

# TABLE OF CONTENTS

<b>INTRODUCTION.....</b>	<b>1</b>
1.1 LASERS IN MATERIALS PROCESSING .....	1
1.2 BRIEF REVIEW OF THE DEVELOPMENT OF LASER CUTTERS .....	2
1.3 RESEARCH OBJECTIVE .....	4
<b>REVIEW OF LASER CUTTING OF MATERIALS .....</b>	<b>6</b>
2.1 CO <sub>2</sub> LASER.....	6
2.2 TYPES OF CO <sub>2</sub> LASER .....	8
2.2.1 Sealed-off System.....	8
2.2.2 Slow-flow System.....	9
2.2.3 Fast-flow System.....	9
2.3 LASER MODES AND FOCUSING PROPERTIES.....	12
2.3.1 Transverse Mode and Gaussian Beam .....	12
2.3.2 Focusing Properties and Spot Size .....	12
2.4 LASER CUTTING MECHANISM .....	14
2.4.1 Light Absorption Process in Laser Cutting .....	15
2.4.2 Thermal Heat Transport .....	18
2.4.3 Energy Requirement.....	19
2.4.4 Plasma Ionisation Effect .....	19
2.5 POSITIONING SYSTEM: X-Y MOTION MACHINE SYSTEM .....	20
2.5.1 Closed Loop Positioning Scheme .....	21
2.5.2 Position Controller.....	24
2.5.2.1 Interpolated Moves.....	25
2.5.2.2 Velocity Profiles .....	26
2.5.2.3 Contoured Moves .....	26
2.5.3 Motor .....	26
2.5.4 Controller Language: MINT.....	27
<b>DESIGN AND INTEGRATION .....</b>	<b>29</b>
3.1 INTEGRATION OF THE LASER SYSTEM .....	30
3.1.1 Power Supply.....	30
3.1.2 Optical Resonator – output coupler, back mirror .....	32
3.1.3 Discharge Channels and Electrodes.....	33
3.1.4 Cooling System and Gas Recirculating System.....	33
3.1.5 Vacuum Pump .....	34
3.2 DESIGN OF THE FRAME STRUCTURE AND THE JIG.....	34
3.3 INTEGRATION OF THE HYBRID POSITIONING SYSTEM.....	36
3.4 DESIGN OF THE BEAM TRANSPORT SYSTEM AND AUXILIARY COMPONENTS .....	37
3.4.1 Beam Folding Mirror.....	38
3.4.2 Beam Shutter and Beam Absorber.....	38
3.4.3 Laser Head and Assist Gas .....	38
3.4.3.1 Focussing Lens .....	38
3.4.3.2 Assist Gas .....	38
3.4.4 Parallelism and Beam Alignment .....	39
3.5 DEVELOPMENT OF THE CONTROLLING SOFTWARE: LASERCAM.....	40
3.5.1 RS232 Protocol .....	41
3.5.2 Terminal Emulation .....	41
3.5.3 Conversion Filter (PLT to MINT).....	41
3.5.4 Code Editing.....	42
3.5.5 Debugging and Simulation .....	42
3.5.6 CAD (AutoCAD) <sup>1</sup> .....	42
<b>EXPERIMENTAL RESULTS .....</b>	<b>43</b>
4.1 LASER.....	43
4.1.1 Current-Voltage Characteristics .....	44

4.1.2	<i>Laser Output Power and Efficiency</i> .....	45
4.1.3	<i>Gas Composition</i> .....	47
4.1.4	<i>Beam Mode</i> .....	47
4.2	POSITION SYSTEM.....	48
4.2.1	<i>PIVF Tuning</i> .....	48
4.2.2	<i>Specifications of the Jig and Its Motion Performance</i> .....	56
4.3	CUT QUALITY .....	56
4.3.1	<i>Mild Steel</i> .....	57
4.3.2	<i>Stainless Steel</i> .....	59
4.3.3	<i>Glass</i> .....	61
4.3.4	<i>Softwood (Pinewood)</i> .....	63
4.3.5	<i>Plastic (Acrylic)</i> .....	64
4.4	PROFILE CUTTING.....	67
<b>SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER STUDIES</b> .....		69
5.1	SUMMARY OF RESULT .....	69
5.2	CONCLUSION.....	70
5.3	SUGGESTIONS FOR FURTHER STUDIES.....	71
<b>REFERENCE</b> .....		73

PERPUSTAKAAN INSTITUT PENGAJIAN  
SISWAZAH DAN PENYELIDIKAN  
UNIVERSITI MALAYA