menjadi sistem tertutup. Sistem penyejukan bumbung baru direka untuk membantu penduduk rumah mendapatkan suhu yang sederhana di dalam rumah. Di kawasan yang panas dan lembap, penyaman udara semakin digunakan untuk mencapai keselesaan terma. Penghawa dingin adalah sangat intensif dari segi tenaga dan adalah wajar untuk membangunkan alternatif tenaga rendah untuk mencapai keselesaan. Sistem penyejukan bumbung ini direka bentuk untuk membantu mengurangkan suhu haba di dalam rumah untuk mendapat suhu yang sederhana. Untuk membina sistem penyejukan ini, reka bentuk bumbung gable telah dipilih sebagai reka bentuk utama untuk sistem ini kerana rekabentuk yang kerap digunakan di kediaman teres oleh sebab kos pembangunan yang rendah. Walau bagaimanapun, tujuan kajian ini ialah untuk membantu setiap penduduk rumah mampu untuk memiliki sistem penyejukan bumbung dengan harga yang berpatutan berbanding dengan harga pasaran yang sesuai tidak lagi mahal. Di samping itu, bumbung direka dengan konsep termofluid bahawa haba akan dipindahkan melalui air yang bergerak di atas bahan bumbung dan air panas akan terus dipindahkan ke sistem penyejukan. Air akan terus dikitar semula di atas bumbung rumah. Pemindahan haba adalah pergerakan bendalir seperti air apabila ia telah dipanaskan akan menyebabkan panas atau tenaga bergerak dan membawa ke tempat lain. Perubahan suhu di penyumbat bumbung dua aliran air masuk dan keluar oleh pam air yang menolak air ke bumbung. Sistem penurunan suhu ini terbukti apabila hasil eksperimen dan bumbung berkembar ini berkesan mengubah suhu luar yang masuk ke ruang rumah. Aliran air dalam saluran itu di dalam bumbung berkembar akan membawa haba keluar dari bumbung ke saluran air keluar. Dalam eksperimen ini, perubahan suhu (± 6.7 °C) atau 17.8 % haba telah dikurangkan.

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LIST OF SYMBOLS AND ABBREVIATIONS

cm	-	Centimeter
m	-	mass
mm	-	Milllimeter
m^2	-	Meter square
Mpa	-	Mega Pascal
%	-	Percentage
°C	-	Degree Celsius
kN	-	Kilo Newton
Kg	-	Kilogram
Pa	-	Pascal
V	-	voluume
ℓ	-	liter
″	-	inch
ft.	-	feet
GWh	-	Gigawatt hour
3D	-	3 Demensional
rpm	-	Revelution Per Meter
W	-	Waltt
V	-	Volt
T_{pin}	-	Top point in
T_{pout}	-	Top point out
T_p	-	Top point
B_{pin}	-	Bottom point in
B_{pout}	-	Bottom point out
B_p	-	Bottom point
T_{so}	-	Temperature surrounding
T_{si}	-	Temperature inside
T_{win}	-	Tank water in
T_{out}	-	Tank water out

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Based on the observations, a cool roof is designed to reduce heat on the roof and inside the house by reflecting sunlight and absorbing less heat than a normal roof. Furthermore, Dehwah et al. (2020) reported that cool roofs and reflective coatings have been highly recommended for reducing building air conditioning loads. According to an investigation by Alnuaimi et al. (2021) Cool roofs can also reduce citywide surrounding air temperature during the summer by minimising the enormous quantity of air conditioning equipment, reducing ozone creation, and ultimately boosting human comfort demands by utilising nature and minimum requirements to meet human comfortable zones. Besides, Hossein et al. (2018) stated that cool roofs reflect a large percentage of incoming sunlight and keep the roof surface lower than ordinary roofs, lowering heat transfer into the building and its cooling load. Participants reported on a comparative examination of reflecting roofs at three separate buildings with air conditioning, chillers in a retail store, a school, and cold storage. In general, Yang et al. (2020) observed that if a surface absorbs less sunlight than it emits to the cold outer space, it will lose heat to the cold outer space, and electricity-free cooling can be achieved even during the day.

Roof cooling systems are almost always mounted on the roof of the house, and due to the extremely hot urban temperatures, most roof cooling systems can be found throughout Asia. According to Ahmed et al. (2021), during heatwaves and future climatic conditions,

natural ventilation by cross-ventilation was insufficient to achieve internal thermal comfort standards. Apart from that, using solar chimneys or windcatchers in conjunction with water evaporation cooling could provide a low-energy solution. Furthermore, Remion et al. (2019) demonstrated that natural ventilation systems, which use natural driving forces, enable energy-efficient buildings to have acceptable Indoor Air Quality (IAQ). Besides, Natural ventilation systems provide energy gains through fan consumption savings as well as night free cooling. In addition, Merlier et al. (2018) found that the performance of ventilation, which has a direct impact on a city's microclimate, is intimately related to the urban building layout and street networks in a city. Many studies show that combining Computer Fluid Dynamics (CFD) simulations and building arrangement scenarios, it's an effective method for assessing the performance of natural ventilation in urban areas. Liu et al. (2018) used CFD to investigate wind flow around a building with two different structured surrounding buildings that were detailed and roughly modelled. Besides, Gülten., 2020 et al. (2020) discovered that the structured model of the surrounding buildings should be considered for accurate wind flow prediction using a CFD simulation.

According to Saw et al. (2021), air conditioning systems are commonly used in tropical countries to provide thermal comfort in buildings. However, running the air conditioner for long periods each day will result in an increased electricity bill. As a result, an efficient roof cooling system is desired to reduce high energy costs while maintaining thermal comfort in buildings.

Furthermore, Guillén et al. (2021) indicated that The following are the main works devoted to thermofluids system design, which is defined as the process of developing a system, subsystem, component, or process that employs heat transfer, thermodynamics, fluid mechanics, or combustion. Apart from that, the heat medium is heated, and fluids include liquids, gases, and vapours. Heat will be transferred through the movement of water as a

fluid in the roof layer in the study of this cooling roof design. Temperature, fluid flow rate, and heat phase transition are also important in the context of thermal fluid because the changing temperature will be studied using the flow velocity of flowing water. Bagheri et al. (2020) investigate the temperature difference between the driving force and the pull pressure for the fluid flow. Besides, the magnitude of the temperature gradient in each direction determines the rate of heat transfer in that direction.

The study's goal is to create a new roof cooling system based on the thermofluid concept. The thermofluid application will include heat transfer, heat flows in the direction of decreasing temperature, and flow rate effects. Distilled water will be used as the fluid.

Apart from that, Zhau et al. (2019) stated that The gable roof form is popular, and the roof slope has a considerable impact on the flow field around the building. Furthermore, Xin et al. (2022) and Tominaga et al. (2018) posited in their research, that wind forms a complicated circumfluence and reattachment when it blows around and over a gable roof. Many elements influence airflow patterns, such as ventilation system configurations, wind conditions, external temperature and humidity, animal presence, and building configurations. Yi et al. (2018) measure that the opening is a manageable component for managing airflow patterns, notably for wind-driven natural ventilation. As a result, it is vital to understand how the apertures affect air flows.

The roof is very important because of the design of the structure and ventilation, and the wind tunnel experiment to inspect buildings with roof fields. This research will investigate temperature reducing via new roof concept by apply water flow inside roof design.

1.2 Problem Statement

This research aims to design and develop a new roof concept. By lowering the temperature of the urban heat on the rooftop, the temperature inside the house can be reduced. Roof cooling systems of various types have been developed to meet the needs of every homeowner. According to Michael et al. (2018), the study on the strategy of attic ventilation is to reduce the heat that is trapped inside the roof indoor space to the outside environment by turbine vent. They discovered that this method is both cost-effective and environmentally friendly due to the use of natural ventilation tools. However, their conclusions are still inadequate due to natural ventilation, which depends on the air surrounding movements.

According to Heidari et al. (2019), the high water usage is one of the key disadvantages of evaporative cooling. Given the worldwide water issue, a cooling system that conserves both water and energy will be more desirable than the current cooling system. As a result, a close concept system is required to overcome the problem highlighted by deficiencies in the open system condition. In this study, a closed system for water flows inside roof materials will be considered in order to control water waste, as well as for sustainability and maintenance purposes.

Roof cooling system processes include water spray and moving water film over an external shade cloth. Halil et al. (2017) demonstrated using the water sprinkler method to cool the house's rooftop in their study. However, this still resulted in water waste due to surrounding losses. Meanwhile, Yaolin et al. (2021) conducted an experiment related to the water movement by draining water from the roof surface to reduce the heat transfer. Due to the open system used in their research, both of these studies have demonstrated a negative impact on the environment by producing wastewater.

Apart from that, the gable roof type is the most popular in Asian countries such as Malaysia due to its simple design, low fabrication cost, and effectiveness in controlling hot urban temperatures through natural air movement. In addition, Roof pitches are classified as 3:10, 5:10, and 7. 5:10. In the experiment on the three roof pitches, pitch 5:10 produced the best results when compared to the others. According to their findings, the gable roof design is good for airflow and wind tunnels due to air circulation. As a result, the gable roof design will be focused on further in this study.

Furthermore, there is a similar design by Yaolin. (2021), the experiment that has been carried out is to minimise heat transfer into the attic. The moving air cavity ventilation system integrated with solar-powered fans is critical for transferring hot air before it enters the ceiling. The proposed new roof cooling system will have the same design as the existing one. However, the cooling concept used is entirely different.

According to a comprehensive literature review, there is no concept like the one used in the adoption of the drainage system via double roofs. This new concept will allow water to freely flow between two roofs while maintaining a controlled closed system. Fluid will flow between the two layers of roofs, and then into two separate tanks namely cold and hot tanks. Using the closed system concept, this process recycles water indefinitely. This study concentrated on lowering the temperature that enters the house so that the home temperature remains cool rather than hot, as is typical of a roof.

1.3 Objectives

The objectives of this research are as follows:

a) To develope a new roof cooling system based on the thermofluid concept and water drainage system (closed system).

b) To investigate the system's effect on temperature reduction and the effectiveness of the new roof design.

c) To evaluate the potential of the new design for use in terms of cost, and manufacturability.

1.4 Scope of Research

The scope of this research are as follows:

a) A new cooling concept will be introduced, with fluids serving as the primary medium for heat transfer.

b) The gable roof design will be used for this project because it is popular in Malaysia due to its low cost and ease of construction.

c) The water pump (aquarium pump) will support the flow of fluid around the roof in the design system.

d) The temperature on the top and bottom of the roof surface will be reduced by two layers of the roof with fluid flowing inside them.

e) This roof cooling system may also recycle water, as well as saving money on water bill

f) The system's design and development will be built using local components with lower manufacturing costs.

1.5 Rationale of The Research

The rationale of this research such as:

a) Through this experimental research, a new experience and knowledge can be gained by using PVC transparent roof for the double roof and identifying its

potential in engineering applications that can be used in the thermo-fluid concept.

b) The fluid that flows inside the double roof is one of the main cooling roof strategies used to aid in the process of temperature reduction that enters the house. The house will remain at a comfortable temperature.

c) The purpose of this study is to investigate the heat change from the water inlet and outlet, as well as the heat change on the top and bottom of the double roof.

d) This cold roof will prevent heat from entering the house, keeping it cool with moderate temperatures and consuming less energy for air conditioning or not using air conditioners.

e) This new cooling process design will be used as a thermo-fluid system for water cycle in the roof cooling process and will be able to control the temperature from outside from entering the house. The cool roof will provide a more comfortable and controlled indoor environment from hot temperatures.

1.6 Summary of Methodology

This design will be formed as a mirror image of the water that will flow through it. The thermofluid cooling process is aided by the continuous movement of water fluid on the double roof. Roof design and material selection using water fluid as a cooling system, water pump for fluid to cycle for cooling process, and process to fabricate the roof cooling system.

Gable roofs are good for airflow outside the house and will assist in the cooling process. The following section identifies the roof material by using a PVC semi-transparent roof. The double roof will be designed with two matching roof materials, the same size as the roof, and space for water to flow through it in the centre of the roof.