

Table of Contents

CHAPTER 1 THE BASICS OF THE LASER CUTTING PROCESS	1
<u>1.1 Introduction</u>	1
<u>1.2 Why Use Laser Cutting?</u>	2
<u>1.3 Types of High Power Laser Cutting Machines</u>	4
<u>1.3.1 Three Dimensional Laser Cutting</u>	6
<u>1.4 The Main Differences between CO₂ and Fiber Laser Cutting</u>	7
<u>1.4.1 Cutting Speeds</u>	7
<u>1.4.2 Cut Quality</u>	8
<u>1.5 Laser Cutting Job Shops</u>	10
CHAPTER 2 HOW LASERS CUT DIFFERENT MATERIALS	12
<u>2.1 General Notes</u>	12
<u>2.2 Cutting Stainless Steels</u>	13
<u>2.3 Cutting Mild and Carbon Steels</u>	15
<u>2.3.1 Cutting Mild Steel with Oxygen</u>	16
<u>2.3.1.1 Flame Cutting</u>	16
<u>2.3.1.2 Laser-oxygen Cutting of Mild Steel</u>	17
<u>2.3.2 Cutting Mild Steel with Nitrogen</u>	20
<u>2.3.3 Improved Edge Quality when Cutting Mild Steel with Nitrogen Rather than Oxygen</u>	20
<u>2.4 Cutting Alloy Steels</u>	22
<u>2.5 Cutting Non-Ferrous Metals</u>	22
<u>2.5.1 Aluminum and Copper Alloys</u>	22
<u>2.5.1.1 The Effect of High Reflectivity</u>	23
<u>2.5.1.2 The Effect of High Thermal Conductivity</u>	24
<u>2.5.2 Titanium Alloys</u>	24
<u>2.5.3 Nickel Alloys</u>	26
<u>2.5.4 Other Alloys</u>	26
<u>2.6 Cutting Non-Metals with CO₂ Lasers</u>	27
<u>2.6.1 General Notes</u>	27
<u>2.6.2 Polymers</u>	27
<u>2.6.2.1 Thermoplastics</u>	27
<u>2.6.2.2 Thermoset Plastics</u>	29
<u>2.6.2.3 Fiber Reinforced Plastics</u>	30
<u>2.6.3 Wood Based Products</u>	30

2.6.4.	<u>Ceramics and Glass</u>	31
2.6.4.1	<u>Ceramics</u>	31
2.6.4.2	<u>Glasses</u>	33
2.6.5	<u>Other Non-metals</u>	33
2.7	<u>Technical Differences between the Fiber Laser and the CO₂ Laser</u>	33
2.7.1	<u>Laser Design Differences</u>	33
2.7.2	<u>Cutting Mechanism Differences</u>	36
 CHAPTER 3 CUT QUALITY		40
3.1	<u>General Comments on Cut Quality</u>	40
3.2	<u>Positional Accuracy</u>	41
3.3	<u>Cut Width and Taper</u>	41
3.3.1	<u>Cut Width</u>	41
3.3.2	<u>Cut Taper</u>	42
3.4	<u>Cut Edge Roughness</u>	43
3.4.1	<u>General Notes</u>	43
3.4.2	<u>Burning During Oxidation Cutting</u>	43
3.5	<u>Dross or Burr on the Lower Edge of the Cut</u>	45
3.5.1	<u>General Note</u>	45
3.5.2	<u>Dross in Laser Cutting Mild or Carbon Steels</u>	46
3.5.3	<u>Dross in CO₂ Laser Cutting</u>	47
3.5.4	<u>Dross in Fiber Laser Cutting</u>	48
3.6	<u>Heat Affected Zones (HAZ)</u>	49
3.6.1	<u>Mild and Carbon Steels</u>	49
3.6.2	<u>Stainless Steels and Non-ferrous Alloys</u>	50
3.7	<u>Chemical Contamination of the Cut Edge</u>	51
3.7.1	<u>Titanium</u>	51
3.7.2	<u>Stainless Steel</u>	51
3.7.3	<u>Non-metals</u>	52
3.8	<u>Stop/Start Marks</u>	52
3.9	<u>Spatter</u>	54
3.10	<u>Thermal Distortion</u>	56
3.11	<u>Troubleshooting the Cutting Process</u>	58
3.12	<u>Concluding Comments</u>	64
 CHAPTER 4 CUTTING SPEEDS		65
4.1	<u>General Comments on Cutting Speeds</u>	65
4.2	<u>The Effect of Laser Power on Cutting Speed</u>	66
4.3	<u>The Effect of Lens Focal Length on Cutting Speed</u>	66
4.4	<u>The Effect of Material Properties on Cutting Speed</u>	67
4.5	<u>Maximum Sheet Thickness</u>	68
4.6	<u>Cutting Speed Tables</u>	68
4.6.1	<u>Cutting Speeds for Metals - CO₂ and Fiber Laser</u>	68
4.6.2	<u>Cutting Speeds for Non-metals – CO₂ Lasers Only</u>	72
 CHAPTER 5 COMMERCIAL CONSIDERATIONS		76
5.1	<u>Introduction</u>	76
5.2	<u>Buying a Laser Cutting Machine</u>	76

5.3	<u>A Commercial Comparison of CO₂ and Fiber Cutting Technologies</u>	78
5.4	<u>Ancillary Equipment</u>	79
5.4.1	<u>Loading Tables</u>	80
5.4.2	<u>Automated Material Storage</u>	80
5.5	<u>Training</u>	80
5.6	<u>Safety Considerations</u>	81

CHAPTER 6 SOME OF THE SCIENTIFIC ASPECTS OF LASER CUTTING..... 82

6.1	<u>Factors Affecting the Efficiency of Laser Cutting</u>	82
6.1.1	<u>Computer Modeling of Beam Absorption</u>	93
6.2	<u>The Physics and Chemistry of Laser-Oxygen Cutting</u>	97
6.2.1	<u>How Much Energy is Created by the Oxidation Reaction?</u>	102
6.2.2	<u>Interactions between the Laser, Oxygen and Mild Steel</u>	103
6.2.3	<u>Does the Melt in the Cutting Zone Experience Any Boiling or Dissociation?</u>	107

REFERENCES

112

LIST OF TABLES.....

114

LIST OF FIGURES

115

INDEX.....

120