INVESTIGATION OF THERMOACOUSTIC COOLER

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INVESTIGATION OF THERMOACOUSTIC COOLER

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Bachelor of Mechanical Engineering

UTeM

اونيۏرسيتي تيکنيکل مليسيا ملاک

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2021

DECLARATION

I declare that this project report entitled “Investigation of Thermoacoustic Cooler” is the result of my own work except as cited in the references.

Signature : 

Name : NURUL FAZIRA BINTI AZIZIZOL

Date : 15 July 2021

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APPROVAL

I hereby declare that I have read this project report and in my opinion, this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature :. .....

Name of Supervisor : DR. FATIMAH AL-ZAHRAH BINTI MOHD SA'AT

Date : 18/7/2021

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DEDICATION

To my beloved mother and father

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ABSTRACT

Thermoacoustic cooler system is an alternative cooling system that transport heat using acoustic power. The system is simple, but the theory is a bit difficult to understand. A common thermoaocoustic cooler consist a loudspeaker, stack, heat exchanger and a resonator. The objectives of this project is to fabricate a thermoacoustic cooler system for experimentation using suitable measurement method, to identify resonance frequency of the available thermoaocustic cooler apparatus and to evaluate temperature drop of thermoaocustic cooler using different stack. The resonator tube is made from PVC pipe and filled with atmospheric air. The methodology describes suitable design for thermoacoustic cooler system. The Conceptual Design have been designed in details based on the selection of the importance parameter and criteria which included stack and cooler box. In this study, the thermoacoustic cooler system is operating with 124.9 Hz with copper tube as heat exchangers. Results showed that the temperature difference across the stack is about 12.17 ^{o}C. Morever, the cooler box which may be used to store the medicine is designed and installed at the cold heat exchanger in this study to see the cooling performance. However, the effectivess of the cooler box is still lacking in terms of heat transfer which to transfer heat to the environment or cooler box. In this project, the results are discussed, and recommendations for further research on flow inside thermacoustic systems are provided in certain Chapters.

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ABSTRAK

Sistem pendingin termoakustik adalah sistem penyejukan alternatif yang mengangkut haba menggunakan tenaga akustik. Penyejuk termookoustik biasanya terdiri daripada pembesar suara, timbunan, penukar haba dan resonator. Objektif projek ini adalah untuk membuat sistem pendingin termoakustik untuk eksperimen menggunakan kaedah pengukuran yang sesuai, untuk mengenal pasti frekuensi resonansi alat pendingin termoaokustik yang ada dan untuk menilai prestasi penyejukan termaokustik pendingin menggunakan timbunan yang berbeza. Tiub resonator dibuat dari paip PVC dan diisi dengan udara atmosfera. Metodologi menerangkan reka bentuk yang sesuai untuk sistem pendingin termoakustik. Reka Bentuk Konseptual telah dirancang secara terperinci berdasarkan pemilihan parameter dan kriteria kepentingan yang merangkumi susun atur dan kotak yang lebih sejuk. Dalam kajian ini, sistem pendingin termoakustik beroperasi dengan 124.9 Hz dengan tiub tembaga sebagai penukar haba. Hasil kajian menunjukkan bahawa perbezaan suhu di timbunan adalah sekitar 12.17^{o}C. Kotak yang lebih sejuk untuk menyimpan ubat dirancang dan dipasang di penukar haba sejuk dalam kajian ini untuk melihat prestasi penyejukan. Walau bagaimanapun, keberkesanan kotak sejuk masih kurang dari segi pemindahan haba untuk memindahkan haba ke persekitaran atau kotak sejuk. Dalam projek ini, hasilnya dibincangkan, dan cadangan untuk penyelidikan lebih lanjut mengenai aliran di dalam sistem termakustik disediakan dalam bab tertentu.

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LIST OF ABBREVIATIONS

TEM	Thermoelectric module
TEG	Thermoelectric generator
TEC	Thermoelectric cooler
AR	Thermoacoustic Refrigerator
TAE	Thermoacoustic engines
COP	Coefficient of Performance
PSM 1	Projek Sarjana Muda 1
PSM 2	Projek Sarjana Muda 2
3D	Three Dimensional
HOQ	House of Quality
AHP	Analytical Hierarchy Process
TADTAR	Thermoacoustic-driven thermoacoustic refrigerator
RVC	Reticulated Vitreous Carbon
MMT	Turbo Machinery Lab

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LIST OF SYMBOLS

Qc	Cooling load
W	Work done
a	Speed of sound
γ	Specific heat ratio
C_p	Heat Capacity
K	Thermal conductivity
σ	Prandtl number
δ_{kn}	Normalized thermal penetration depth
δ_v	Viscous penetration depth
p_m	Mean pressure
L_s	Stack length
T_h	Stack's hot end temperature
T_c	Stack's cold end temperature.
T_m	Mean temperature
ΔT_{mn}	Temperature difference
ρ	Density
ω	Angular frequency
λ	Wavelength
μ	Dynamic viscosity gas

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Q_{cn}	Cooling power.
W_n	Acoustic power
L_{sn}	Normalized Stack length
x_n	Normalized Stack position
B	Blockage Ratio
l	Half stack plate thickness
f	Frequency
y_0	Plate half-gap

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CHAPTER 1

INTRODUCTION

1.1 Background

As living in this modern era, technology and innovation improve the standard and quality of life. A cooler system is the one technology that retain the temperature of a system from reaching limits defined by needs of safety and efficiency. Nowadays, most of the cooling systems were applied in automobile engines, nuclear, industrial power plants, and many other machinery applications. An acoustic or sound wave that is performed in the system produces the cooling effect. Thermoacoustic is the combination of acoustic and thermodynamics branches which transfer thermal energy using sound wave. There are different sorts of thermoacoustic, which are thermoacoustic engines and thermoacoustic cooler.

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Thermoacoustic deals with temperature, density, motion oscillations, and pressure differences of acoustic waves. Thermoacoustic can also invest the temperature differences along the wave to play an important part to perform the thermoacoustic effect. Heat and sound are applicable in all forms of conversion ways. Thermoacoustic devices create acoustic oscillations by providing heat at the hot part

of a stack. In contrast, the refrigerant effect may be triggered by sound oscillations by supplying pressure wave within the resonator where a stack (porous media) is locate. A high-temperature gradient along the resonator at which the working media(gas) contains causes differences in the thermoacoustic system's density. This temperature will can cause certain changes in a constant volume of matter force changes in pressure. The combination of heat transfer and pressure changes in the sinusoidal pattern perform a thermoacoustic oscillation cycle.

The simple thermoacoustic cooler is shown schematically in Figure 1.1. There are four prime parts in the thermoacoustic cooler: loudspeaker, resonator, stack, and heat exchanger. The loudspeaker also known as acoustic drive is driven by electricity to produces waves of required frequency. The stack (porous media) is located in the resonator. The design of the resonator must interface with the speaker and stack cross sections. Mostly, a simple tube is be selected such as cylinder tube as the resonator geometry.

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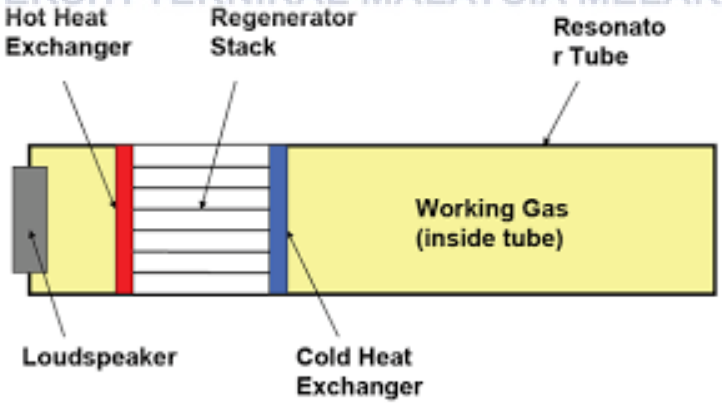

Figure 1.1: Schematic of thermoacoustic cooler

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