



**STUDY ON BODY TEMPERATURE EFFECT TOWARDS
WORKERS THAT WORKS IN HOT AMBIENT BY USING
COOLING FAN**



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**BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY
(REFRIGERATION AND AIR CONDITIONING SYSTEMS) WITH
HONORS**

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**Faculty of Mechanical and Manufacturing Engineering
Technology**



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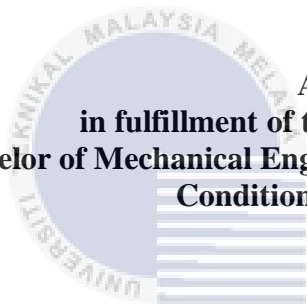
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**STUDY ON BODY TEMPERATURE EFFECT TOWARDS WORKERS THAT
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MOHAMAD ZAHIM BIN MOHAMAD SUKAIRI

A thesis submitted
in fulfillment of the requirements for the degree of
**Bachelor of Mechanical Engineering Technology (Refrigeration And Air
Conditioning Systems) With Honors**



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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical and Manufacturing Engineering Technology

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2022

DECLARATION

I declare that this thesis entitled “Study On Body Temperature Effect Towards Workers That Work in Hot Ambient By Using Cooling Fan” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

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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 Engineering Technology (Refrigeration And Air Conditioning Systems) With Honors

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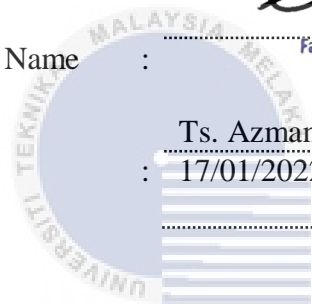
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DEDICATION

I would like to dedicate my work to my beloved parents

Mohamad Sukairi Bin Sohot and Zaleha Binti Anuar

Thank you for your warmest and softness in taking care of me, supporting, advisory and

That gives my life happiness all the time.

To my supervisor, Ts. Azman Bin Ibrahim and all my friends,

Thanks for all the supports.



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ABSTRACT

The term global warming refers to the increase in the global average temperature. Global warming is expected to produce a 2-5 degrees Celcius increase in the Earth's temperature by the end of the 21st century. As a result, long-term exposure to hot and humid surroundings makes workers feel uncomfortable and causes excessive sweating, affecting their performance. Personal electric cooling fans are one of the potential solutions to increase the productivity and efficiency of the workers. Previous research and innovation are studied throughout this research. The objective is to learn the effect of prolonged exposure of direct sunlight towards body temperature and develop an optimization design concept of the Fabric Duct Fan Belt. This research will be using Mini Hanging Waist Fan as the main supply and fabric duct design as the design concept. This study aimed to examine the effects of temperature body with and without Fabric Duct Fan Belt using an electric cooling fan as the main supply. Subjects aged 24 underwent six 20 minutes experiments with body temperature recorded every 30 seconds. The investigation is conducted with an ambient temperature of 37 °C, 60% relative humidity, 0.3m/s air velocity, and 450 W/m² of solar radiation. Subjects were given a bottle of water with 350ml that could be drunk during the ongoing experiment. Ambient temperature and temperature of the front and back of the body are aiming to be measured. The analyses prove that continuous air flows circulating the body can reduce and maintain body temperature. This research used a C shape to balance the airflow throughout the body in terms of shape. Finally, the minimum number of holes for the Fabric Duct Fan Belt is 25. If less than 25 holes, the temperature will rise and does not in the control condition.

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ABSTRAK

Istilah pemanasan global merujuk kepada peningkatan suhu purata global. Pemanasan global dijangka menghasilkan peningkatan 2-5 darjah Celcius dalam suhu Bumi menjelang akhir abad ke-21. Akibatnya, pendedahan jangka panjang kepada persekitaran yang panas dan lembap menyebabkan pekerja berasa tidak selesa dan menyebabkan berpeluh berlebihan yang boleh menjejaskan prestasi mereka. Kipas penyejuk elektrik peribadi adalah salah satu penyelesaian yang berpotensi untuk meningkatkan produktiviti dan kecekapan pekerja. Penyelidikan dan inovasi terdahulu dikaji sepanjang penyelidikan ini. Objektifnya adalah untuk mengkaji kesan pendedahan berpanjangan cahaya matahari langsung terhadap suhu badan dan untuk membangunkan dan mengoptimumkan konsep reka bentuk Tali Kipas Saluran Fabrik. Penyelidikan ini akan menggunakan Kipas Pinggang Gantung Mini sebagai bekalan utama dan reka bentuk saluran fabrik sebagai konsep reka bentuk. Kajian ini bertujuan untuk mengkaji kesan suhu badan dengan dan tanpa Fabric Duct Fan Belt menggunakan kipas penyejuk elektrik sebagai bekalan utama. Subjek yang berumur 24 tahun menjalani eksperimen enam 20 minit dengan suhu badan yang direkodkan setiap 30 saat. Eksperimen dijalankan dengan suhu ambien 37 °C, 60% kelembapan relatif, halaju udara 0.3m/s, dan 450 W/m² sinaran suria. Subjek diberi sebotol air dengan kuantiti 350ml yang boleh diminum semasa eksperimen dijalankan. Suhu ambien dan suhu depan dan belakang badan bertujuan untuk diukur. Keputusan daripada analisis membuktikan bahawa aliran udara berterusan yang beredar dalam badan boleh mengurangkan dan mengekalkan suhu badan. Dari segi bentuk, kajian ini menggunakan bentuk C untuk mengimbangi aliran udara ke seluruh badan. Akhir sekali, bilangan lubang minimum untuk Tali Kipas Saluran Fabrik ialah 25. Jika kurang daripada 25 lubang, suhu akan meningkat dan tidak berada dalam keadaan kawalan.

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LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
WGBT	-	Wet Bulb Globe Temperature
AC	-	Alternating Current
DC	-	Direct Current
DOSH	-	Department Occupational Safety and Health
HVAC	-	Heating and Ventilation Air Conditioning
IAQ	-	Indoor Air Quality
ASHRAE	-	American Society of Heating, Refrigeration, and Air-Conditioning
OSHA	-	Occupational Safety and Health Administration
HIRARC	-	Hazard Identification, Risk Assessment, and Risk Control
PPE	-	Personal Protective Equipment
TLVs	-	Threshold Limit Value
BEIs	-	Biological Exposure Indices
ACGIH	-	American Conference of Governmental and Industrial Hygienists
T _{db}	-	Dry Bulb Temperature
T _{nwb}	-	Natural Wet Bulb Temperature
T _g	-	Globe Temperature
Rh	-	Relative Humidity
V	-	Air Velocity
PCM	-	Phase Change Materials
HCV	-	Hybrid Cooling Vest
TPU	-	Thermoplastic Polyurethane film
CAD	-	Computer-Aided Design

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CHAPTER 1

INTRODUCTION

1.1 Background

The term global warming refers to the increase in the global average temperature. In other words, it is the process of our entire world heating up. The planet warmed by an average of 1°C during the previous century. This may not appear to be a massive change, but it has the potential to significantly influence people and animals all over the world at present and in the future. Global warming is expected to produce a 2-5 degrees Celcius increase in the Earth's temperature by the end of the 21st century. And, as a result of climate change, our weather will become more unpredictable, threatening the extinction of many species and making life much more difficult.

The greenhouse effect causes climate change, a natural phenomenon. Humans have consumed enormous amounts of fossil fuels like oil and gas since the industrial revolution. Fossil fuels release massive amounts of carbon dioxide into the atmosphere. During this process, the gases released into the atmosphere act as an unseen “blanket” warming the Earth and trapping heat from the Sun. The “Greenhouse Effect” is the name for this phenomenon. Not only that, deforestation contributes significantly to global warming. Trees take a large quantity of carbon dioxide from the air and release oxygen back into it. Unfortunately, people are cutting down many rainforests to manufacture furniture and paper and create highways, oil mining, dams, and urban development. As a result of

reducing the number of trees and forests, carbon dioxide stays in the atmosphere and warms the planet.

There are many sectors of the industry affected by global warming. One of the affected sectors is outdoor workers such as manufacturing, mining, quarrying, construction, and agriculture. Mostly, all of this sector can't be avoid working under the hot temperature. Working in higher temperatures are the risk that employees confront due to climate change. Heat-related illnesses, stress, and tiredness can put these employees at risk of harm. Workers may also have less control than the broader population over their exposure to high temperatures (Smith, 2016).

As the problem of climate change is increasing, Schuyler Wheeler invented the first electric fan in 1886 (Tech, 2014). This innovation has sparked a revolution in the world. Initially, early fans were made all DC powered. Fans using AC motors began to be manufactured after the 1890s. GE introduced a version with overlapping blades in the late 1920s, which made the fans significantly quieter. Other materials, such as nylon and wood, were utilized in the designs as the decades advanced. After the 1920s, there were additional colours and styles. Previously, fans were only available in black.

However, due to the large size of the fans, they cannot be taken anywhere into the sites or hot environment by outdoor workers. Therefore, the innovation of fans has been thriving toward modern fans. Modern fans are composed mainly of plastic and contain far fewer materials. The use of rare-earth elements in motor magnets, such as cobalt-iron alloys, allows sure high-end fans to be compact and powerful.

This research aims to develop a design and fabricate for Fabric Duct Fan Belt that has been modified for improvement from conventional fans. This research will be using a mini hanging waist fan as the main supply for cooling the body temperature. This device will be using a fabric duct as the design concept. The Fabric Duct Fan Belt will be measured on human subjects to get physiological data and subjective comfort.

1.2 Problem Statement

Workers in hot environments are at risk of developing severe heat-related sickness, leading to fatal incidents. Therefore, from an emotional and financial standpoint, it is essential to protect workers from heat-related sickness. Ilangkumaran et al. (2015) stated that hot environment sectors include foundries, steel mills, and glass manufacturers, require workers to operate near furnaces and extremely hot or molten metal. According to Aryal et al. (2017), the hot environment sectors generally involve physically tricky jobs frequently done in harsh environments, leading to tiredness, poor judgment, poor job quality, an increased risk of accidents, and lack of job satisfaction.

Workers forced to work in extreme temperatures while performing complicated physical tasks in direct sunlight are more likely at risk of heat stress (Jungsun Park, Yangho Kim, and Inbo Oh, 2017). Heatstroke, heat exhaustion, heat syncope, heat cramps, heat rashes, and even death resulting from long-term exposure to extreme temperatures. Due to global temperatures being predicted to rise due to global climate change, heat-related sickness will become a more significant issue for outdoor workers (Rebekah A I Lucas et Al. 2014). Recent studies reported that working in higher temperatures is the risk

employees confront due to climate change. Workers may also have less control than the broader population over their exposure to high temperatures (Smith, 2016).

The ability to provide comfort is getting more difficult because of global warming. Therefore, Innovation is required to cool the body temperature of outdoor workers to provide comfortable working environments in warm or hot weather. The previous study has utilized various personal and local cooling techniques to minimize heat stress on outdoor workers (Ouahrani et al., 2017). Moving air across the skin with devices like electric fans provides an individual-level cooling method. In other words, it can avoid the problem associated with refrigerant gases and reduce power consumption by 30% (Morris et Al. 2021).

Concerning the current 35°C threshold for fan usage is based on the fact that once the ambient temperature reaches skin temperature, fan use increases the rate of convective heat gain to the body from the surrounding environment. This factor can significantly increase sweat evaporation (Morris et Al. 2021). However, fan usage is usually prohibited at critical ambient temperatures ranging from as low as 32.3 °C with 35% relative humidity to between 35.6 °C and 37.2 °C without humidity specified. Surprisingly, these suggestions do not appear to be founded on any experimental data since the Cochrane Collaboration recently stated that no evidence presently exists in the literature supporting or opposing the usage of electric fans during climate change (Morris, 2014).

1.3 Objective of Research

This research aims to develop personal cooling using electric fans as the main power and using the belt and fabric duct as the conceptual design. Specifically, the objectives are as follows:-

- i) To study the effect of prolonged exposure of direct sunlight towards body temperature
- ii) To study the effect of body temperature with and without Fabric Duct Fan Belt.
- iii) To fabricate and optimization design concept of Fabric Duct Fan Belt

1.4 Scope of Research

The limitation of this project is based on the following scopes:

- Fabricate of fabric duct fan belt is only available for 3-4 hours usage using high-speed mode.
- Fabricate especially for outdoor workers that work in a hot and humid environment
- Fabricate of Fabric Duct Fan Belt is only for workers that have a range of waist circumferences around 28-40 inches

1.5 Rationale for Research

Thousands of research have been conducted to investigate various elements of climate change. However, this topic is far from being exhausted as a research field. New research in the field of climate change may be performed to examine the effects of cooling garments on workers like cooling vests using phase change material (PCM), cooling safety helmets using PCM, and Head-neck cooling using Peltier on outdoor workers applications. Alternatively, this research has specifically studied the hot environment outdoor workers face while performing a task. The effect of the hot climate of 2015-2021 may be examined in-depth manner. The same idea applies to almost every aspect of industry and economics.

This study evaluates experimentally electric fan cooling on the belt performance and fabric duct when incorporating two electric fan cooling units. The last study objective tackles the back body, neck, and head, while this research aims to vary air distribution on the front, back, and side bodies. In other words, this research aims to tackle all over the area body. Experiments on four volunteers were conducted to assess the cooling rate observed with the electric cooling fan after sunbathing in the middle of direct sunlight. The temperature of the body and airflow rate aim to be measured for 20 minutes, and the data will be recorded every 30 seconds. The experiment was conducted in an opening condition in a warm area with a temperature of 30-32°C, 60% relative humidity, 0.3 m/s air velocity, and 450 W/m² of solar radiation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This literature review chapter will cover information and summarize body temperature effects on workers who work in hot ambient and their characteristic. This section explains how to obtain and summarize relevant information using reviews of journals, books, internet tools, articles and, other sources. It provided context information for the studies and served as a reference for the project's later stages. Besides, this chapter will provide information on human comfort, type of jobs that exposed to heat, problems faced by the workers when working in hot ambient, the benchmark of the Department of Occupational Safety and Health (DOSH), where heat sources come from, how the body reacts to heat, and current innovation

Working in a hot environment or being exposed to high temperatures for the long term can put the body under a lot of strain. Dehydration and fatigue can cause body disturbances when combined with physical activities. This can lead to severe health conditions for staff working in hot ambient, which may increase workplace accidents. The results of compliance exercises and heat stress tests at different workplaces revealed that many Malaysian workplaces with machinery or processes that operate at high temperatures are at risk.

Because of the Sun, occupational employees are at risk of heat stress. The mission requires physical exertion, hot working conditions, and clothing and tools for self-