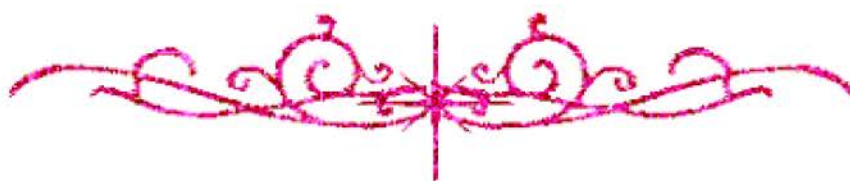


سامية محمد مصطفى



شبكة المعلومات الجامعية

بسم الله الرحمن الرحيم



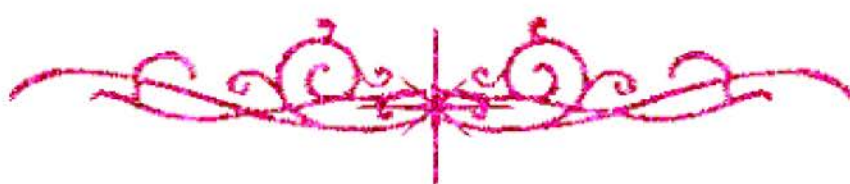
سامية محمد مصطفى



شبكة المعلومات الجامعية



شبكة المعلومات الجامعية التوثيق الالكتروني والميكروفيلم



سامية محمد مصطفى



شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

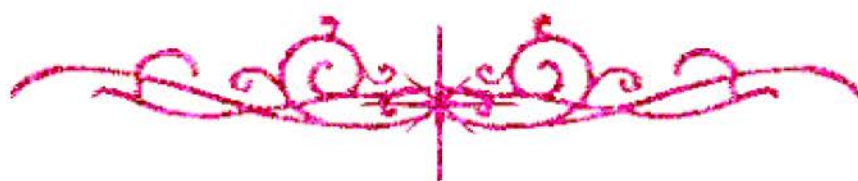
قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات



يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار



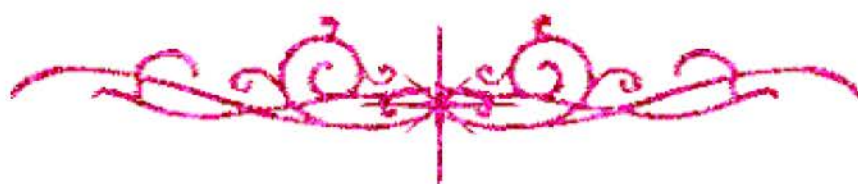
سامية محمد مصطفى



شبكة المعلومات الجامعية



بعض الوثائق الأصلية تالفة



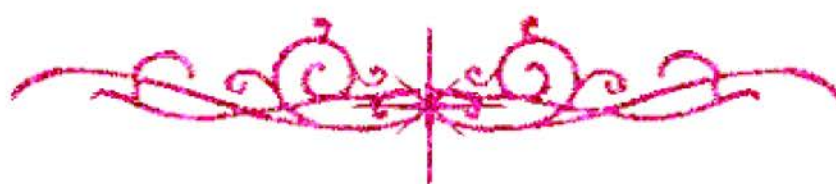
سامية محمد مصطفى



شبكة المعلومات الجامعية



بالرسالة صفحات
لم ترد بالأصل



**MATHEMATICAL MODELS WITH APPLICATION FOR THE EFFECT OF
HYDROGRAPHIC FACTORS ON ACOUSTIC ENERGY
TRANSMISSION FROM THE AIR GUN SOURCES**

A Thesis

Submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Science (M. Sc.) in
Geophysics

By

YASSER ALI HASSAN

B.Sc. Mathematics (1990) – Dip. Geophysics (1993)
Alexandria University

Supervised by

Prof. Dr. A. I. Bayoumi
Prof. of Geophysics
Geophysics Department – Faculty of Science
Cairo University

Prof. Dr. M. B. Awad
Prof. of Geophysics
Chairman of Division of Marine Environment
National Institute of Oceanography and Fisheries
Alexandria

B
10/11/2001

2001

APPROVAL SHEET

Title of the M. Sc. Thesis:

MATHEMATICAL MODELS WITH APPLICATION FOR THE EFFECT OF HYDROGRAPHIC FACTORS ON ACOUSTIC ENERGY TRANSMISSION FROM THE AIR GUN SOURCES

Submitted to:

Faculty of Science, Cairo University

Name of candidate

Yasser Ali Hassan Ali

Supervision Committee

1. Prof. Dr. A. I. Bayoumi

Geophysics Department, Faculty of Science, Cairo University

2. Prof. Dr. M. B. Awad

Chairman Division of Marine Environment

National Institute of Oceanography and Fisheries (NIOF), Alexandria

Approved

Prof. Dr. Y. E. Abdel-Hady

Chairman of Geophysics Department

Faculty of Science, Cairo University

A STATEMENT

The present thesis is submitted to the Faculty of Science, Cairo University in partial fulfillment of the requirements for the degree of Master of Science in Geophysics. Besides the research work materialized in thesis, the candidate has attended the following courses for one academic year in the following topics:

1. Applied Geophysics,
2. Earthquake Engineering,
3. Exploration Geophysics,
4. Geotectonic,
5. Marine Geophysics,
6. Mathematical Methods in Geophysics,
7. Seismic Reflection Methods,
8. Seismic Refraction Method,
9. Selected Topics in Gravity,
10. Well-logging, and
11. Data Processing.

Approved

Prof. Dr. Y. E. Abdel-Hady

Chairman of Geophysics Department

Faculty of Science, Cairo University

ACKNOWLEDGMENTS

The author wishes to express his deep gratitude and appreciation to Professor Dr. Abd El-Rehim Bayoumi, Professor of Geophysics, Faculty of Science, Cairo University for his thorough supervision, continuous encouragement and revisions. His valuable suggestions are of great value to present this scientific work in the most perfect presentation.

Deep thanks are to my Professor Dr. Morad Bacily Awad, Chairman Division of Marine Environment, and Professor of Marine Geophysics, National Institute of Oceanography and Fisheries (NIOF), Alexandria, for suggesting the point of research, his continuous supervision and his restless work to present the thesis in the best upgraded presentation.

Acknowledgments are also due to Professor Dr. Yehia Abd-Elhady, Chairman Geophysics Department, Faculty of Science, Cairo University, for his help and continuous encouragement.

Thanks are also conveyed to Dr. Samira Abd El-Kawi Mohamed Hussien, Lecturer of Marine Geophysics, Department of Marine Geology and Geophysics, Division of Marine Environment, NIOF, Alexandria, for her continuous follow-up of the present work, reading the text and valuable scientific contribution.

Special thanks are dedicated to my parents who offered me the whole comfortably to go through and to finish successfully this work.

SYMBOL KEY

a	Instantaneous Bubble radius; $a=a(t)$ [cm]
$\dot{a}$	Velocity of the bubble wall [cm/sec.]
a_i	Initial bubble radius [cm]
a_o	Equilibrium radius of the bubble [cm]
A	Relative bubble radius; $A=a/a_o$
$\dot{A}$	Velocity of the bubble wall in new unit
C	Sound speed in the fluid (saline water) [cm/sec.]
$\bar{C}$	Dimensionless sound velocity
d	Depth of the pulser in water [m]
E_o	Potential energy contained in the pulse [joule]
E_s	Total energy radiated by shock wave [joule]
K	Coefficient dependent on fish species.
$P(r,t)$	Acoustic pressure at distance r from the bubble in water [bar]
P_c	Chamber pressure of the air gun before releasing [atm]
P_m	Minimum pressure in the bubble when its volume is maximum
P_o	Hydrostatic pressure just outside the air bubble [μ bar]
r	Radial distance from the bubble center [cm]
R	The damage zone radius [m]
t	Time [sec.]
t_B	Bubble pulse oscillation period [sec]
$\bar{T}$	Adapted unit of time
V_c	Volume of the air gun chamber [liter]
V_o	Equilibrium volume of the air bubble
W	Charge weights [kg]
x_1	New variable represent relative bubble radius; $x_1(\tau) = A(\tau)$
x_2	New variable represent velocity of the bubble wall in new unit;
ε	Constant dependent on potential energy of the pulser
γ	The variable of state of expansion of the air stored in pulser
γ_o	The variable of state of the air during the bubble oscillation
ρ	Density of the fluid (saline water) [g/cm^3]
τ	Time in adapted units; $t = \tau \bar{T}$
τ_B	Bubble period in adapted units; $t_B = \tau_B \bar{T}$

ABSTRACT

The present study, which is confined to investigate the effect of hydrographic parameters on the acoustic pressure wave radiated by the air-gun in the water and the effect of the shock wave introduced by non-explosive air-gun (volume $V_c=1/6$ L and chamber pressure $P_c=150$ atm), reveals that the primary pressure is found to be directly proportional to both the water density and temperature whereas acoustic pressure (at first maximum bubble radius) is found to be inversely proportional to both the water density and temperature. Moreover, the instantaneous primary-to-bubble ratio increase by 0.008% when the water temperature was increased from 20 °C to 40 °C and the primary pressure and the acoustic pressure (at first maximum radius) are directly proportional to the depth of the water.

The present study indicates that the bubble pulse oscillation period is found to be decreasing by about 1.6% over that period predicted for the smaller value of the specific heat ratio when it increases by 0.01. Through the shock pulse duration - the intensity of the energy radiated near the source is inversely proportional to the bubble radius-square. The energy intensity approaches the conditions of decreasing is proportional to the bubble radius as the velocity of the bubble wall less more than critical.

As for the effect of the energy radiated by an air gun of volume 1/6 L, chamber pressure 150 atm and has an initial energy of 13600 joule on the marine life, it is indicted that if the value of K (coefficient dependent on fish species) is 54 the maximum dangerous radius is 4.4 m (i.e., the risk of damage to invertebrata is 4.4 m), if the value of K is 12 the minimum dangerous radius is 1 m (i.e., the risk of damage to vertebrata is 1 m), if the value of K is 25.5 the middle dangerous radius is 2.1 m (i.e., the risk of damage to protochordata is 2.1 m) and the risk of damage to marine life increases with increasing depth at which the air gun is fired.

PREFACE

During the last few years the air gun, or the airpulser, with some physical processes among which are those which control the free bubble oscillation characteristics as well as the total energy by the shock wave spreading out in either incompressible or compressible water medium has become very common as an energy source of non-explosive nature for marine seismic surveys taking into consideration that the usual theory of these oscillations when treating the water as incompressible yields undamped oscillations of constant period whereas in treating the water as compressible damped oscillations of diminishing period are obtained.

In either case one has to compute radius-time curves in order to find out the pressure waves emitted by the bubble, a matter which is considered of major importance in evaluating explosive damage. Because of the rapidly development of new and improved equipments and techniques in marine operation, a vast amount of data had been recorded each day around the world and leading to important results for the sedimentary section under the sea water.

Thus, **the purpose of the present work** is **first** to review different explosive and non-explosive tools used as energy sources in marine seismic surveys and **second** to give a brief review on the theory of free bubble oscillation. In addition to that a new mathematical approach for calculating the radius-time curve as well as the acoustic pressure of the air bubble are introduced through analyzing Keller and Kolodner equation (1956)/ which describes the motion of the air bubble in the water/ by converting it into two first order ordinary differential equations, and solving them by Runge-Kutta method (Cheney Ward; Kincaid David Jan 1980). In this analysis two initial conditions for the initial bubble radius and velocity of the bubble wall rather than those used by Kelier and Kolodner are introduced in order to attain a more or less specific radius-time curve and pressure data that are most accurate for any case when computed by a large number of periods and variety of explosions.

The present study also deals with evaluation of the effects of hydrographic parameters (water density, temperature, and depth) on acoustic pressure as well as to determine the total energy radiated by the shock wave that satisfying both the cylindrical and spherical divergence.

TABLE OF CONTENTS

	Page
<i>ACKNOWLEDGMENTS.</i>	
<i>SYMBOL KEY</i>	
<i>ABSTRACT</i>	
<i>PREFACE</i>	
CHAPTER I: INTRODUCTION.	1
I-A. Marine Energy Sources.	1
I-A-1. Dynamite.	1
I-A-2. Flexotir.	1
I-A-3. Maxipulse.	2
I-A-4. Aquaseis.	3
I-A-5. Air Gun.	4
I-A-6. Water Gun.	5
I-A-7. Aquapulse.	6
I-A-8. The Vaporcho (Steam Gun).	7
I-A-9. Sparkers.	8
I-A-10. Imploders.	9
I-B. Previous Works.	11
CHAPTER II: DETERMINATION OF THE ACOUSTIC PRESSURE..	14
II-A. Theory of Free Bubble Oscillation.	14
II-B. A New Mathematical Approach to Calculate the Radius- Time Curve and hence the Pressure.	14
II-B-1. Initial bubble radius.	15
II-B-2. The equilibrium radius.	16
II-C. Application for One Pulser Types.	16
II-C-1. Radius-time curve.	16
II-C-2. Acoustic pressure of the bubble.	17
II-D. New Initial Conditions Approach.	22
II-D-1. Radius-time curve.	22
II-D-2. Acoustic pressure of the bubble.	22

CHAPTER III: THE EFFECT OF THE HYDROGRAPHIC FACTORS	
ON ACOUSTIC PRESSURE.	27
III-A. Effect of Water Density on Acoustic Pressure.	33
III-B. Effect of Water Temperature on Acoustic Pressure.	49
III-C. Effect of Depth on Acoustic Pressure.	63
CHAPTER IV: TOTAL ENERGY RADIATED BY THE SHOCK	
WAVE.	77
IV-A. Application in Case of the Airpulser.	79
IV-B. Air Gun / Dynamite Picture.	83
IV-C. Effect on Marine Life.	85
CHAPTER V: SUMMARY AND CONCLUSION.	88
REFERENCES.	93
APPENDICES.	
APPENDIX I. SIMPLE INTERPRETATION / INTEGRATION	
PROGRAM FOR COMPUTATION OF TOTAL ENERGY	
RADIATED BY AIR GUN.	97
APPENDIX II. OUTPUT OF THE PROGRAM; THE INSTANTANEOUS	
ACOUSTIC PRESSURE AND ENERGY INTENSITY	
THROUGH THE SHOCK PULSE DURATION.	101
ARABIC SUMMARY.	