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CO_2 LASER CUTTING OF GLASS FIBRE REINFORCED POLYMER COMPOSITE

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ABSTRACT

Glass fibre reinforced polymers hard to machine due to matrix, fibre structure combination. CO_2 lasers were used to cut of glass fibre reinforced polymer composite. To know the prospective factors that considerably affect the cutting quality is essential. This research outlines a method to investigate CO_2 laser machining of composites and to evaluate the process variables include cutting speed, current, and nozzle work material gap. Experiment indicate that the higher the current and the higher the cutting speed, result in higher the material removal rate and other parameter such as current and nozzle, work material gapare also significant impact on the cutting process of the glass fibre polymer composite.

Keywords: glass fibre, CO_2 laser, polymer composite.

1. INTRODUCTION

Application of Glass fibre reinforced plastic (GFRP) composites in many sectors increased due to their hardness and strength. Parts made from GFRP are in near-net-shape, though, machiningis still required. Selection of appropriate cuttingfactor is important to improve the manufacturing efficiency [1]. Demands for laser machining in industries are steadily increasing [2]. Presently, laser cutting is commonly used to as machining process for all type of materials [3]. In composites machined by turning and milling produced poor quality surfaces due to protruding fibres and delamination [4]. Laser machining is an ideal process for cuttingfibre reinforced composites due to high cutting speed, flexible process. However, laser power may damage the composites thermally and affects their properties. Laser cutting uses thermalenergy, here a focused laser beam is directed with lens system on to the work material [5]. Many authors reported experiment on CO_2 laser machining quality of composites [6]. To understands the quality of cut surface, the cutting width of the laser machining investigated. The laser cutting on polymers may damage the surfaces [7-8]. In this article the effect of laser speed, nozzle-work material gap and power on material removal rate (MRR)and cutting width of glass fiber reinforced composite was investigated on cutting speeds, current and nozzle-work material gap.

2. MATERIAL AND METHODS

A CNC CO_2 Laser Cutting Machine (EzLaser40400 with Hermetic Sealed CO2 Glass Tube Laser of 50W power, 10.64μm wavelength, 42 Stepper Motor, Cutting Speed: 0 - 50 mm/s was used to cut the GFRP composites. The influencing process variables such as cutting speed, current, and nozzle-work material gap were investigated on the effect of cutting width and material removal rate (MRR). The laser finite diameter CO_2 laser is focused on to the work material. The work material was set in flat position on machine table. The cutting was carried out on a 100 x 50 x 3 mm GFRP composite sheet for a length of 100 mm. The cutting was carried out by varying cutting speed, power and nozzle - work material gap. The performance of CO_2 laser cutting was evaluated against MRR and cutting width. The laser cutting parameters and their three levels were given in the Table-1. The width of cut was measured with anopticalmicroscope. Power, gap, and the cutting speed were varied in order to investigate the interaction behaviours. Table-2 shows the experiment plan and measured results.

Table-1. Laser cutting process parameters and their levels.

Input Parameter	Levels		
	Level 1	**Level 2**	**Level 3**
Power	40	45	50
Speed (mm/Sec)	5	10	15
Gap (mm)	6	7	8

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Table-2. Experiment plan and result.

No.	Current (A)	Speed (mm/sec)	Gap (mm)	Fibre cut width (mm)	MRR (mm^3/sec)
1	40	5	6	1.32	19.8
2	40	5	7	0.75	11.25
3	40	5	8	0.75	11.25
4	40	10	6	0.64	19.2
5	40	10	7	0.59	17.7
6	40	10	8	0.59	17.7
7	40	15	6	0.61	27.45
8	40	15	7	0.51	22.95
9	40	15	8	0.55	24.75
10	45	5	6	1.08	16.2
11	45	5	7	0.85	12.75
12	45	5	8	0.75	11.25
13	45	10	6	0.84	25.2
14	45	10	7	0.64	19.2
15	45	10	8	0.58	17.4
16	45	15	6	0.52	23.4
17	45	15	7	0.58	26.1
18	45	15	8	0.57	25.65
19	50	5	6	1.32	19.8
20	50	5	7	0.82	12.3
21	50	5	8	0.95	14.25
22	50	10	6	0.75	22.5
23	50	10	7	0.63	18.9
24	50	10	8	0.67	20.1
25	50	15	6	0.56	25.2
26	50	15	7	0.57	25.65
27	50	15	8	0.61	27.45

3. RESULTS AND DISCUSSIONS

The cutting width was measured using a Meiji optical microscope an optical microscope (MEIJI Techno MT7000). Figure-1 shows the laser cut width for different current. In general, for all current settings, cutting speed increases, cutting width decreases at all three different current range tested and shorter the gap wider the cutting width for the current setting except for 50A current setting. The maximum cutting width of 1.32 mm achieved was for the 6 mm gap settings and smaller the width of the cutting was observed for the higher cutting speed, 15 mm/sec. Finding also revealed that at high cutting speeds, narrow area of materials only melted.

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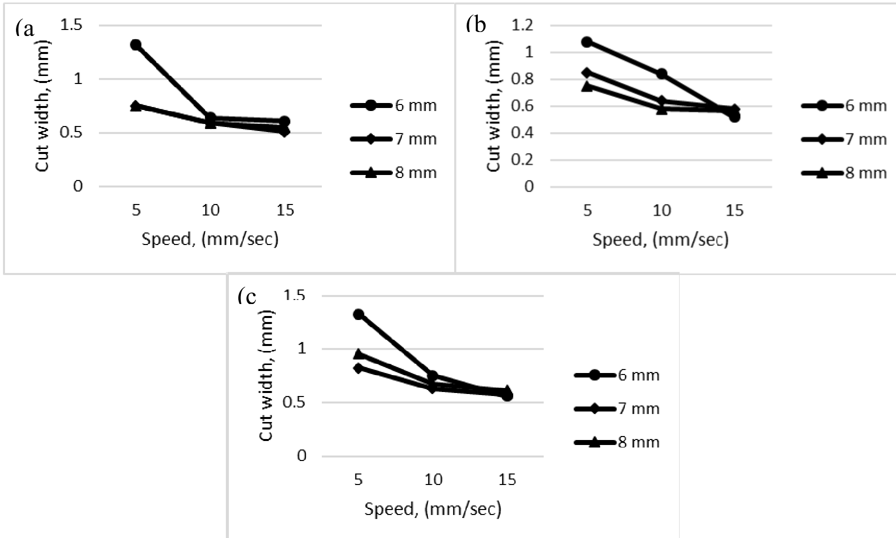

Figure-1. Laser cut width for different speed and gap (a) 40 A current (b) 45 A (c) 50 A current.

Figure-2 illustrates material removal rate (MRR) for cutting speed and at gap and current. MRR increased with cutting speed regardless current settings. MRR increased with increasing cutting speed for all gap tested except for 45A current with 15 mm/sec speed. MRR increased cutting speed increased irrespective of nozzle, work gap. In general, MRRs at 15 mm/sec cutting speed increased more than one fold of those at 5 mm/sec. Maximum MRR of 27.45 mm^3/sec was achieved when cutting at 15 mm/sec. Findings also revealed that gap and current had little influence on the material removal rate.

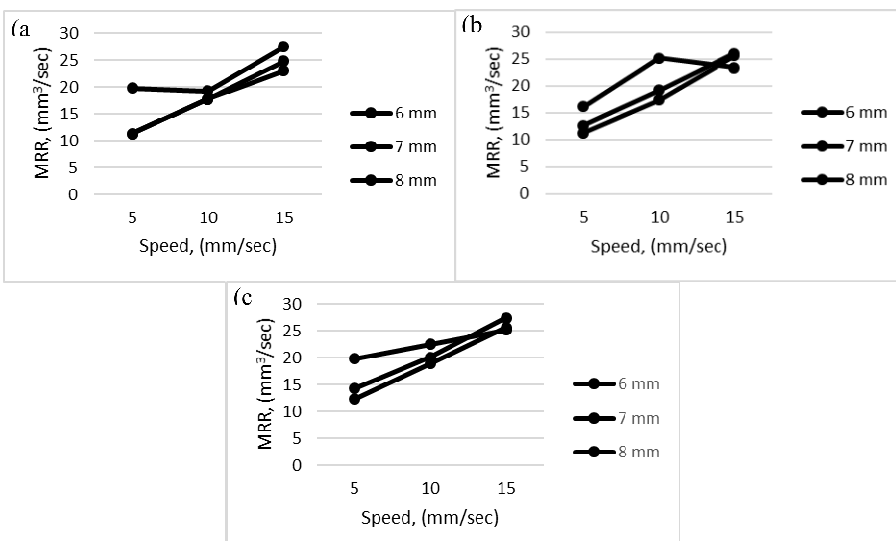

Figure-2. Material Removal Rate for different speed and gap (a) Current, 40 A (b) Current, 45 A (c) Current, 50 A.

Figure-3 shows that the cutting width reduces with an increase in the current for a particular cutting speed. As the maximum cutting speed, 15 mm/sec, the cutting width increases. Increase in the gap causes the cutting width decreases except for higher cutting speed. In addition, the decreasing trend of the cutting width could be explicated by the fact that a narrow width is due to high cutting speed laser beam not able to melt the work material. The wider cutting width in lower cutting speed is due to laser beam have in more contact time to melt the material [9]. Subsequently, more laser energy getting on to the material which results in a wider cut widths [10].

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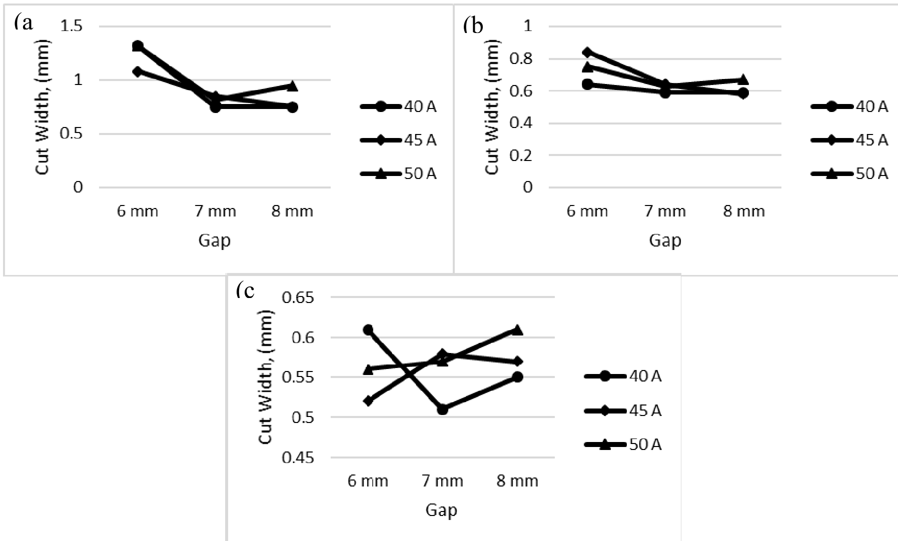

Figure-3. Laser cut width for different current and gap (a) Cutting speed, 5 mm/sec (b) Cutting speed, 10 mm/sec (c) Cutting speed, 15 mm/sec.

Figure-4 illustrates the MRR for current and gap for different cutting speeds. MRR at higher cutting speeds compared to other two cutting speed tested. Furthermore, highest MRR obtained for 15 mm3/sec cutting speed with 6 mm gap conditions for all current settings. This is due to the fact that the gap closer, laser energy rises, and the high cutting speed increased the cutting efficiency. Lowest MRR noticed for the slowest cutting speed, 5 mm^3/sec at higher gap of 8 mm increasing gap.

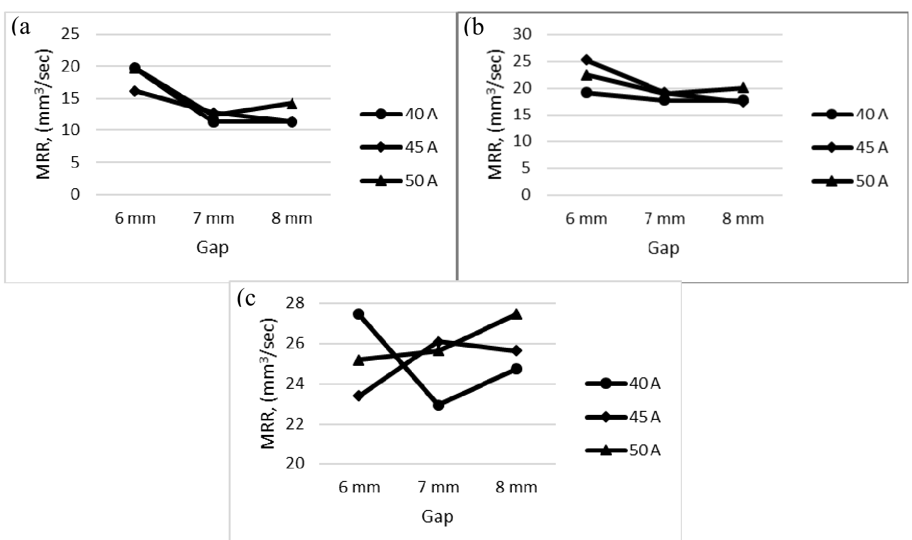

Figure-4. MRRfor different current and gap (a) Speed, 5 mm/sec (b) Speed, 10 mm/sec (c) Speed, 15 mm/sec.

4. CONCLUSIONS

This experiment results shows that the higher the current and higher the cutting speed, result in higher the material removal rate. This is due to higher the laser power with higher the current and faster the speed removed more material. Cutting width are wider for small gaps for all cutting speeds tested. Nozzle, work material gap increases narrow cutting widths are obtained. The cutting speed parameter of laser cutting significantly influence the material removal rate in GFRP composite. This is due to that the laser beam exposed to more area of the work material. Therefore, other parameter such as power and nozzle, work material gapare also helping in the cutting process of the glass fibre polymer composite.

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REFERENCES

[1] Effects of grinding process parameters and coolants on the grindability of GFRP laminates. P Chockalingam, KC Kuang, TR Vijayaram. Materials and manufacturing processes. 28(10): 1071-1076.

[2] Neila Jebbari, M. M. J., Faycal Saadallaha, Annie Tarrats Saugnaca, Raouf Bennaceuraand Jean Paul Longuemard. 2008. Thermal affected zone obtained in machining steel XC42 by high-power continuous CO2 laser. Optics and Laser Technology. 40(6): 864-873.

[3] K. Li, D. W. Z., K. C. Yungb, H. L. W. Chana and C. L. Choy. 2002. Study on ceramic/polymer composite fabricated by laser cutting. Materials Chemistry and Physics. 75(1-3): 147-150.

[4] A. Slocombe L. L. 2000. Laser ablation machining of metal/ polymer composite materials1. Applied Surface Science. 154-155: 617-621.

[5] F. A. Al-Sulaiman, B. S. Y. a. M. A. 2006. CO2 laser cutting of a carbon/carbon multi-lamelled plain-weave structure. Journal of Materials Processing Technology. 173(3): 345-351.

[6] J. Paulo Davim, N. B., Marta Conceicao and Carlos Oliveira. 2008. Some experimental studies on CO2 laser cutting quality of polymeric materials. Journal of Materials Processing Technology. 198(1-3): 99-104.

[7] A. A Cennaa, P. M. 2002. Analysis and prediction of laser cutting parameters of fibre reinforced plastics (FRP) composite materials. International Journal of Machine Tools and Manufacture. 42(1): 105-113.

[8] A Slocombe, J. C. a. L. L. 2000. The effect of pigment addition in diode laser ablation machining of ceramic/ polymer composite material. Applied Surface Science. 168(1-4): 21-24.

[9] Optimization of Laser Cut Quality Characteristics Considering Material Removal Rate Based on Pareto Concept MADIĆMiloš, RADOVANOVIĆ Miroslav, SLĂTINEANU Laurenţiu, and DODUN Oana, Applied Mechanics and Materials 657(2014): 216-220doi:10.4028/www.scientific.net/AMM.657.216.

[10] Majid Hashemzadeh, Mehdi Mohammadi. 2020. The Effect of Power and Maximum Cutting Speed on the Material Removal Rate and Cutting Volume Efficiency in CO2 Laser Cutting of Polycarbonate Sheets Journal of Modern Processes in Manufacturing and Production. 9(1): 5-23.