Review: Effect of Cutting Parameters on CO_2 Laser Cutting of CFRP

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Abstract **- The paper outlines study of effect of various cutting parameters on Co_2 laser cutting of CFRP. Laser cutting is accepted as a technically superior and cost-effective approach in manufacturing technology. Precision, high quality and fast cut rates are the hallmarks of this process.Co2 laser Cutting of CFRP is state of art today but it is complex to cut CFRP by Co_2 laser because of CFRP properties and process parameters. This study includes process parameters: laser power, cutting speed and assist gas pressure etc. which affect cutting process.**

Keywords-**Co2 laser cutting, Kerf Width, Heat Affected Zone Etc.**

I. INTRODUCTION

Co2 laser-

The laser stamp for the amplification of light by radiation-stimulated emission was discovered in 1960. The laser beam is different from that of the normal luminous beam due to the very narrow and narrow spectral band. Here the amplification of light is achieved by a laser active medium (gain medium). This medium is obtained by the stimulated emission of photons from a lower energy state to a higher energy state previously populated by a pump source. To start active lasers in the environment, it must be in the non-thermal energy distribution known as the population reversal. The photon wavelength is changed according to the need for an active environment. The wavelength is the color and amount of stored energy. It is important to react the photon generated in the active medium using a resonator so that a large number of identical photons accumulate for further stimulated emissions. Pumping action is required to ensure continuous energy supply in the active laser environment. This contributes to the production of insufficient emissions on a continuous basis. Lasers are classified in different ways, that is, depending on their mode of operation or the type of active laser environment.

CO2 gas lasers contribute to over 40% of the industrial lasers. The laser beam is different from that of the normal luminous beam due to the very narrow and narrow spectral band. Here the amplification of light is achieved by a laser active medium (gain medium). This medium is obtained by the stimulated emission of photons from a lower energy state to a higher energy state previously populated by a pump source.

Advantages of laser cutting

1. The edges are clean, free from burning and dust formation.
2. High level of precision and precision of the cutting line.
3. No material deformation due to contactless machining.
4. Low thermal influence.
5. Cutting materials of various thicknesses and combinations at a time.
6. No tooling cost.

II. CARBON FIBRE REINFORCED POLYMERS (CFRP)

Carbon fibre reinforced polymers (CFRPs) are a kind of composite materials widely used in the aerospace or automotive industries due to its outstanding strength and inherent low density. Its main advantage is low thermal conductivity. Other advantages include an improved fatigue life, excellent corrosion resistance and reduced assembly costs. These properties make them a very attractive material for structural applications, especially in the aerospace industry due to the greater weight savings that results in improved performance, greater payloads, longer range and fuel savings.

Carbon Fibre Reinforced Plastics (CFRP) is a composite lightweight material where yarns are weaved in a cross-ply substrate and a polymer is infused during the manufacturing phase or more easily the polymer component may be previously added, partially cured, in order to achieve a pre-impregnated composite fibres (pre-pregnation).

The processing of composites in general and fiber reinforced polymer composites (FRP) in particular is very different from metalworking. This is due to the inhomogeneous and anisotropic properties of these structures. Moreover, because the fibers and the matrix are physically combined (i.e. not chemically), despite their structural properties, they retain their own mechanical and thermal properties, which are usually heavily different (i.e, heterogeneous properties). Typically, reinforcement fibers, such as glass, graphite, boron, alumina and silicon carbide, are very abrasive and hard (sometimes as hard or even

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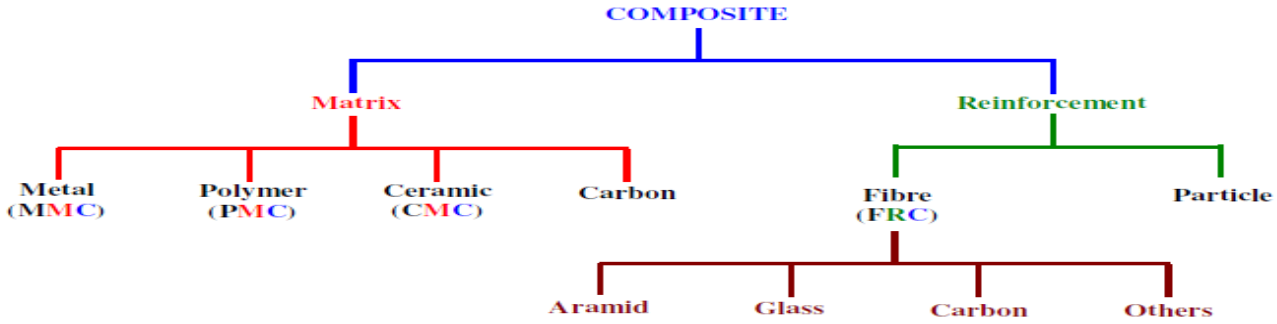
harder as the tool material). Therefore, special cutting materials and tools should be used to minimize tool wear. Currently, composite processing and assembly is a challenge. 60% of the rejection of the parts is due to processing errors and to the special design and operating requirements of the tools. The processing challenges are particularly experienced in the case of carbon fiber reinforced polymer composites (CFRP). This is due to the large difference in the mechanical and thermal properties of the components. Processing defects, including inter-laminar and intra-laminar delamination, fiber retraction and poor surface quality may affect partial performance. In addition, an inability to comply with dimensional tolerances may require secondary repairs or even partial rejections.



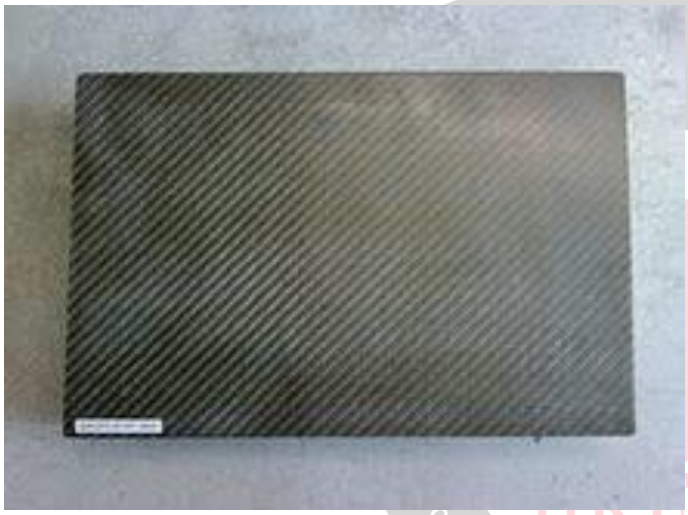


Fig. - CFRP

III. LITERATURE REVIEW

[1]A. Riveiroa,*, F. Quinteroa, F. Lusquiñosa, J. del Vala, R. Comesañab, M. Boutinguizaa, J. Poua–(2017)

Cut by a high quality CO2 laser was investigated in this work. A 3.5 kW CO2 slab laser was used to cut CFRP plates with a thickness of 3 mm. The influence on the cut quality of different processing parameters such as pulse frequency, pulse energy, duty cycle, type and pressure of the assist gas were studied. The presence of a HAZ is unavoidable, but it can be minimized selecting the optimum processing parameters. Reduced laser powers (up to 1600 W), and cutting speeds ranging from 2000 mm/min to 4000 mm/min are required to avoid an excessive thermal input into the workpiece, and to obtain sound cuts.

[2] A. Salama1• L. Li1• P. Mativenga1• D. Whitehead1- (2016)

Design of experiment and statistical modeling , based on **response surface methodology**, was used to understand the interactions between the process parameters such as laser influence, repetition rate and cutting speed and their effects on the cut quality characteristics including size of HAZ, machining depth and material removal rate (MRR). Based on this study, process parameter optimization was carried out to minimize the HAZ and maximize the MRR.

[3] Islam Shyha- (2013)

The paper outlines results for an investigation of **CO_2**laser trimming of fibre reinforced plastic (frp) composites. Process variables include cutting speed, laser beam power, gas pressure and workpiece material. Higher MRR have been obtained when trimming GFRP. Maximum MRR of 8 cm3 /min was acquired when trimming GFRP at 1750 mm/min, 5 bar and 2500 watt respectively. Maximum entry kerf width of 0.5 mm and 0.28 mm was measured for GFRP and CFRP samples respectively.

[4] A.N. Fuchs , M. Schoeberl, J. Tremmer, M.F. Zaeh- (2013)

Experiments with remote laser cutting and gas assisted laser cutting were carried out in order to identify achievable machining speeds. Using the described system technology, it was shown that cutting speeds of up to 12 m/min can be achieved for a material with six layers and a thickness of approximately 3 mm. With both processes, cuts with a high edge quality can be generated.

[5] A. Riveiro, F. Quintero, F. Lusquinos, J. Del Val, R. Comesana, M. Boutinguiza, J. Pou-(2012)

Kerf width is higher in entry side and it is most influenced by laser power. Optimum duty cycle is equal to 50%,high assist gas pressure equals to larger erosion in entry side. Cuts with a minimum heat affected zone, about 540 lm, were achieved using a high-beam quality **CO_2** laser working in pulsed mode. In consequence, the CFRP strength remains practically unaffected compared to more conventional mechanical machining.

[6] F.A. Al-Sulaiman, B.S. Yilbas,M. Ahsan- (2006)

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Laser cutting of composite structure consisting of 64 layers of plain-weave carbon/carbon fibres with 0◦ orientation is carried out. It is found that Kerf width size increases with increasing laser power intensity. The orientation of the carbon fibre axis relative to the axis of work piece movement during cutting has significant effect on the Kerf size. Use of nitrogen as assisting gas suppresses the oxidation reactions taking place in the cutting section.

[7] W.S. Lau , W.B. –(1991)

MRR is faster in laser cut. Material damage occurs in both processes but EDM produces better surface finish than laser cutting. This damage will affect the reliability of the composite material in service.

[8] G. CaprinoAnd V. Tagliaferri-(1988)

It has been shown that the proposed model closely agrees with experimental results obtained by laser machining of polymer matrix composites reinforced with aramide glass and carbon fabric .the model is expected to work well for high power density and feed rates; under these conditions low interaction times are necessary for obtaining through cuts, heat conduction losses can be effectively neglected and the cut process can be considered quasi-adiabatic.

IV. RESEARCH GAP

1. The presence of heat affected zone was found unavoidable, only it can be minimize
2. Kerf was found during laser cutting. Kerf is higher at entry side then exit side
3. Charring /melting of material and adhered to cut surface results due tomatrix constituent.
4. Emission of dust, toxic gases.
5. Striation formation when using higher laser power
6. Surface roughness due to high laser –material interaction

V. APPROACHES USED TO IMPROVE LASER CUTTING

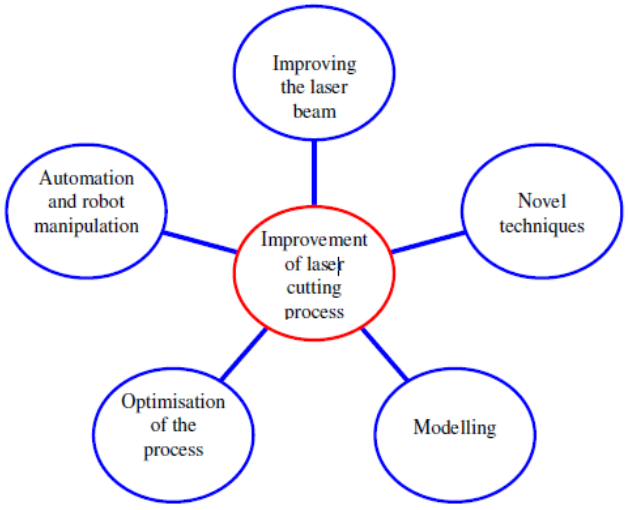

Fig.-Classification of different approaches used to improve laser cutting process

Effect of cutting parameters –(Continuous wave vs Pulsed wave)

CW Mode-

Laser power as the most influencing parameter on the evaluated quality characteristics. width in the entry side is more affected by the laser power than the kerf width in the exit side; however, there exists a level of laser power (around 1000 W) which minimizes both values. Focusing of the laser beam onto the surface of the workpiece induces a larger vaporization of the material in the entry of the cut slot; then, more material is removed and consequently the cut exhibits a lar-ger width in the entry side.

Pulsed Wave Mode

The kerf width in the entry side is always larger than in the exit side; moreover, the difference between the width in the entry and exit sides is larger as the assist gas pressure is increased The increment of the assist gas pressure promotes a larger erosion in the entry side due to the higher dynamic pressure of the jet onto the cutting front; however, the kerf width in the exit side is prac- tically unaffected by the assist gas pressure.

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