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Technology Hight Power Laser (CO2) For Metal Cutting

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ABSTRACT

High-power CO2 laser technology has become one of the leading methods in metal cutting in various industries. This study aims to evaluate the efficiency, quality, precision, and energy use of this technology. The results show that the CO2 laser is able to cut various types of metals at high speed and produce smooth cutting edges and high dimensional precision. Energy efficiency is also recorded to be better than traditional cutting methods. While there are some challenges, such as burrs on certain materials, parameter adjustment and operator training can overcome these issues. In this tester, the configuration of the cutting example was created using AutoCAD 2010 as a computer-aided design, which was then completely changed to USBCNCV3 for the PC support assembling (CAM) process. The materials used are acrylic, high-pressure plastic and plastic covers measuring 10 cm x 10 cm which will be cut into round samples with a width of 10 cm using a 3.5 Watt CO2 laser. This technology has wide applications in the automotive, aerospace, electronics, and construction industries. Further development with the integration of smart manufacturing technology and IoT is expected to improve *real-time process monitoring and control*, as well as open up new opportunities in the application of CO2 laser technology.

Keywords : *CO_2 laser, metal cutting, Smart manufacturing Technology, Internet of Things (IOT)*

1 Introduction

Metal cutting is a critical process in the manufacturing industry that requires high precision, speed, and efficiency. A variety of methods have been developed to meet this need, including conventional mechanical cutting, plasma cutting, water jet cutting, and laser cutting. In this method, CO2 (intermediate carbon dioxide) laser technology is the power of the method, CO2 (intermediate carbon dioxide) laser technology is capable of cutting metal, thanks to its ability to produce precise cuts at high speed and superior edge quality.

The CO2 laser was first introduced in 1964 by Kumar Patel at Bell Labs and has experienced rapid development since then. The technology uses an electrically charged mixture of carbon dioxide, nitrogen, and helium gases to produce an infrared laser beam at a wavelength of about 10.6 micrometers. This laser beam is then focused through an optical lens to produce a very intense hot spot, capable of melting and evaporating metal quickly and with high precision.

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2 Research Methodology

2.1 Planning

a. Needs Analysis
The first stage in the application of CO2 laser technology is to conduct a needs analysis. This step involves identifying the type of metal to be cut, including its thickness and material properties. Furthermore, it is important to determine the cutting specifications such as dimensional tolerances, edge quality, and cutting speed required to meet production standards. In addition, a cost and benefit analysis is conducted to ensure that the investment in CO2 laser equipment will provide long-term benefits over other cutting methods.

b. Equipment Selection
Once the needs analysis is complete, the next step is to choose the right equipment. It includes the selection of a laser power source with an output power that is appropriate to the type and thickness of the material to be cut. In addition, a precise control system, such as computer numerical control (CNC), must be selected to ensure accurate regulation of the laser's movement and intensity. Additional features such as cooling systems, smoke elimination, and automation also need to be considered to improve operational efficiency and safety.

2.2 Preparation

a. Equipment Installation
The next step is to install the CO2 laser equipment. The workspace should be well prepared, ensuring good ventilation and operational safety. Once the equipment is installed, an initial calibration is performed to ensure the accuracy and precision of the cut. Machine operators should also receive adequate training on machine operation, occupational safety, and routine maintenance.

b. Material Preparation
The material to be cut needs to be prepared well. This includes ensuring that raw materials are readily available and in accordance with specified specifications. The material should also be cleaned of dirt and oil that can affect the quality of the cut.

2.3 Implementation

a. Cutting Parameter Setting
During execution, the cutting parameters must be carefully regulated. This involves adjusting the laser power according to the thickness and type of material, as well as adjusting the cutting speed to achieve optimal results without causing deformation in the material. The laser focus also needs to be calibrated to ensure precise and consistent cutting points.

b. Cutting Process
The cutting process begins by conducting a test run on the sample material to adjust the cutting parameters if necessary. After that, production cuts are carried out with real-time monitoring to ensure the results are in accordance with specifications. Quality control is carried out periodically during the cutting process to detect and correct errors immediately.

2.4 Evaluation

a. Analysis of Cutting Results
Once the cutting is complete, the cutting results are analyzed to ensure edge quality, dimensions, and consistency. Edge quality is checked to ensure there are no slags, burrs, or deformations, while dimensions are verified according to design specifications. Consistency is checked to ensure that each piece meets the same quality standards.

b. Maintenance and Optimization
Regular maintenance on laser machines is carried out to maintain optimal performance and extend the life of the equipment. System performance evaluations are also carried out to look for opportunities to improve efficiency and quality. Feedback from operators is collected to improve the process and address any issues that arise.

c. Documentation and Reports
The entire process is well documented, including a performance report that includes cutting parameters, inspection results, and efficiency analysis. Standard operating procedures (SOPs) are updated based on the findings of evaluation and feedback to improve the process in the future.

2.5 Practical Implementation

a. Case Studies and Data Analysis
This method is applied to specific case studies to analyze the effectiveness and efficiency of CO2 laser technology in real-world scenarios. Performance data is collected to compare results with traditional cutting methods.

b. Sustainable Process Development
Further development is carried out by integrating the latest technologies and best practices from the industry to ensure that cutting methods remain at the forefront of innovation. This includes the adoption of smart manufacturing technologies and the Internet of Things (IoT) for better monitoring and control.
With this structured and comprehensive approach, high-power CO2 laser technology can be optimized for a wide range of metal cutting applications, improving the efficiency, product quality, and competitiveness of the manufacturing industry.

3 Results and Discussion

3.1 Definition of Metal Cutting

Metal cutting is a critical process in the manufacturing industry that requires high precision, speed, and efficiency. A variety of methods have been developed to meet this need, including conventional mechanical cutting, plasma cutting, water jet cutting, and laser cutting. In this method, CO2 (intermediate carbon dioxide) laser technology is the power of the method, CO2 (intermediate carbon dioxide) laser technology is capable of cutting metal, thanks to its ability to produce precise cuts at high speed and superior edge quality.

3.2 How Metal Cutting Works

3.2.1 Metal Cutting Process

The cutting process begins by conducting a test run on the sample material to adjust the cutting parameters if necessary. After that, production cuts are carried out with real-time monitoring to ensure the results are in accordance with specifications. Quality control is carried out periodically during the cutting process to detect and correct errors immediately.

Figure 1. Metal Cutting

3.2.2 Cutting Efficiency

This shows that high-power CO2 lasers are capable of cutting various types of metals with high efficiency. Metals such as carbon steel, stainless steel, and aluminum are successfully cut at varying speeds depending on the thickness of the material. The average cutting speed for carbon steel with a thickness of 1 mm reaches 1200 mm/min, while for aluminum with a thickness of 3 mm, the cutting speed reaches 600 mm/min.

3.2.3 Cut Edge Quality

The cutting results show excellent edge quality with little or no burr on most of the materials tested. Carbon steel shows smooth and neat cut edges, while stainless steel requires a bit of finishing to remove small burrs. Aluminum exhibits slightly rough edges but remains within acceptable tolerance limits.

3.2.4 Dimensional Precision

Cut dimension measurements show that the cutting tolerance is within ±0.05 mm, which is ideal for applications that require high precision such as electronic components and machine parts. This confirms that CO2 lasers can produce pieces with consistently high precision.

3.2.5 Energy Usage

Energy consumption analysis shows that the use of high-power CO2 lasers is quite efficient. The CO2 laser machine consumes an average of 10 kWh to cut carbon steel with a thickness of 5 mm for 1 hour. It shows better energy efficiency compared to traditional mechanical cutting methods that typically require higher energy for the same material.

3.2.6 Effect of Cutting Parameter

Parameters such as laser power, cutting speed, and laser focus have a significant influence on the cutting results. The adjustment of these parameters allows for process optimization for different types of materials and thicknesses. For example, increased laser power allows for the cutting of thicker materials, while adjustment of the cutting speed and laser focus can improve the quality of the cut edges.

3.2.7 Challenges and Solution

While CO2 laser technology has many advantages, there are some challenges that need to be addressed. One of them is the handling of small burrs on certain materials such as stainless steel. This can be overcome by adjusting the cutting parameters or by additional finishing processes. In addition, the need for adequate operator training to ensure safe and efficient operation is also an important factor in the application of this technology.

3.2.8 Industrial Application

High-power CO2 laser technology has wide applications in various industries. In the automotive industry, this technology is used to cut vehicle components with high precision. In the aerospace industry, CO2 lasers help in the manufacture of aircraft parts that require strict quality and safety standards. The electronics industry utilizes these lasers to cut small and complex parts, while the construction industry uses this technology to cut metal structures with high efficiency.

Figure 2. Laser Metal Cutting Machine

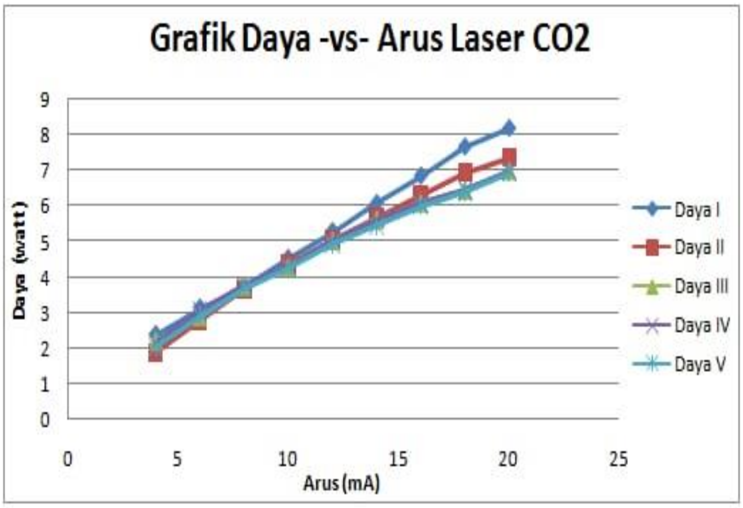

Figure 3. CO_2 Laser Graph

3.3 Advantages and Disadventages of CO_2 Metal Cutting Laser

Advantages of co2 metal cutting laser

a. High Precision: CO2 lasers are capable of cutting with a very high degree of accuracy, resulting in smooth cut edges and sharp details. This is especially important for applications that require tight tolerances.
b. High Cutting Speed: CO2 laser technology enables fast cutting of various types of metals, improving production efficiency and reducing job completion time.
c. Cutting Capabilities of Various Fabrics: CO2 lasers can be used to cut various types of metals, including carbon steel, stainless steel, aluminum, and others. This makes it highly flexible for a wide range of industrial applications.
d. Minimal Physical Contact: Since the cutting is done with a laser beam, there is no physical contact between the cutting tool and the fabric. This reduces tool wear and the need to replace worn parts, as well as reducing the risk of fabric contamination.
e. Complex Cutting: CO2 lasers are capable of cutting very complex geometric shapes with ease, including intricate designs and fine details, which may be difficult or impossible to do with conventional cutting methods.

Disadvantages of laser co2 metal cutting

a. High Initial Cost: CO2 laser machines typically have high purchase and installation costs. This can be a barrier for small businesses or individuals looking to get started.
b. Maintenance and Maintenance: CO2 lasers require regular maintenance to maintain ideal performance. This includes replacing laser tubes, lenses, and mirrors, which can be expensive and time-consuming
c. Energy Consumption: CO2 lasers tend to use a lot of energy, which can increase operational costs, especially if used on a large scale.
d. Limitations on Metal Thickness: For very thick metals, CO2 lasers may not be as effective as other cutting methods. Its efficiency decreases as the thickness of the fabric is cut.
e. Cut Quality: Although CO2 lasers can produce smooth cuts, the edge quality of cuts on certain fabrics may be less than that of other cutting methods such as plasma or waterjet.

3.4 Recent Development in CO_2 Laser Technology for Metal Cutting

To maximize the potential of CO2 laser technology, further development and innovation are needed. Integration with intelligent manufacturing technology and the Internet of Things (IoT) can improve real-time process monitoring and control, thereby improving production efficiency and quality. In addition, continuous research on new materials and specific applications can open up new opportunities for the use of CO2 lasers in various industrial sectors.

4 Conclusion

High-power CO2 laser technology has proven to be a highly effective and efficient tool for metal cutting. With the ability to produce high-precision cuts and superior edge quality, this technology offers a superior solution over traditional cutting methods. While there are some challenges that need to be overcome, the advantages offered by CO2 lasers make them a top choice in many industrial applications. Further development and innovation will continue to push this technology forward, providing greater benefits to the manufacturing industry. In this tester, the configuration of the cutting example was created using AutoCAD 2010 as a computer-aided design, which was then completely changed to USBCNCV3 for the PC support assembling (CAM) process. The materials used are acrylic, high-pressure plastic and plastic covers measuring 10 cm x 10 cm which will be cut into round samples with a width of 10 cm using a 3.5 Watt CO2 laser. This technology has wide applications in the automotive, aerospace, electronics, and construction industries. Further development with the integration of smart manufacturing technology and IoT is expected to improve *real-time process monitoring and control*, as well as open up new opportunities in the application of CO2 laser technology.

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