



**IN THE EXISTANCE OF SOUND WAVE: THE DEVELOPMENT OF
BESSEL HORN WAVEGUIDE TO FOCUS SOUND WAVE ENERGY
AND PRODUCE FIRE EXTINGUISHER EFFECT**

THESIS

**Submitted in Partial Fulfillment of the Requirement for the Degree
of Magister Teknik in Master Program in Electrical Engineering**

UNIVERSITAS
MERCU BUANA

by

Galang Persada Nurani Hakim

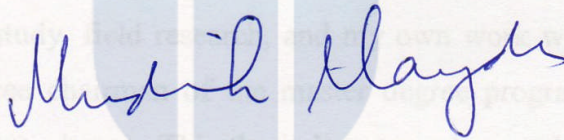
55415110010

**UNIVERSITAS MERCU BUANA
POSTGRADUATES PROGRAM**

THESIS APPROVAL FORM

Title : In The Existance Of Sound Wave: The development Of
Bessel Horn Waveguide To Focus Sound Wave Energy
And Produce Fire Extinguisher Effect
Name : Galang Persada Nurani Hakim
NIM : 55415110010
Program : Post Graduate Electrical Engineering Master Program
Date : 29 April 2017

Approved By :
Advisor

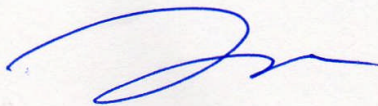


(Prof. Dr. Ing. Mudrik Alaydrus)

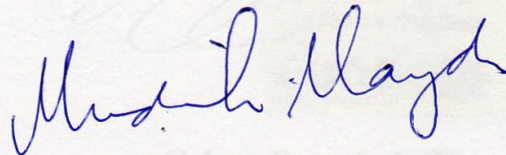
UNIVERSITAS
MERCU BUANA

Director of Postgraduate Studies

The Head of Study Program



(Prof. Dr. Didik J. Rachbini)



(Prof. Dr. Ing. Mudrik Alaydrus)

STATEMENT FORM

I Hereby declare that the result of this Thesis that I have made this is the work of my self and true authenticity

Title : In The Existance Of Sound Wave: The Development
Of Bessel Horn Waveguide To Focus Sound Wave
Energy And Produce Fire Extinguisher Effect

Name : Galang Persada Nurani Hakim

NIM : 55415110010

Program : Post Graduate Electrical Engineering Master Program

Concentration : Computer Security

Date : 29 April 2017

Is the result of literature study, field research, and my own work with guidance counselor set by the decree chairman of the master degree program electrical engineering universitas mercu buana. This thesis has never been submitted for a master's degree in similar programs in other universities. All of the information, data, and processing results used, has been clearly stated and verifiable

MERCU BUANA

Jakarta,



Galang Persada N. H.

PREFACE

Alhamdulillah, Praise to the almighty God ALLAH SWT The Most Gracious, the Most Merciful, so that the author can complete this report with the title “In The Existance Of Sound Wave: The Development Of Bessel Horn Waveguide To Focus Sound Wave Energy And Produce Fire Extinguisher Effect”

This report is written with every things passion that author have, therefore I hope the book can make a significant contribution to science community. The completion of writing this Final Report is also due to the help of colleagues around the author, Without them I cannot completed the report. The appreciation and gratitude as deep as the author is to say to:

1. Prof. Dr. Ing. Mudrik alaydrus as a conselor.
2. Both of my Loving father and mother, also for brother and sister I have.
3. My wife Diah Septiyana, also my son Laksamana Sinatriya Ramagandhi Hakim and daughter Karina Lentera Hakim.
4. And every friends at post graduates program Universitas Mercu Buana.

The author is aware of the deficiencies in this book, and the authors apologize profusely for the deficiency. All the criticism and suggestions all welcome with a big heart. The author can only say thanks as much as possible and hopefully all will be rewarded with kindness by Allah SWT. Amen.

Tangerang, 29 April 2017

Penyusun,

Galang Persada N. H.

DAFTAR ISI

COVER	i
APPROVAL FORM	ii
STATEMENT FORM	iii
ABSTRACTS.....	iv
PREFACE	v
TABLE OF CONTENTS	vii
LIST OF FIGURES	x
LIST OF TABLES	xii
CHAPTER I INTRODUCTION.....	1
1.1 Background	1
1.2 Problem statement	2
1.3 Research Goal.....	3
1.4 Research Discussion Limitation	3
1.5 Research Methodology and Design	3
CHAPTER II THEORETICAL BACKGROUND.....	4
2.1 Sound Phenomena	4
2.1.1 Sound Wave Energy Measurement	5
2.1.1.1. Sound Wave Energy in dB SPL	6
2.1.1.2. Sound Wave Energy in dBA	8
2.1.2 Sound Wave Propagation Model.....	9
2.1.3 Bessel Horn Wave Guide.....	12
2.2 Loud Speaker.....	13
2.2.1 Loud Speaker construction	14
2.2.2 Loudspeaker Radiation Direction	15
2.3 Fire Phenomena.....	16
2.4 Measurement for fire energy and sound wave energy	17

2.4.1	Sound Wave Energy Measurement Method	17	
2.4.2	Fire Energy Measurement Method	19	
2.4.3	Sound Versus Fire Measurement Time Variable.....	20	
2.4.4	Sound Versus Fire Measurement Range Variable.....	20	
2.4.5	Sound Versus Fire Measurement aperture variable.....	21	
2.5	Related Research	22	
2.5.1	Darpa Acoustic Instant Flame Suppression	22	
2.5.2	Eryn Beisener Flame Suppression Microgravity	23	
2.5.3	Ahn, I.S. Sound Lens for Sound Fire Extinguisher	24	
2.5.4	This Work	25	
CHAPTER III HARDWARE DESIGN & MEASUREMENT METHOD.		26	
3.1.	Hardware Design	26	
3.1.1	Low Signal Generator	26	3.1.2
	Audio Pre-Amplifier	27	
3.1.3	2 Channel Power Amplifier	28	3.1.4
	LoudSpeaker – SubWoofers	29	
3.1.5	Waveguide Bessel Horn design	30	
3.2.	Sound Wave Energy Measurement Device	31	
3.3.	Measurement Design Methods	32	
CHAPTER IV TESTING AND ANALYSIS		33	
4.1	Measurement Result.....	33	
4.1.1	Environmental Measurements	33	
4.1.2	Fire Extinguisher System Output Measurement.....	34	
4.1.3	Sound Wave With & Without Waveguide Tube	36	4.1.4
	Sound wave with effect of measurement angle	37	
4.1.5	Fire Energy Measurement.....	38	4.1.6
	Sound Wave Energy Versus Fire Energy	39	
4.1.7	Effectiveness of fire extinguisher function of range....	41	4.1.8
	Sound and Fire Energy with Aperture Variable	43	

4.2	Analisis.....	44
CHAPTER V CONCLUSION AND SUGGESTION.....		46
5.1	Conclusion	46
5.2	Suggestion.....	47
REFERENCE		48



UNIVERSITAS
MERCU BUANA

LIST OF FIGURES

Figure 2.1 Sound source from moving membrane.....	4
Figure 2.2 Comparison between logarithmic scale and linier scale	5
Figure 2.3 Common decibel references	7
Figure 2.4 Audible Spectrum Divided Into Decades	8
Figure 2.5 Sound Pressure Measurement in dBA.....	9
Figure 2.6 Sound Wave propagation model with distance from source	11
Figure 2.7 Sound Wave propagation model with Inverse Square law.....	11
Figure 2.8 Wavefront at horn mouth.....	12
Figure 2.9 the form of Bessel horn	12
Figure 2.10 Loud Speaker Alnico magnet woofers—Altec 515-8LF.....	13
Figure 2.11 SubWoofer Construction.....	14
Figure 2.12 Loud speakers SubWoofer Construction on side view.....	15
Figure 2.13 Loudspeaker Radiation Direction with function of wavelength	16
Figure 2.14 Fire tetrahedron	16
Figure 2.15 Sound Wave Energy Measurement Method.....	18
Figure 2.16 Sound Wave Energy Measurement with out Bessel horn	18
Figure 2.17 Sound Wave Energy Measurement with Bessel horn	19
Figure 2.18 Sound Wave Energy Measurement With respective angle	19
Figure 2.19 LPG Gas Stove	20
Figure 2.20 Sound Versus Fire with time variable	20
Figure 2.21 Sound Versus Fire with range variable	21
Figure 2.22 Sound Versus Fire with Bessel horn exit aperture variable	21
Figure 2.23 Sound Fire extinguishers equipment use by DARPA	22
Figure 2.24 Sound Fire extinguishers diagram in micro gravity	24
Figure 2.25 Sound Fire extinguishers with sound lens	25
Figure 3.1 System Block	26
Figure 3.2 Audio Signal Generated Software	27

Figure 3.3 LM386 Audio Amplifier schematic with 200 Gain	28
Figure 3.4 STK456 Audio Power Amplifier Left-Right Channel schematic	29
Figure 3.5 Hollywood HW10 Subwoofers	30
Figure 3.6 Waveguide Bessel Horn design. Entry point of view (Left), Side pint of view (middle), and Exit point of view (Right)	30
Figure 3.7 Benetech GM1351 digital sound level meter	31
Figure 3.8 Research Design flowcharts Method.....	32
Figure 4.1 Environmental Condition Measurement temperature & humidity	34
Figure 4.2 Fire Extinguisher System Output Measurement	35
Figure 4.3 Sound Wave Energy Measurements w/o Guidance Tube	37
Figure 4.4 Sound Wave Energy Measurement with angle measurement	38
Figure 4.5 Fire Energy Measurements.....	39
Figure 4.6 Sound Wave Energy versus Fire Energy effectiveness	41
Figure 4.7 Ranges between Fire Source & Sound Source	42
Figure 4.8 exit aperture variation.....	44



DAFTAR TABEL

Table 1.1 Matrix Related Research	2
Table 4.1 Fire Extinguisher System Output Measurement	35
Table 4.2 Sound Wave Energy Measurement w/o Sound Wave Guide Tube..	36
Table 4.3 Sound Wave Energy Measurement with angle measurement	38
Table 4.4 Fire Energy Measurements	39
Table 4.5 Sound Wave Energy versus Fire Energy	40
Table 4.6 Sound Wave Energy versus Fire Energy with Range Variabel	42
Table 4.7 Sound Wave Energy versus Fire Energy with Exit Aperture Variabel	43





UNIVERSITAS
MERCU BUANA