

شبكة المعلومات الجامعية

بسم الله الرحمن الرحيم



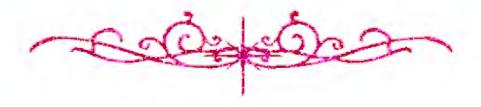
-Call 16000

سامية محمد مصطفى

شبكة اللعلومات الحامعية



شبكة المعلومات الجامعية التوثيق الالكتروني والميكروفيلم





سامية محمد مصطفى

ثبيكة اللعلومات الجامعية

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

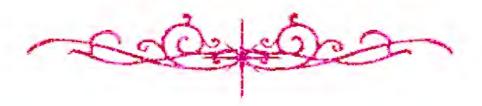
قسم

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



Krivori ASUNET

سامية محمد مصطفى

شبكة المعلومات الجامعية





سامية محمد مصطفى

شبكة المعلومات الجامعية



بالرسالة صفحات لم ترد بالأصل





AIN SHAMS UNIVERSITY FACULTY OF ENGINEERING DESIGN AND PRODUCTION ENGINEERING DEPARTMENT

OPTIMIZATION OF CO₂ LASER CUTTING PARAMETERS FOR ADVANCED MATERIALS

A Thesis Submitted in Partial Fulfillment for the Requirements of the Degree of Ph.D. in Mechanical Engineering

(Design and Production Engineering)

by

Eng. Ahmed Mohamed El Wardany Mohamed

M.Sc. In Mechanical Engineering (Design and Production Engineering) Faculty of Engineering, Ain Shams University, 2014

Supervised by

Prof. Dr. Mohamed Abdel Mohsen Sayed Mahdy Prof. Dr. Hesham Aly Abdel Hamid Sonbol

Cairo -(2019)



AIN SHAMS UNIVERSITY FACULTY OF ENGINEERING DESIGN AND PRODUCTION ENGINEERING DEPARTMENT

OPTIMIZATION OF CO₂ LASER CUTTING PARAMETERS FOR ADVANCED MATERIALS

by

Eng. Ahmed Mohamed El Wardany Mohamed

M. Sc. In Mechanical Engineering (Design and Production Engineering) Faculty of Engineering, Ain Shams University, 2014

Supervising Committee

Name, Title and Affiliation	Signature
Prof. Dr. Mohamed Abdel Mohsen Sayed Mahdy	
Professor of Production Engineering,	
Design and Production Engineering Department,	
Faculty of Engineering, Ain Shams University.	
Prof. Dr. Hesham Aly Abdel Hamid Sonbol	
Professor of Production Engineering,	
Design and Production Engineering Department,	
Faculty of Engineering, Ain Shams University.	

Date: 11 April 2019



AIN SHAMS UNIVERSITY FACULTY OF ENGINEERING DESIGN AND PRODUCTION ENGINEERING DEPARTMENT

OPTIMIZATION OF CO₂ LASER CUTTING PARAMETERS FOR ADVANCED MATERIALS

by

Eng. Ahmed Mohamed El Wardany Mohamed

M. Sc. In Mechanical Engineering (Design and Production Engineering) Faculty of Engineering, Ain Shams University, 2014

EXAMINERS COMMITTEE

Name, Title and Affiliation	Signature
Prof. Dr. Samy Jimmy Ebeid	
Professor of Production Engineering, Design and Production Engineering Department, Faculty of Engineering, Ain Shams University.	
Prof. Dr. Ahmed Mohamed Abdel Aziz Kohail	
Professor of Production Engineering, Manufacturing Engineering and Production Tech. Department, Modern Academy for Engineering and Technology.	
Prof. Dr. Mohamed Abdel Mohsen Sayed Mahdy	
Professor of Production Engineering, Design and Production Engineering Department, Faculty of Engineering, Ain Shams University.	
Prof. Dr. Hesham Aly Abdel Hamid Sonbol	
Professor of Production Engineering, Design and Production Engineering Department, Faculty of Engineering, Ain Shams University.	

Date: 11 April 2019

Researcher data

Name: Ahmed Modamed El Wardany Mohamed

Date of birth: February 11, 1984

Place of birth: Giza, Egypt

Last academic degree: Master of science in mechanical

engineering

Field of specialization: Design and production Engineering

University issued the degree: Ain shams university

Date of issued degree: June 2014

Current job: Lecturer assistant, Modern academy for engineering and technology

Email: wardany2012@gmail.com

Statement

This thesis is submitted as partial fulfillment of Doctor of Philosophy in Mechanical Engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no Part of it has been submitted for a degree or qualification at any other scientific entity.

Ahmed Mohamed El Wardany Mohamed

Signature

Date: 11 April 2019

Abstract

Laser beam cutting is one of the major applications of lasers in sheet metal working. In this thesis, an experimental study in CO₂ laser cutting process is presented. The aim of this research is to investigate the effect of the laser cutting process variables on the cutting-edge quality parameters. Further to develop mathematical models and optimize the various laser cutting variables for each of the studied materials. Two different techniques namely: statistical regression and artificial neural networks were used to develop the mathematical models. Three difficult to cut materials namely: stainless steel 316, Armox500T, and aluminum AG5 were chosen as workpiece materials in this research. A 4.4 kW CO₂ Bystar L 4025-65 industrial laser cutting machine was used to perform the cutting operations. Several experiments were conducted to investigate the influence of four input variables: focal plane position, assist gas pressure, laser power, and cutting speed on the four most important performance parameters, namely: upper kerf width, lower kerf width, kerf taper angle, and the arithmetic average surface roughness Ra. The experimental plan was performed using L₃₂ 1²×3⁴ Taguchi standard orthogonal matrix. The developed ANN models are based on multilayer feed-forward neural networks. The experimentally acquired data was used to train, validate and test the ANN performance, and special graphs were drawn for this purpose. Minitab software was used to build up the mathematical models using regression analysis. As well as to generate the main effects plot for the process variables on the performance parameters in order to determine the most significant variables. The developed models were validated and proved their capability to predict the laser cutting process output parameters for certain input variables inside the covered range of this study. Genetic optimization search algorithm was used to suggest the near optimal setting combinations of the four input variables in their operating range, to achieve a minimum of surface roughness Ra and kerf taper angle θ_k .

This research would provide a good demonstration for the most significant input variables and new models based on regression, and ANN technique to predict the cutting-edge quality parameters, which can be used for solving related industrial problems.

Keywords

Laser beam cutting, stainless steel 316, ARMOX 500T, aluminum AG5, artificial neural networks, genetic algorithm, surface roughness, upper kerf width, lower kerf width, kerf taper angle.

Acknowledgement

I would like to thank Allah Almighty for blessing and giving me strength to accomplish this thesis. A special thanks to my supervisors, Prof. Dr. Hesham Aly Abdel Hamed Sonbol who greatly helped me in every way I need to go through this study, Prof. Dr. Mohamed Abdel Mohsen Mahdy co-supervisor and also for his encouragements.

I would like to express my sincere appreciation to my professors Prof. Dr. Ahmed Kohail, Prof. Dr. Nabil Gadallah, and Dr Nasr Aref for their interest and continuous support in every way I need to go through this study. I am also grateful to all of my friends and colleagues in modern academy for engineering and technology especially Dr. Yahia Elattar for his advice and continuous support.

Many thanks to Eng. Abdel Sadek abdel Reheem, and all of the engineers and technicians in laser cutting station, Kader factory for developed industries-Arab organization for industry, for their cooperation and assisting me in conducting the various experimental tasks.

Deepest gratitude to my parents, Mohamed El Wardany and A. Ibrahim, who give me a real love, pray, support, and all they have. Also, to my wife Fatma Hassan for her continuous encouragement and patience.

Finally, I am grateful to Modern Academy for engineering and technology especially Eng. Khalid Ghaly, and Ahmed Mokhtar for their cooperation and assisting me in the various laboratory tasks in the metrology lab. during the period of this research work.

Table of Contents

Researcher data I
Statement II
AbstractIII
AcknowledgementV
List of FiguresXI
List of TablesXVII
List of AbbreviationsXIX
Chapter 1 : Introduction1
1.1. General introduction1
1.2. Historical background
1.3. Problem statement
1.4. Research objectives5
1.5. Research methodology6
1.6. Thesis organization
Chapter 2 : Literature review9
2.1. Introduction to laser9
2.2. Types of Lasers
2.3. The carbon dioxide (CO ₂) laser13
2.3.1. The sealed tube laser system15
2.3.2. Transversely excited atmospheric pressure laser system (TEA)15
2.3.3. Slow axial flow laser system16
2.3.4. Fast axial flow laser system
2.3.5. Transverse flow lasers
2.4. laser applications in materials processing
2.5. Laser beam cutting
2.5.1. Mechanisms of material removal in LBC21
2.5.2. Laser cutting process parameters