LASER HOLE CUTTING IN F-12 ARAMID COMPOSITES

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Abstract
Laser machining has considerable advantages over the conventional methods due to precision and rapid processing especially when drilling aramid fiber materials such as F-12 composites . In the present study, laser holes cutting into F-12 laminates with different processing parameters of laser machining and composites properties are carried out by application of the CO_2 laser. F-12 composites are found to be cut satisfactorily by the CO_2 laser at the optimum process parameter ranges. The results showed that laser power is the most significant parameter affecting the quality of cut parameters. It is also found that the quality of holes is affected significantly by the fiber contents of the F-12 composites.

1. Introduction

Advanced Composite Materials (ACM), such as aramid fiber reinforced composites are widely used in industry and civil engineering due to their high strength, low density and resistance to corrosion. Composites can be designed and manufactured into different geometric forms and shapes using various processes including machining. Conventional machining methods are, however, known to offer low end product quality due to abrasive reinforcement and inhomogeneous structure of aramid composites [1]. Compared with this conventional machining methods, many works have reported great advantages provided by laser machining of aramid composites[1-3] like precision of operation and improved end-product quality. There are several thermal processing including solid heating, melting, evaporation, and high temperature combustion involved in laser machining of aramid composites. Most investigations were carried out in the area of controlling the laser power and the pressure of shielding gas which can be optimized through the optimization of process parameters. The shielding gas such as Nitrogen is commonly used to eliminate the high temperature oxidation reactions [4].

In this paper, not only the optimum process parameters of laser machining, but also the properties of aramid composites were considered to obtain satisfactory machining result of aramid composites which has few research on it in literature before.

2. Experiments

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The F-12 aramid fiber supplied by Inner Mongolia Aerospace New Materials Co,Ltd., China was used to prepare the aramid fiber fabric. The F-12 aramid fiber fabric prepregs from Aerospace Research Institute of Materials and Processing Technology (ARIMT), China was used to preparing the aramid composites laminates. 2mm thickness laminates were prepared by autoclave at 130℃ for 2 hours. Different fiber content laminates were prepared by controlling the resin content during the curing process.

The laser used in the experiment is a CO_2 laser (B6015 Laser Cutter, Han's Laser, China,) delivering nominal output power of 2,000 W at 50Hz pulse frequencies. Nitrogen emerging from a conical nozzle and co-axially with the laser beam is used. A 127-mm focal lens with defocusing facilities is used to focus the laser beam. The laser output power was ranged 500–2,000W during drilling of various workpieces. 2mm diameter hole in aramid composite laminates machined by laser was used for evaluating the laser machining parameters and others which could influence the quality of laser machining of aramid composites.

Optical Microscope from Keyence, Model:VHX-1000E was used for obtaining the micrographs of the cutting section.

3. Results and Discussion

Three different laser power ranged from 1200W, 1500W and 1800W at a constant assisting gas pressure were selected for evaluating the influence of the laser power on the quality of laser machining of 2mm aramid composites laminates. Nitrogen was used as the assisting gas. The pressure of Nitrogen was 200 kPa.

As shown in Figure 1, the surface morphology of aramid composites machined by different laser power are different from each other which indicates that the laser power influence the quality of aramid composites laminates significantly. Machined at high laser power of 1800W, the edge of the hole is full of char which formed at a relatively high temperature. Moreover, the bottom section of the hole has more char than the top section. Along the flow direction of the Nitrogen, the pressure of the gas decease gradually which cause the different pressure of Nitrogen between the top section and the bottom section of the hole and result in the phenomenon. This is also observed by other researcher [5]. Around edge of the hole, some areas with lighter color were observed after laser machining of aramid composites. T his could be resulted from the melt resin during the high temperature laser machining process or from the delaminate defects caused by the volatiles of the decomposition of the aramid composites. Machined at low laser power of 1200W, the edge quality of the hole is relatively unstable.

Compared with 1800W and 1200W laser power, the surface morphology of the hole machined at 1500W of laser power are relatively more smooth and the char formed at the bottom section of the hole are relatively less. However, like other two conditions, some areas with light color also appear around the surface of the hole for the sample machined at 1500W of laser power. This indicates the intrinsic defect of laser power machining of aramid composites. As we know, the heat conductivity of aramid fiber is quite small which will result the heat accumulation during the laser machining processing. This accumulated heat will cause the defects appear around the machined hole.

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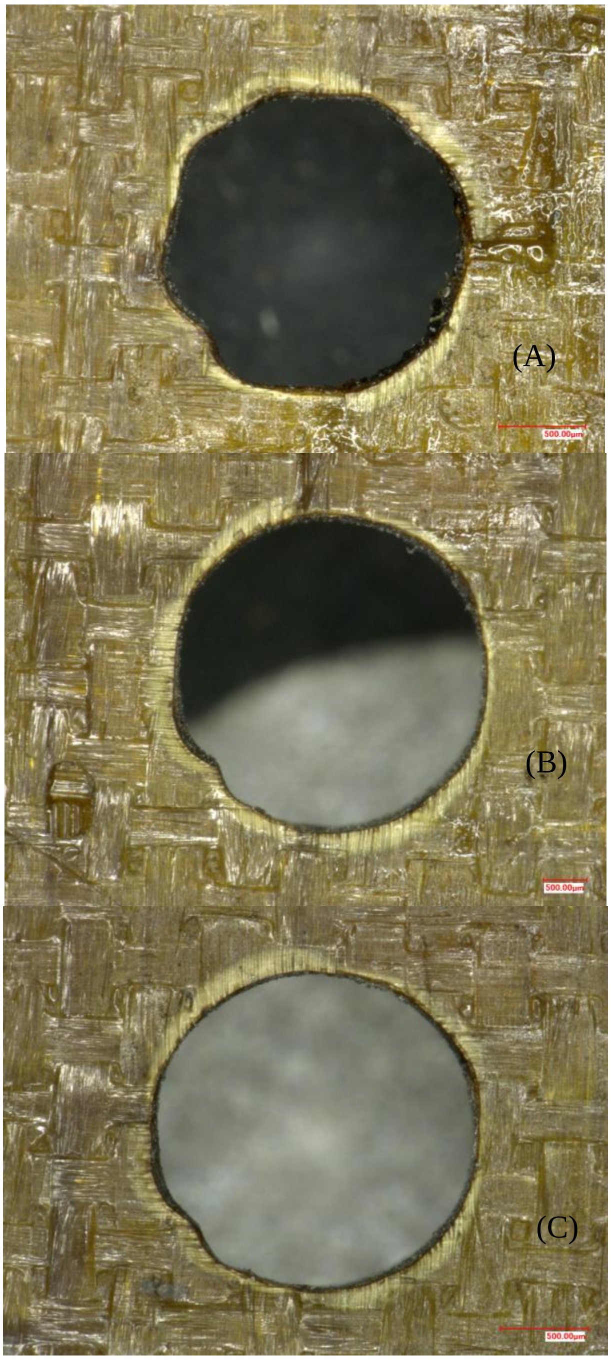

Figure 1. 2mm diameter hole machined at different laser power: (A) 1200W, (B) 1500W, (C) 1800W.

Three different fiber content of aramid composites ranged from 53%, 57% and 60% were prepared for evaluating the effect of fiber content on the laser machining quality of aramid composites. Machined at a constant laser power and pressure of Nitrogen gas, different surface morphologies of the cross section of the hole were observed, as shown in Figure 2. As the fiber content increasing, the char area of the cross section of the hole increase gradually.

These different surface morphologies were caused by the different fiber content of the aramid composites. As mentioned above, the thermal conductivity of the aramid fiber is quite small which will cause heat accumulation during the laser machining and affect the condition around the hole.

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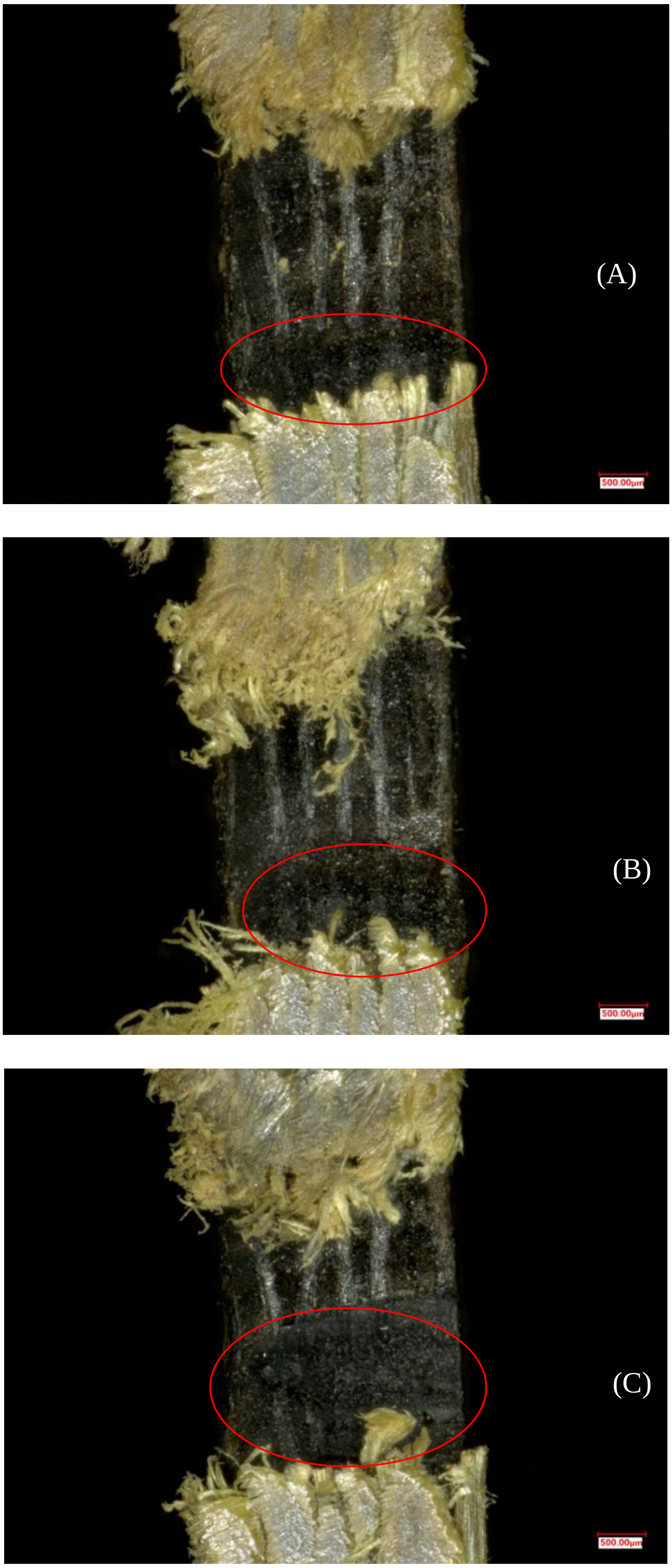

Figure 2. Cross section of the samples with different fiber content machined by laser: (A) 53%, (B) 57% and (C) 60%, the char area of the cross section of the hole increase gradually.

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4. Conclusions

In the present study, laser holes cutting into F-12 laminates with different machining parameters and composites properties are carried out by application of the CO2 laser. F-12 composites are found to be cut satisfactorily by the CO2 laser at the optimum processing parameter ranges. The results showed that laser power at 1500W is the most optimum parameter affecting the quality of cut parameters. It is also found that the quality of holes is affected significantly by the fiber contents of the F-12 composites. Some intrinsic defects of laser machining of aramid composites found in this work should be taken further research to confirm the mechanism.

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