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# EXPERIMENTAL INVESTIGATION OF CO2 LASER CUTTING OF COMPOSITE MATERIAL (CFRP- CARBON FIBER REINFORCED POLYMER): A REVIEW

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**Abstract:** It is difficult to cut composites using traditional conventions and CO2 laser devices suitable for this. In this study, kerf width was conducted to explore the effects of laser cutting parameters (e.g., laser power, speed cutting, compressed wind, and partition distance). Genetic Algorithm design has been used to formulate and make a relation in between the different process parameters and to evaluate its importance using ANOVA technology. The proposed study shows that laser power has influenced the width of composite material and other various parameters.

**Keywords**: CO2 laser cutting; kerf width; Genetic Algorithm; ANOVA; composite material;

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## INTRODUCTION

Laser cutting is a technology that uses a laser to cut materials and is generally used for industrial production applications, but is also starting to be used by schools, small businesses and amateurs. Laser cutting works by directing the output of a high power laser more commonly through the optics. The laser optics and the CNC (computerized numerical control) are used to direct the material or the laser beam generated. A typical commercial laser for cutting materials implied a motion control system to follow a CNC or a G code of the model to be cut into the material. The focused laser beam is directed to the material, which then melts, burns, vaporizes or is ejected from a jet of gas, leaving an edge with a high quality surface finish. Industrial laser blades are used to cut materials from flat plates and structural materials and pipes.

### 1.1 Why lasers are used for cutting

Lasers are used for a variety of purposes. One way is cutting the metal plates. For lightweight steel, stainless steel and aluminum plates, laser cutting delivers extremely accurate, excellent cutting quality, very low cutting width and low temperature range, and allows cutting very complex shapes and small holes.

### 1.2 How it works

The laser beam is a very high intensity single-wavelength or color light column. For a typical CO2 laser, this wavelength is located in the infrared portion of the light spectrum so it is visible to the human eye. The radius has only a diameter of about 3/4 inch, as it moves from the laser resonator, which creates the beam through the machine beam. Some mirrors or "beam bends" may jump in different directions before finally focusing on the plate. The focused laser beam passes through a nozzle hole before it hits the disc. Compressed gases such as oxygen or nitrogen flow through the hole in the nozzle. The focus of the laser beam can be done with a special lens or bent mirror and is done in the laser cutter head. The beam should be focused precisely so that the focal point and energy density at this point are perfectly circular and consistent and placed on the nozzle. If the high beam is focused on exactly the point, the heat density at this point is extreme. High power density results in rapid heating, melting and partial or total evaporation of the material. When cutting mild steel, the heat of the laser beam is enough to trigger a typical "oxygen burning" process and the laser beating gas is pure oxygen like an oxygen-containing torch. When cutting stainless steel or aluminum, the laser beam simply melts the material and high-pressure nitrogen is used to extract the molten metal from the groove.

In a CNC laser cutter, the laser cutting head moves on the metal plate as the desired part so that the plate is cut off. The capacitive height control system maintains a very accurate distance between the end of the nozzle and the slapped plate. This distance is important as it determines the focal point relative to the surface of the disc. The quality of the cut can affect

the lifting or lowering of the focus point over the surface of the disc, on its surface or directly below the surface. Many other parameters affect the quality of the cut, but if everything is properly controlled, laser cutting is a stable, reliable and very accurate cutting process.

**1.2 Background**

**In 1963,** Kumar **Patel** developed the first carbon dioxide (CO2) laser in Bell Labs. At present, the chemical laser is the most popular type of Rabbie Laser, which is less costly and more efficient. We are the laser we use for our Online Laser Cutting Service. In 1967 there was a sample of CO2 of more than 1000 watts.
Peter Houldcroft, scientific director of the Cambridge Welding Institute, continued to push in **1967** when he was using a laser cutting nozzle with an oxygen-pressure chamber. What does an additional gas flow in the focal area of the laser beam for cutting a 1 mm thick steel plate? This was the first commercial application of laser cutting. With the development of more powerful lasers, it is also possible to cut thicker and different materials, including non-metals. The slimness of the cut promises precision that was not previously obtained by thermal cutting techniques.

**In 1965: Laser is used as a drilling tool**
The Western Engineering Research Center, in Buffalo, USA, was the very first one to **employ laser as a cutting device**. At this time, diamond dies were used to manufacture wire for electrical connections. Thousands of dies were required for this kind of operations, and piercing the dies or resizing them was both a costly and a slow process, up to 24 hours of making. Instead of metal drill or diamond dust, used so far, engineers used a laser. Many of the conducted tests were safety-testing. The effects of laser beams on eyes and skin or of the vaporized materials on the worker's health had not yet been established. The Western Engineering Research Center, Buffalo, United States. It was the first to use laser as a cutter. At this time, diamond tools were used for electrical connections. For this type of operation, thousands of tools were needed, and drilling or changing the size of the tools was a costly and slow process, up to 24 hours production. Up to now, the engineers used a laser instead of a metal drill or a diamond powder. Many tests carried out were a safety test. The effects of laser beams on the eyes and the skin or the effects of the volatile substances on the health of the worker have not yet been established.

**In 1967: First gas assisted laser-cut**
Gas assisted laser cutting, and especially CO2 laser cutting meant an increased efficiency, which allowed broadening the range of applications.

**In 1969: First industrial use in Boeing factories**
The American company Boeing is the first one to integrate laser-cutting on its production lines. In August 1969, three employees from the Boeing Company produced a paper on the CO2 laser

cutting off “hard” materials titanium, Hastelloy and ceramic using the assist gas technique. They concluded that the laser “could be an effective and economical cutting tool, but a great deal of research and development may be required before such a machine could be put on the production line”. In the 1970’s, Boeing patented the multi-beams laser-cutting and was among the pioneering companies cutting titanium with a laser.

**2. LITERATURE SURVEY:**

**Riveiroet. al. Published Experimental study on the CO2 laser cutting of carbon fiber reinforced plastic composite and suggested**

Promoting the massive use of carbon-based plastic (CFRP) in the industry can be achieved through faster and more flexible technologies such as laser cutting. The anisotropic and heterogeneous properties of CFRP are a major challenge for laser processing. We present an exhaustive study on laser cutting performance composed of CFRP (3 mm thick). The high emission CO2 laser is used to familiarize with the capabilities of CO2 laser cutting machines widely used in metal machining applications for the machining of this material. On the other hand, the effect of the processing parameters has been studied in both CW and pulse mode. The minimum areas affected by heat, approx. At a depth of 540 lm, a high pressure CO2 laser was used in pulse mode. As a result, the strength of the CFRP does not change in practice compared to more conventional mechanical machining.

**A. Goeke, C. Emmelmann published an article Influence of Laser Cutting Parameters on CFRP Part Quality** and suggested that technologies are the most modern today. These processes are still performed in certain applications, in the absence of part quality, such as delaminating and low productivity. Therefore, laser cutting processes have great potential for processing CFRP materials. Laser printing parameters should be carefully adjusted to reduce the area affected by heat and affect the quality of the piece.

**Caprino and V. Tagliaferri suggested in paper Maximum Cutting Speed in Laser Cutting of Fiber Reinforced Plastics** that a simple thermal model of a parameter that predicts the maximum feed rate, which still results in cutting through the radius of performance. The focal length and thickness of the machined material are described and discussed for CO2 laser cutting of complex materials. A wide-ranging experimental program was carried out, including fiberglass, carbon and aramid-reinforced polyester resins, which changed all parameters in the model. There was an excellent agreement between experimental data and theoretical forecasts. In addition, a criterion for grading the quality of the cutting was determined based on the geometry of the cut and the size of the area affected by the heat to choose the optimum cutting conditions to achieve the best cutting quality.

**Annett Klotzbach, Markus Hauser, Eckhard Beyer published an article Laser Cutting of Carbon Fiber Reinforced Polymers using Highly Brilliant Laser Beam Sources** and stated that Carbon Fiber Polymers (CFRPs) are increasingly used in the aeronautics industry and the automotive industry. The main reason for this is high mechanical loads and low density. In addition,

corrosion resistance and damping behavior of the material can be fully exploited in heavily stressed structures. However, the concept of manufacturing CFRP parts near the final contour does not replace the need for cutting. The different properties of fiber and matrix material are an ambitious challenge when cutting CFRP with a laser beam. This article deals with the analysis of the laser remote cutting process and CFRP gas-assisted laser cutting.

**C. Emmelmanna, M. Petersen, A. Goeke, M. Canisius published paper Analysis of Laser Ablation of CFRP by Ultra-Short Laser Pulseswith Short Wavelength** suggested that Processing of carbon fiber reinforced polymer (CFRP) materials by shaping technologies is the latest technology. These processes are still performed in certain applications, in the absence of part quality, such as delaminating and low production efficiency. Therefore laser processing of ultrashort laser pulses has great potential in the ablation of CFRP materials. However, the parameters of the laser process should be carefully adjusted to reduce the area affected by heat (HAZ) and affect the quality of the piece

**2.1 Research Gaps**

Many scientists have researched a letter that taught the process of review and impact and the periphery of processing carbon dioxide-reinforced polymeric materials (CFRPs). Laser cutting other than the import of metals, non-metals, super alloys, ceramics and composites. A large amount of research was found on the surface roughness of the laser-alloyed aluminum alloy plate. Optimizing the roughness of the surface and modeling the Al laser cut and the alloy characteristics can achieve better quality. Predictive modeling requires a lot of techniques to better understand laser cutting.

**3. OBJECTIVE**

Experimental investigation & study concerns the use of a CO2 laser in cutting composite material under various laser processing parameters.

**4. TOOLS**

Anova and MS Excel (Data Analysis Integration)

**5. EXPECTED RESULT**

This study concerns the use of a CO2 laser in cutting composite material under various laser processing parameters. To reduce the number of experiments, Genetic Algorithm of experiment will be apply to investigate the effects of laser power, cutting speed, stand-off distance and compressed air pressure on kerf width of the cutting process. The effect of each parameter will be also discussed. The significance of the cutting parameters on overall mean kerf width is evaluated quantitatively using ANOVA technique. According to ANOVA results, laser power has expected to be dominant effect and it will be followed by compressed air pressure, stand-off distance and cutting speed.

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