METHODS OF CUTTING PROFILES WITH SHARP CURVATURE IN CO₂ LASER CUTTING

By

CHU PAU LOONG

A Project Report Submitted in Partial Fulfillment for the Degree of

Master of Science (Applied Physics)

2003

Department of Physics

Faculty of Science

University of Malaya
ACKNOWLEDGEMENT

I would like to thank my supervisor Professor Dr. Low Kum Sang for his invaluable guidance, advice and encouragement. I also like to express my gratitude to my project partner Mr. Law Sie Chong for his cooperation in this project. I am grateful to other Research Assistants Mr. Phua Yong Nam, Mr. Lee Jer Vui, Mr. Albert Ng for their help and assistance.
ABSTRAK

ABSTRACT

The main objective of this project is to develop a sharp curvature cutting algorithm and integrate into a CO₂ Laser Cutting (2D CAD/CAM) program. The existing 8-tube FAF CW CO₂ laser system developed at the University of Malaya together with an existing XY control table is utilized to study the cutting of sharp curvature profiles. A CO₂ laser cutting program with user-friendly graphical user interface is developed using Visual Basic 6 and MINT programming language via MINT Interface Library to drive the controller card and hence the motor. A Rounded Corner cutting algorithm is developed which blends an arc motion in between two straight line segments so that no abrupt stop is experienced during the turn at the sharp corner. Constant speed is maintained throughout the corner cutting. The cutting results and quality for different corner angle sizes and directions are analyzed and studied.
CONTENTS

ACKNOWLEDGEMENT

ABSTRAK

ABSTRACT

CONTENTS

CHAPTER 1: INTRODUCTION

1.1 CO₂ Laser Cutting Background and Applications 1
1.2 Brief Review of CO₂ Laser Machining Process 1
1.3 Objectives of the study 3

CHAPTER 2: LITERATURES REVIEW

2.1 Basic Principle of CO₂ Laser 4
  2.1.1 The CO₂ Molecule Vibrational Mode 4
  2.1.2 Excitation of the CO₂ Molecule 6
  2.1.3 The Role of Nitrogen in Lasing 7
  2.1.4 The Role of Helium in Lasing 8

2.2 Laser Cutting Parameters 9
  2.2.1 Laser Beam Properties 9
  2.2.2 Material Properties 16

2.3 Laser Cutting Mechanism 18
  2.3.1 Laser-Material Interaction 18
  2.3.2 Heat Conduction 20
  2.3.3 Moving Heat Source 23
  2.3.4 Oxidation 24
  2.3.5 Striation Formation 25

2.4 Sharp Curvature 27
  2.4.1 Heat Transfer in Curved Trajectories 27
  2.4.2 Classification of Corner Types 31
  2.4.3 Sharp Curvature Cutting Techniques 32
## CHAPTER 3: EXPERIMENTAL METHODOLOGY

3.1 The CO₂ Laser System
   3.1.1 Power Supply System 34
   3.1.2 Laser Resonator 37
   3.1.3 Vacuum and Recirculation System 40
   3.1.4 Gas Cooling System 42

3.2 Beam Delivery System 43

3.3 The Motion Control System
   3.3.1 The XY-Table 44
   3.3.2 The Controller Card 45
   3.3.3 Servo Motor Driver 47
   3.3.4 Motor Lead Screw and Encoder 48

3.4 Development of 2D CAD/CAM Program
   3.4.1 Visual Basic 6 Programming Language 49
   3.4.2 MINT Programming Language 54
   3.4.3 MINT Interface Library 61

## CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 CO₂ Laser Cutting Program
   4.1.1 XY Motion Form 66
   4.1.2 Database Entry 67
   4.1.3 System Setup 68
   4.1.4 System Status 69
   4.1.5 Drawing Area 70

4.2 Rounded Corner Method
   4.2.1 Geometric Analysis 71
   4.2.2 Constructing a Visual Basic Corner Fillet Function 74
   4.2.3 Corner Fillet Function 75
   4.2.4 Corner of Any Size 75
   4.2.5 Axes Rotation 77
   4.2.6 Corner Fillet Function Source Code 77
   4.2.7 CO₂ Laser Cutting Program Flow Chart 78
   4.2.8 Cutting Results and Analysis 79
   4.2.9 Discussions 88
CHAPTER 5: CONCLUSION

5.1 Summary  89
5.2 Suggestion for future studies  90

REFERENCES  vii

APPENDIX 1  xii

APPENDIX 2  xviii