

HEAT TRANSFER APPARATUS

By

Alvin Kusnadi
danielalvin47@gmail.com
11601051

BACHELOR'S DEGREE
in

MECHANICAL ENGINEERING – MECHATRONICS CONCENTRATION
FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY



SWISS GERMAN UNIVERSITY
The Prominence Tower
Jalan Jalur Sutera Barat No. 15, Alam Sutera
Tangerang, Banten 15143 - Indonesia

Revision after Thesis Defense on 6 July 2020

STATEMENT BY THE AUTHOR

I hereby declare that this submission is my own work and to the best of my knowledge, it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at any educational institution, except where due acknowledgement is made in the thesis.

Alvin Kusnadi

Student

Date

Approved by:

Dr. Yunita Umniyati, S.Si., M.Sc.

Thesis Advisor

Date

(OPTIONAL)

Dr. Eka Budiarto, S.T., M.Sc.

Thesis Co-Advisor

Date

Dr. Maulahikmah Galinium, S.Kom., M.Sc.

Dean

Date

Alvin Kusnadi

ABSTRACT**HEAT TRANSFER APPARATUS**

By

Alvin Kusnadi

Dr. Yunita Umniyati, S.Si., M.Sc., Advisor

Dr. Eka Budiarto, S.T., M.Sc., Co-Advisor

SWISS GERMAN UNIVERSITY

In this era of globalization, scientific research is very useful in order for the students in university to learn about the subject itself. The main problem for each universities in Indonesia is that they are still lacking in terms of the completeness in the laboratory experiment tool. By doing this thesis, I hope that we can complete the experiment tool for the physics lab of Swiss German University one by one as many student will also create an experiment tool for the lab in the next few years. In this thesis, I will be making a heat transfer apparatus that can be use to conduct heat transfer experiment on the lab of physics in SGU, it will be controlled by arduino and the material for this thesis is very commonly used so that everyone can make the same heat transfer apparatus.

Keywords: Heat Transfer, Arduino, Thermocouple, Water.

© Copyright 2020
by Alvin Kusnadi
All rights reserved

DEDICATION

I dedicate this works to God

My Family

My Friends

My University

ACKNOWLEDGEMENTS

While working on this thesis, I learned a lot of new things that I didn't know while working together as a team. I learned how to do many things on my own and push myself to the limit. And I want to express my gratitude to these following people who have contributed to the completion of my Thesis with no particular order.

Firstly, I would like to thank my thesis advisor Mrs. Yunita Umniyati for the help and guidance during my thesis work. She is a very friendly person and helps me through a lot of hard times and keeps on motivating me to do my thesis. Secondly, I would like to thank Mr. Eka Budiarto, for all the help from during the first month of thesis until I am in quarantine at home because, he made me realize about a lot of things that are wrong with my thesis. Without him I won't know that I had a lot of mistakes. Also I thank Mr. Yohanes Freddy for helping me with my heat transfer apparatus as he guides me on choosing the correct material for the apparatus. Lastly, I want to thank my family for the support, and their prayers for the 4 years of my study program in Swiss German University. I would like to thank my friends, to Group WA Keluarga, Audrey Satriajaya, Andrian Marcello, Agustinus Pratama, Billy Susantio, Einser Nahiman Turjono, Deo Marcellino Njoto, Heverett Louisious, Ivan Goldy, Alvin Tri Hartono, Joseph Radya for being my friends these past 4 years in my uni life. Also, I want to thank PIKSI, my highschool friends for encouraging me to do my thesis, Joses Julius, Christopher Rolando, Kevin Sudjono, Axel Manuel, Wibisana Jeremia, Caroline Wijaya, Michellyn Angelina, Levina Nathania, Ellen Dianty, Iola Novianty. Also to my friends Devin Alice Derian, Christopher Dog Clarence, Edwin Backdoor Salto, Andre Astral Pribadi, Elizabeth Vanessa, Charissa Naomi, Rizki Giovanni for giving me good humor everyday. I also would like to thank my classmates for helping me with my study during my university life. Lastly, I would like to thank my girlfriend Merry Oktofenti, for the support during the thesis work. I love you all. And most importantly, None of these is possible without the help of God's grace and blessings.

TABLE OF CONTENTS

	Page
STATEMENT BY THE AUTHOR.....	2
ABSTRACT.....	3
DEDICATION.....	5
ACKNOWLEDGEMENTS.....	6
TABLE OF CONTENTS.....	8
LIST OF FIGURES.....	11
LIST OF TABLES.....	13
CHAPTER 1 - INTRODUCTION.....	14
1.1. Background.....	14
1.2. Research Problems.....	15
1.3. Research Objectives.....	15
1.4. Significance of Study.....	15
1.5. Research Questions.....	15
1.6. Hypothesis.....	16
1.7. Scope.....	16
1.8. Limitation.....	16
1.9. Thesis Structure.....	16
CHAPTER 2 - LITERATURE REVIEW.....	18
2.1. Stefan-Boltzmann Constant.....	18
2.2. Heat Transfer.....	18
2.2.1. Conduction.....	18
2.2.2. Convection.....	19
2.2.3. Radiation.....	19
2.2.4. Convection vs Conduction vs Radiation.....	19
2.2.5. Radiation Intensity.....	20
2.2.6. Emissivity of radiating surfaces.....	21
2.2.7. Radiating Energy.....	21
2.2.8. Lambert's cosine law for light.....	21

2.2.9.	Lambert’s law of absorption	22
2.3.	Leybold’s Solar Collector	22
2.4.	Types of Print Filaments for 3d Printing	23
2.4.1.	ABS Filament	23
2.4.2.	PLA Filament.....	24
2.4.3.	PET Filament	25
2.4.4.	PETT Filament.....	26
2.4.5.	Nylon Filament	27
2.4.6.	PVA Filament	28
2.5.	Types of Thermocouples	29
2.5.1.	Type J Thermocouple	29
2.5.2.	Type K Thermocouple	30
2.5.3.	Type T Thermocouple	30
2.5.4.	Type N Thermocouple	30
2.5.5.	Type S Thermocouple.....	31
2.6.	Types of Arduinos	31
2.6.1.	Arduino Uno	32
2.6.2.	Arduino Micro	32
2.6.3.	Arduino Mega 2560	32
2.7.	Types of Lamps	33
2.7.1.	Incandescent lamps	33
2.7.2.	alogen lamps	34
2.7.3.	Metal halide Lamps	35
2.7.4.	Light Emitting Diode	35
2.8.	Thermodynamics	36
2.8.1.	First Law of Thermodynamics.....	36
2.8.2.	Second Law of Thermodynamics	36
2.8.3.	Third Law of Thermodynamics	36
CHAPTER 3 – RESEARCH METHODS		38
3.1.	System Overview	38
3.2.	Thermocouple & Max 6675.....	40
3.3.	Design References	40
➤	Mechanical Components for Heat Trasnfer Apparatus	41
1.	Polylactic Acid (PLA)	41
2.	Water Sealant.....	42

3.	Glass	42
4.	Silicone stopper	43
➤	Electrical Components for Heat Transfer Apparatus	44
1.	Arduino Mega.....	44
2.	Thermocouple type-K.....	44
3.	MAX 6675 Module	45
4.	Unomat LX 901 GZ Studio Light	46
3.4.	Electrical Drawing	47
CHAPTER 4 – RESULTS AND DISCUSSIONS.....		48
6.1.	Mechanical Design	48
6.2.	Resulted Assembly	49
4.3.	Data Taking.....	50
4.4.	Data Analysis (Heating).....	50
4.5.	Efficiency of the Apparatus	54
4.6.	Heat Transfer via Convection	56
4.7.	Heat transfer via Conduction	56
4.8.	Heat Transfer via Radiation.....	57
4.9.	Comparison.....	57
4.10.	Cooling Experiment.....	58
6.11.	Data Analysis (Cooling)	58
6.12.	Newton’s Law of Cooling.....	61
6.13.	Anova Analysis for Heating Experiment.....	64
6.14.	Anova Analysis for Cooling Experiment.....	66
CHAPTER 5 – CONCLUSIONS AND RECCOMENDATIONS		69
5.1.	Conclusions.....	69
5.2.	Recommendations.....	69
APPENDIX.....		71
CURRICULUM VITAE		92

LIST OF FIGURES

Figures	Page
Figure 1	23
Figure 2	24
Figure 3	25
Figure 4	26
Figure 5	27
Figure 6	28
Figure 7	30
Figure 8	30
Figure 9	30
Figure 10	31
Figure 11	31
Figure 12	32
Figure 13	32
Figure 14	33
Figure 15	34
Figure 16	34
Figure 17	35
Figure 18	35
Figure 19	39
Figure 20	40
Figure 21	41
Figure 22	42
Figure 23	42
Figure 24	43
Figure 25	44
Figure 26	44
Figure 27	45
Figure 28	46
Figure 29	47
Figure 30	48
Figure 31	49
Figure 32	50
Figure 33	50
Figure 34	51
Figure 35	51
Figure 36	52
Figure 37	52
Figure 38	53
Figure 39	53

Figure 40	54
Figure 41	59
Figure 42	59
Figure 43	60
Figure 44	60
Figure 45	61
Figure 46	65
Figure 47	71

LIST OF TABLES

Table	Page
Table 1	20
Table 2	46
Table 3	55
Table 4	62
Table 5	64
Table 6	65
Table 7	67
Table 8	68
Table 9	68
Table 10	72
Table 11	73
Table 12	75
Table 13	76
Table 14	77
Table 15	77
Table 16	78
Table 17	79
Table 18	79
Table 19	80
Table 20	80
Table 21	81
Table 22	82
Table 23	82
Table 24	83
Table 25	84
Table 26	85
Table 27	86
Table 28	88