Perspective
Volume 11:03, 2024

Fluid Mechanics: Open Access

ISSN: 2476-2296 **Open Access**

Assessing Mechanical Performance and Weldability of Pure Copper Foils: Fluid Mechanics Perspectives in Blue Diode Laser Welding

Tirimasu Sukto*
Department of Engineering Design, Western Michigan University, Kalamazoo, USA

Introduction

The rapid dissipation of heat away from the weld zone can prevent the material from reaching the melting point, or can cause excessive heat distribution leading to a large Heat-Affected Zone (HAZ). This can result in poor weld quality, distortion, and thermal damage to surrounding materials Copper has a high reflectivity for most laser wavelengths, which means that a significant portion of the laser energy is reflected rather than absorbed by the material. This results in inefficient energy transfer and difficulty in achieving the temperatures necessary for welding. Traditional infrared lasers, commonly used in welding, are particularly ineffective due to the high reflectance of copper at these wavelengths. Copper's excellent thermal conductivity, while advantageous for many applications, poses a significant challenge in welding.

Blue diode lasers operate at wavelengths around 450 nm, which are absorbed more efficiently by copper compared to the infrared wavelengths typically used in laser welding. The higher absorption rate translates to more effective heating and melting of the copper foil, allowing for more precise and controlled welding. Modern blue diode lasers offer sufficient power to weld thin copper foils effectively. The improved absorption means that less power is needed to achieve the same or better results compared to infrared lasers, making the process more energy-efficient. Pure copper foils, typically with a thickness ranging from 50 to 200 micrometers, are prepared for welding. The purity of the copper is crucial, as impurities can significantly affect the weld quality and mechanical properties. The foils are cleaned to remove any oxides, oils, or contaminants that could interfere with the welding process. Key parameters for the blue diode laser include power output, beam diameter, welding speed, and focal position. Optimizing these parameters is essential for achieving high-quality welds. For example, a power output ranging from 50 to 150 watts, with a beam diameter of 50 to 100 micrometers, and a welding speed of 10 to 100 mm/s are typical starting points for experimentation [1-4].

Description

Blue diode laser welds typically exhibit tensile strengths that are close to those of the base copper material, indicating strong and reliable joints. Micro hardness measurements provide insight into the changes in material properties within the weld zone and HAZ. The weld zone often shows increased hardness due to rapid cooling and solidification, while the HAZ may exhibit different characteristics depending on the thermal gradients experienced during welding. Fatigue testing evaluates the durability of the welded joints under cyclic loading conditions. Copper welds created with blue diode lasers generally demonstrate good fatigue resistance, which is essential for applications subject to repetitive mechanical stresses [5].

Blue diode lasers, due to their efficient energy absorption, tend to produce a smaller HAZ compared to infrared lasers, resulting in less thermal damage to the surrounding material. The ability to achieve high welding speeds without compromising weld quality is a significant advantage of blue diode lasers. This enhances productivity and makes the process suitable for industrial applications where speed and efficiency are paramount. The higher absorption rate of blue light by copper translates to lower energy consumption. This not only reduces operational costs but also minimizes thermal distortion and residual stresses in the welded components. Blue diode lasers are versatile tools that can be adapted for various welding applications beyond copper foils, including other metals and alloys that exhibit similar welding challenges. The initial investment in blue diode laser systems can be higher compared to traditional welding equipment. However, the long-term benefits in terms of efficiency and weld quality can justify the expenditure.

The quality of welds produced by blue diode lasers is assessed through visual inspection, metallographic analysis, and non-destructive testing methods. High-quality welds are characterized by minimal porosity, absence of cracks, and uniform weld beads. The extent and properties of the HAZ are crucial in determining the overall weld quality. The shorter wavelength of blue diode lasers allows for finer focusing of the laser beam, providing greater precision in the welding process. This is particularly beneficial for thin copper foils where control over the weld bead is critical.

Conclusion

The copper foils are positioned with precision on a stable platform to ensure consistency and repeatability. The laser is then used to create welds under controlled conditions, with variations in parameters to study their effects on the weld quality and mechanical properties. Tensile strength is a critical measure of the mechanical integrity of welded joints. Tests are conducted on welded samples to assess the maximum stress they can withstand before failure. The resulting welds exhibit excellent mechanical properties, including tensile strength, microhardness, and fatigue resistance, making them suitable for a wide range of industrial applications. Despite the higher initial costs and the need for process optimization, the benefits of precision, energy efficiency, and versatility make blue diode laser welding a valuable tool in modern manufacturing. As technology continues to evolve, we can expect even greater improvements in the capabilities and applications of blue diode lasers in copper welding and beyond.

Acknowledgement

None.

Conflict of Interest

None.

***Address for Correspondence:** Tirimasu Sukto, Department of Engineering Design, Western Michigan University, Kalamazoo, USA; E-mail: stirimasu@gmail.com*

Received: 01 June, 2024, Manuscript No. fmoa-24-146781; **Editor Assigned**: 03 June, 2024, PreQC No. P-146781; **Reviewed**: 15 June, 2024, QC No. Q-146781; **Revised**: 21 June, 2024, Manuscript No. R-146781; **Published**: 28 June, 2024, DOI: 10.37421/2476-2296.2024.11.330

References

1. Tange, Rinze A. and Wilko Grolman. "An analysis of the air-bone gap closure obtained by a crimping and a non-crimping titanium stapes prosthesis in otosclerosis." *Auris Nasus Larynx* 35 (2008): 181-184.

2. Huber, Alexander M., Thomas Schrepfer and Albrecht Eiber. "Clinical evaluation of the nitibond stapes prosthesis, an optimized shape memory alloy design." *Otol Neurotol* 33 (2012): 132-136.

3. Lundström, E., Gert Brodin, Joakim Lundin and Mattias Marklund, et al. "Using high-power lasers for detection of elastic photon-photon scattering." *Phys Rev Lett* 96 (2006): 083602.

4. Zhang, Lin-Jie, Gui-Feng Zhang, Jie Ning and Xing-Jun Zhang, et al. "Microstructure and properties of the laser butt welded 1.5-mm thick T2 copper joint achieved at high welding speed." *Mater Des* 88 (2015): 720-736.

5. Beck, Tobias, Christoph Bantel, Meiko Boley and Jean Pierre Bergmann. "OCT capillary depth measurement in copper micro welding using green lasers." *Appl Sci* 11 (2021): 2655.

How to cite this article: Sukto, Tirimasu. “Assessing Mechanical Performance and Weldability of Pure Copper Foils: Fluid Mechanics Perspectives in Blue Diode Laser Welding.” *Fluid Mech Open Acc* 11 (2024): 330.