JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Laser Beam Welding Simulation of Cu & Ni

Rishi Nagwanshi, *Research scholar, Department of Mechanical Engineering, Shri Shankaraharya Tehnical Campus, Bhilai(C.G.) Pin 490020.*
*Email:**rishinagwanshi29694@gmail.com***
Lakshman Sondhi, *Associate Professor, Department of Mechanical Engineering, Shri Shankaracharya Technial Campus, Bhilai(C.G.) Pin 490020.*
*Email:**lsondhii@gmail.com***

***Abstract**:* Laser Beam Welding (LBW) is a welding process, in which heat is generated by a high energy laser beam targeted on the workpiece. The objective of current research is to investigate the fusion zone developed in laser welding process. The numerical analysis is conducted using ANSYS software and heat flux applied in the analysis is 1000W and 2000W. The thermal distribution and heat flux are generated which has shown that heat flux on copper side is higher than nickel side.
Key Words: Laser beam, welding

1. INTRODUCTION:

Laser Beam Welding (LBW) is a welding process, in which heat is generated by a high energy laser beam targeted on the workpiece. The laser beam heats and melts the edges of the workpiece, forming a joint. The energy of a narrow laser beam is highly concentrated at 10^8-10^{10} W/cm^2, so a weak weld pool is formed very rapidly (for about 10^{-6} sec). The laser beam welding works on the principle that when the electrons of an atom are excited by receiving some energy. And then after some time when it returns to its ground state, it emits a photon of light. The concentration of this emitted photon is increased by the excited emission of radiation and we get high energy focused laser beam. The light amplification by stimulated emission of radiation is named as a laser.

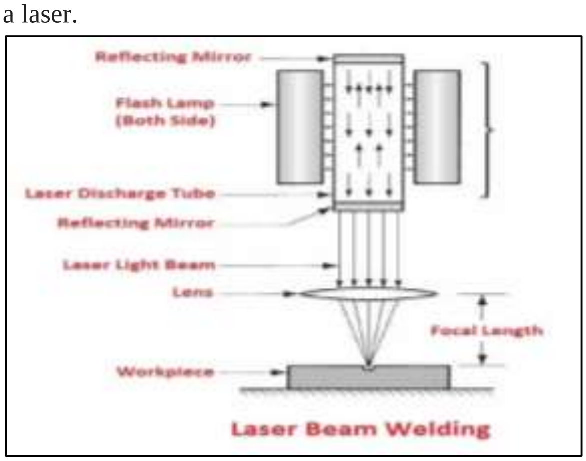

Figure 1: Laser Beam Welding

Initially, the welding machine is setup (between the two metal pieces to join) at the desired location. Later setup, a high voltage power supply is applied to the laser machine to perform an operation. The lens is used to focus the laser into the area where welding is required. The solidification of the weld pool surrounded by cold metal occurs as rapidly as the melt. Since the time the molten metal is in contact with the atmosphere is low, there is no contamination and therefore no gradient (neutral gas, flow) is required.

2. LITERATURE REVIEW

Daurelio et al. [1] improved the laser beam absorptivity of copper with cupric and cuprous oxides pre-coated materials.

In another study, Pelletier et al. [2] improved the copper laser energy coupling efficiency with the addition of stainless-steel powder into the copper molten pool during laser welding.

In another study, Chen et al. [3] improved the copper laser thermal efficiency with the nano-composite absorber sprayed on the copper surface. Summing up, coating the copper surface with less reflective material significantly improved the copper laser beam absorptivity. However, it is expensive and laborious for industrial applications. Other studies focused on using dual laser beam and laser power modulation to improve the copper absorptivity [4]

For instance, Hess et al. [5] improved the absorptivity of the copper welding process using a combined low power green laser spot (532 nm) and infrared laser spot (1064 nm).

Heider et al. [6] observed improved stability and weld penetration of laser welding of copper while using laser power modulation.

Welding at higher laser power and high welding speed was also found to improve the weld quality [24, 28].

Heider [28] established a process window for a stable welding of pure copper without power modulation or the need for a second harmonic beam source. According to these authors, a stable laser beam welding process with welding depth over 3 mm in pure copper was achieved if the laser power and welding velocities were set to high values (laser power ≥ 10 kW and welding velocity ≥ 9 m/min).

Zhang et al. [24] also reported that when the laser power and welding velocities were set to high values, the welding defects could be minimized.

3. OBJECTIVE

The objective of current research is to investigate the fusion zone developed in laser welding process. The numerical analysis is conducted using ANSYS software and heat flux applied in the analysis is 1000W and 2000W.

4. METHODOLOGY

The CAD model of laser welding specimen is developed in Creo design software using sketch and extrude tool. The developed CAD of laser welding specimen is converted in .iges file format and imported in ANSYS design modeler. The laser beam welding model is checked for geometric errors, hard edges etc.

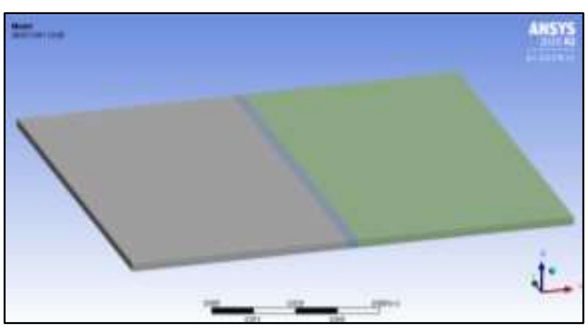

Figure 2: CAD model

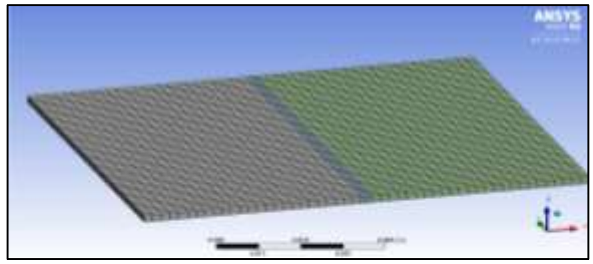

Figure 3: CAD model

The beam welding design is discretized in to fine elements. The element used in the discretization of the specimen is of hexahedral type. The growth rate is set to 1.2 and inflation is set to normal for meshing process.

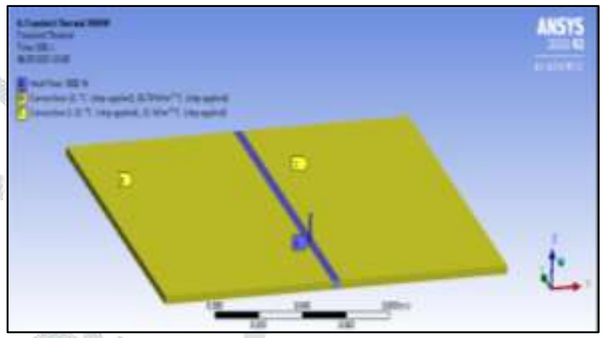

Figure 4: Loads and Boundary conditions

The thermal loads and boundary conditions are applied on the beam welding specimen as shown in figure 4 above. The model is applied with heat flow of 1000W which is represented by dark blue colored region. The other exposed regions are applied with convection coefficient of 20.78W/m^2 and 22 W/m^2. The transient thermal boundary conditions are defined with simulation time set to 500secs and defined by sub steps.

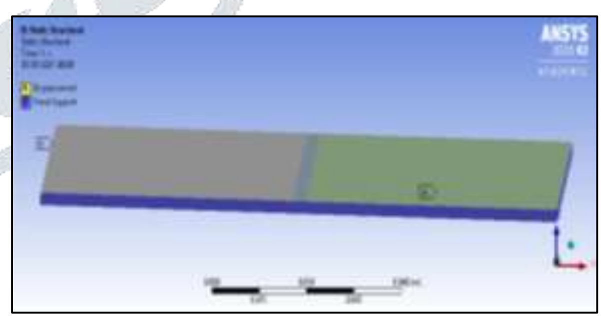

Figure 5: Structural loads and boundary conditions

The laser beam welding specimen is applied with fixed support at the bottom face as represented by yellow color. The side faces of specimen are also applied with fixed support as shown in dark blue color.

5. RESULTS DISCUSSION

The results are obtained for transient thermal analysis and temperature plots are generated. The temperature plot for 1000W heat flux is shown in figure 5 below. The temperature plot shows maximum magnitude at the zone of application of heat flux as represented by red color. The temperature decreases on moving away from the center zone. The temperature reduces below 520K on copper side.

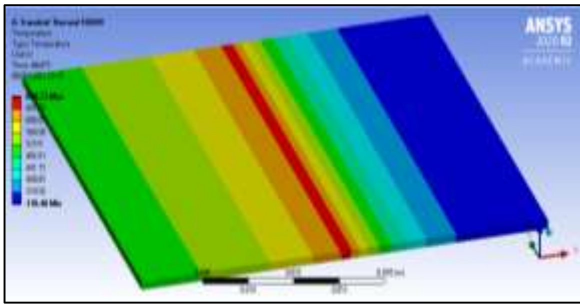

Figure 6: Temperature plot of heat flux

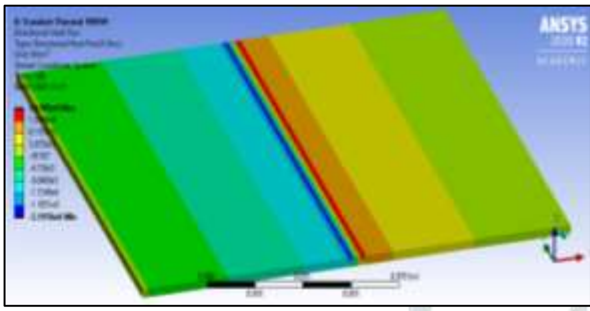

Figure 7: Directional heat flux plot

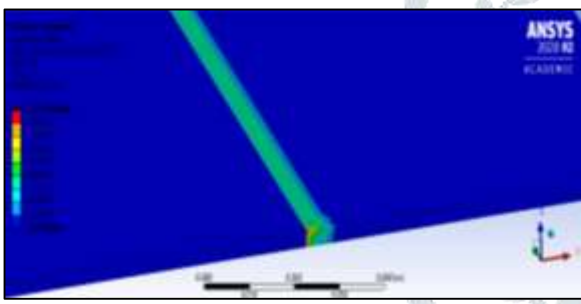

Figure 8: Equivalent stress plot

The equivalent stress plot is generated when the specimen is subjected to thermal loads. The equivalent stress generated is more than 5.8009E9Pa and most of the zone on which heat is applied has equivalent stress 3.625E9Pa. The remaining portion of specimen has stress lower than 570Pa.

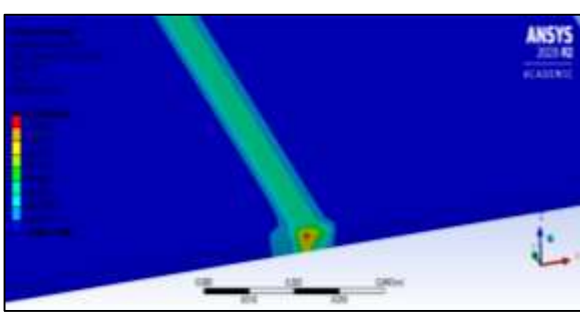

Figure 9: Equivalent elastic strain plot

The equivalent elastic strain plot of laser welding specimen is shown in figure 9 above. The plot shows maximum equivalent elastic strain of more than .029m/m and the equivalent elastic strain is lower at the center of heat application zone. The equivalent elastic strain at this region is nearly .018m/m.

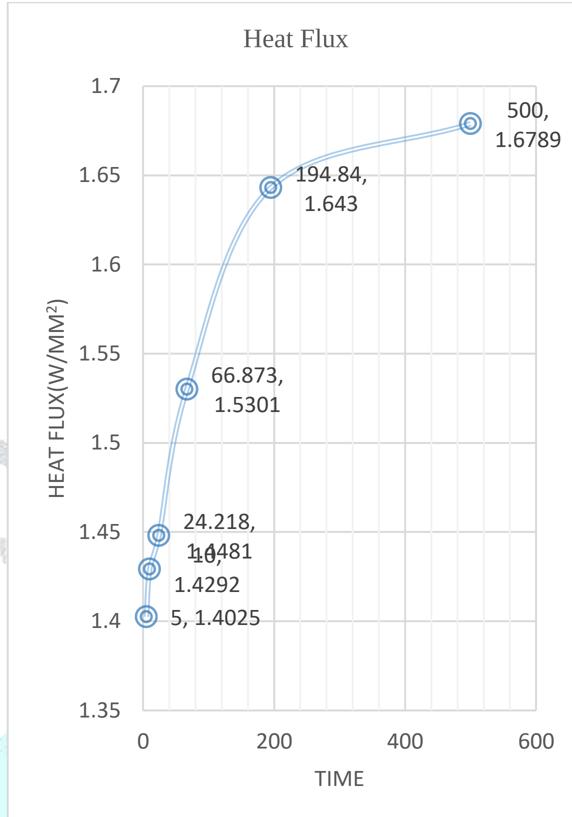

Figure 10: Heat flux with respect to time

The variation of heat flux with respect to time is shown in figure 10 above. The heat flux is initially less and then linearly increases to 1.53W/mm^2. The heat flux further increases parabolically and reaches maximum value of 1.67W/mm^2 at 500 counter secs.

6. CONCLUSION

The FEA is a viable tool to determine structural and thermal characteristics of laser beam welding process. The temperature distribution plot shows different temperature zones for copper and nickel material. The heat flux on copper side is higher than nickel side. The region of heat flux incident has higher equivalent elastic strain as compared to other regions. The equivalent elastic strain is maximum of .0326mm/mm.

REFERENCES

[1] Daurelio G, Giorleo G (1991) Experimental techniques to cut and weld copper by laser-a review. Material And Manufacturing Process 6(4):577 – 603. https://doi.org/10.1080/10426919108934791

[2] Pelletier J, Sallamand P, Druette L (1996) Laser welding of pure copper sheets with continuous powder feed. Laser Institute of America, Orlando

[3] Chen HC, Bi GJ, Nai MLS, Wei J (2015) Enhanced welding efficiency in laser welding of highly reflective pure copper. J Mater Process Tech 216:287–293. https://doi.org/10.1016/j.jmatprotec.2014.09.020

[4] Hess A, Schuster R, Heider A, Weber R, Graf T (2011) Continuous wave laser welding of copper with combined beams at wavelengths of 1030 nm and of 515 nm. Lasers in manufacturing 2011: proceedings of the Sixth International Wlt Conference on Lasers in Manufacturing, Vol 12. Pt A 12:88–94. https://doi.org/10.1016/j. phpro.2011.03.012

[5] Engler S, Ramsayer R, Poprawe R (2011) Process studies on laser welding of copper with brilliant green and infrared lasers. Lasers in manufacturing 2011: proceedings of the Sixth International Wlt Conference on Lasers in Manufacturing, Vol 12. Pt B 12:339– 346. https://doi.org/10.1016/j.phpro.2011.03.142

[6] Heider A, Stritt P, Hess A, Weber R, Graf T (2011) Process stabilization at welding copper by laser power modulation. Phys Procedia 12:81–87. https://doi.org/10.1016/j.phpro.2011.03.011

[7]. Zhang LJ, Zhang GF, Ning J, Zhang XJ, Zhang JX (2015) Microstructure and properties of the laser butt welded 1.5-mm thick T2 copper joint achieved at high welding speed. Mater Design 88: 720–736. https://doi.org/10.1016/j.matdes.2015.09.072

[8] Heider A, Stritt P, Weber R, Graf T High-power laser sources enable high-quality laser welding of copper. In: Proceedings 33rd International Conference on Applications of Lasers and Electro optics Icaleo, San Diego, USA, 2014