Optimization Weld Beed Geometry And Shape Of Robotic Arc Welded Inconel Sheet

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Abstract- *optimization of weld bead geometry and shape of robotic arc welded Inconel sheet. Robot welding means welding that is performed and controlled by robotic equipment. In general equipment for automatic arc welding is designed differently from that used for manual arc welding. Automatic arc welding normally involves high duty cycles, and the welding equipment must be able to operate under those condition. In addition, the equipment components must have the necessary features and controls to interface with the main control system.*

Keywords- Inconel sheet,Rockwell Hardness, macroscopic view, microscopic view.

I. INTRODUCTION

Robotic gas metal arc welding (GMAW) process is one of the most important in the industry. So different efforts have been made to anticipate the parameters to covert this process into a stable one capable of joining parts with minimum human interference. In this sense controlling is essential for automated application because properties such as the weld mechanical strength are metal composition, the microstructure, and the weld bead geometry. Nevertheless, performing this automatic control to guarantee quality characteristic similar to a humanin mechanical welding system is still tricky.

The development of automated arc welding solutions continues to be driven by the requirement for higher product quality, productivity and reduced costs. In addition, good manufacturing system flexibility, which is essential for responding to the dynamic of the market and therefore keeping products competitive, has become a key development target for the manufacturing industries. As a result, robotic welding processes offer attractive alternative solutions to traditional manual operation and hard automation.

I. Advantages of robotic gas metal arc welded

The main advantage of GMAW is itsversatility. It can weld multiple metals, including steel, aluminum, stainless steel, and nickel alloys. The process also produces high-quality welds with minimal heat distortion or burn-through. This makes it ideal for more delicate projects where precision and accuracy are key. Additionally, GMAW can be used indoors and outdoors without sacrificing quality or speed.

II. EDM PROCESS

Electrical discharge machining (EDM) is a popular nonconventional machining approach that is often used on hard materials. This method is popular because of the fact that EDM can machine any materials irrespective of its hardness. Modern engineering materials that are deployed in extreme conditions are often shaped or manufactured by EDM process. But this process has its own drawbacks. Lower material removal rate and significant tool wear can often hinder the machining efficiency in this method. Other conventional or nonconventional manufacturing methods can be combined with EDM to create a more uniform and balanced machining setup. Hybrid or combined approaches of machining can overcome the inherent drawbacks of EDM process. The performance of machining can improve significantly when other manufacturing processes are incorporated with conventional EDM.

EDM is a thermoelectric process used to remove metala series of discrete sparks between the metal and workpiece. In EDM an electric spark is used as the cutting tool to cutthe workpiece and produce the finished part to the required shape. Electricity flows through the electrode in the form of a square wave attacking the points of least resistance on the workpiece, similar to a bolt of lightning hitting a tree before in hits the ground.

Sample fig.01

III. EXPERIMENTAL SETUP

MOUNTING PROCESS

Mounting is a process by which a computers operating system makes files and directories on a storage device. In general, the process of mounting comprises the operating system acquiring access to the storage medium recognizing reading and processing file system structure and metadata on it before registering them to the virtual system components.

POLISHING PROCESS

Polishing is a finishing process in which a smooth and shiny surface is created by rubbing or applying a chemical treatment. Polishing can be done by using a fine-micron or sub-micron abrasive particle in combination with a liquid and a pad. Polishing can also use mechanical, chemical or electrochemical effects to reduce the surface roughness of the workpiece

Sample fig.03

ETCHING PROCESS

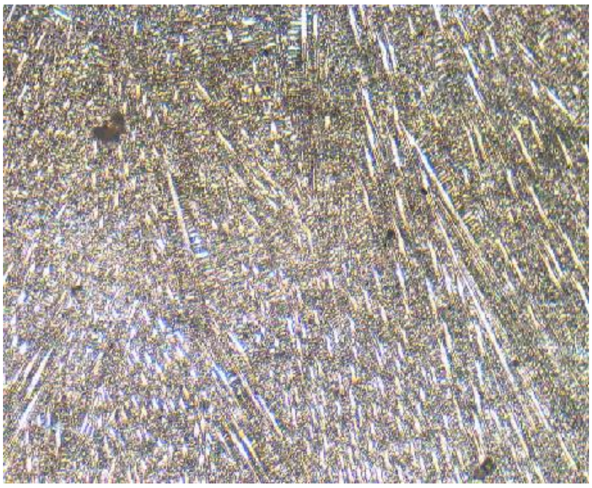
1. Cut the weldment into a cross-section using a saw.
2. Sand down the saw marks.
3. Polish the cross-section.
4. Brush on the Ferric Chloride.
5. Rinse off the etched weld.

The etching process can be accomplished by either swabbing or immersing the parts in a solution made by dissolving $(NH_4)_2(SO_4)$ in H_2O, dissolving powdered $FeCl_3$ in warm HCl, mixing (a) and (b) above, and adding HNO_3. To conduct the 95ml of distilled water and to mixing the acid is the powder format. (Electrode light technique) to pass the 1 amp current in 12V.

Sample fig.02

Macroscopic view

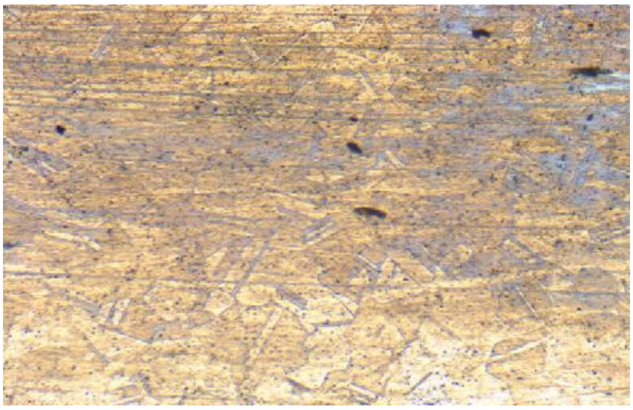
The arc welding process is widely used in industry, but the automatic control is limited by the difficulty in the process for measuring the principal magnitudes and to close the control loop. Adverse environmental conditions make use of conventional measurement systems difficult for obtaining information of the weld bead geometry. Under these conditions, indirect sensing techniques are a good option. Different sensing and estimation techniques are used, but few researchers are focusing on the flat welding position. The theory and practice prove that the dynamic models are the best representation to control the welding process, but most studies are performed with static models. This work is a review of the algorithms and sensing techniques used for collecting values of the arc welding process that allow the measurement or estimation of the weld bead geometry. Special attention is given to sensor fusion techniques due to its promising future in the welding process. Discussed in this text are the papers, patents, thesis and other documents found on the theme. It shows a summary of their evolution over the last 50 years.



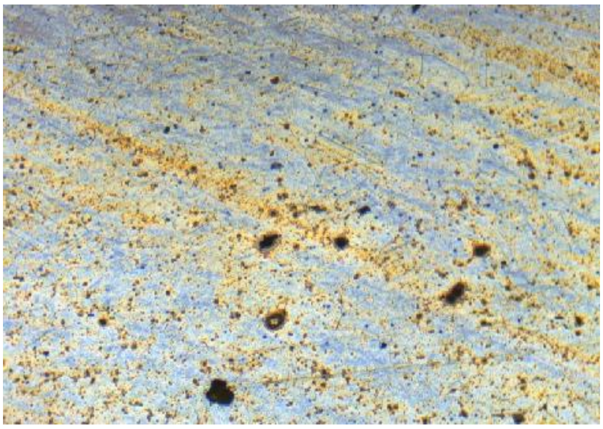
Sample fig.04

MICROSCOPIC VIEW

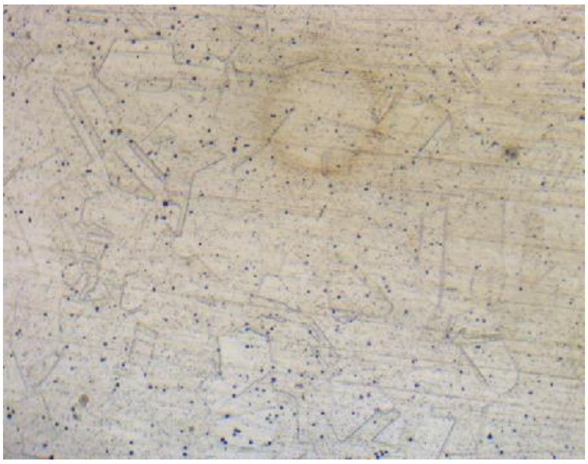
optical microscope. Magnified photographs are taken and images are processed digitally to measure the weld bead geometry parameters including bead width, reinforcement, and penetration. To observe the mechanical behavior of the weld zone, Vickers microhardness is measured.



Sample fig.05

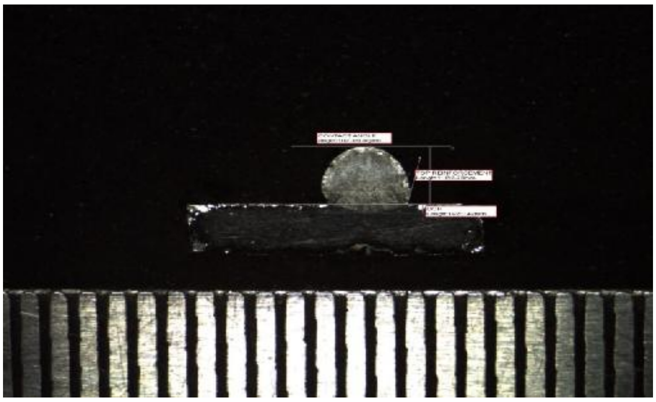


Sample fig.06



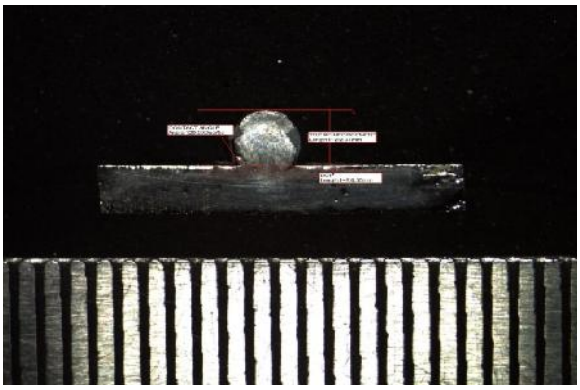
Sample fig.07

TRAIL OF MICROSCOPIC VIEW



Trail no.01

First trail to take the microscopic view to take the depth and arc curve.

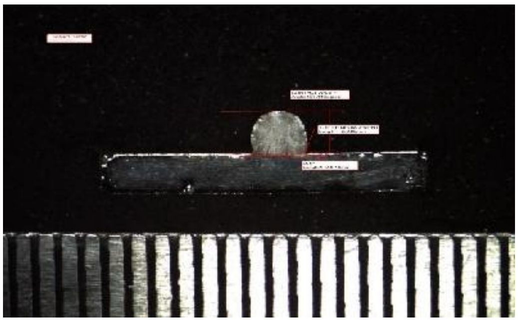


Trail no.02

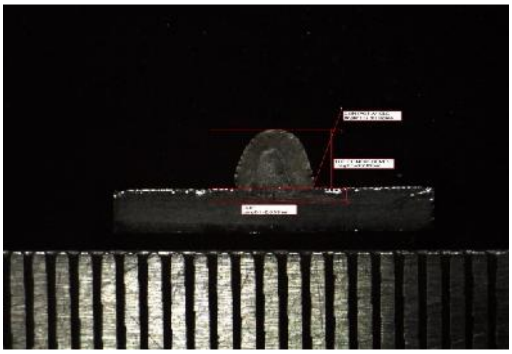
- Bead on plate welding trials are conducted on the Inconel sheet using Robotic arc welding process.
- Welded sheets are sectioned using wire cut EDM process.
- Welded specimens are mounted and polished (metallographically prepared samples).
- Finally, the polished welded samples are etched with a suitable etchant to reveal the macrograph.
- The macrographs are presented below for various process parameters.
- Microhardness measurements (load of 500g with a dwell time of 10s) are carried out on the welded samples to find out the mechanical integrity.
- Process parameter window

Trial no.	**Welding Current (I), Amps**	**Welding Speed (S), mm/min**	**Welding Voltage (V), Volts**
1	130	170	15.9
2	130	165	15.9
3	130	150	15.9
4	125	170	15.3
5	125	165	15.3
6	125	150	15.3
7	120	170	14.6
8	120	165	14.6
9	120	150	14.6

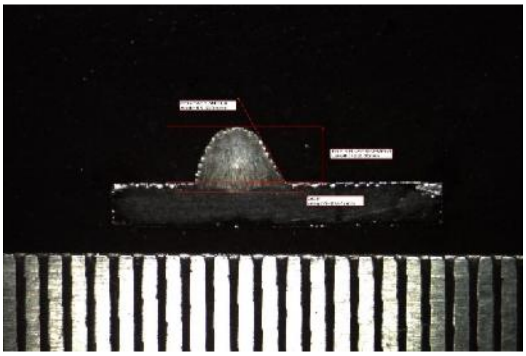
- Shielding gas environment: 99.999% Argon; 15 l/min and 18 bar.
- The sample no. 10 is conducted with the best parameter (with highest depth of penetration) on a butt joint configuration. The macro photograph of sample no. 10 envisages the complete penetration of the butt joint configuration.



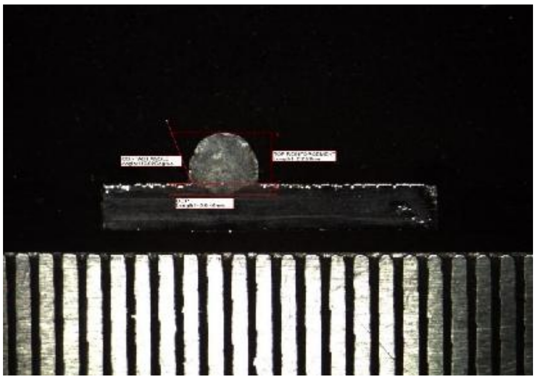
Trial no. 3



Trial no. 4

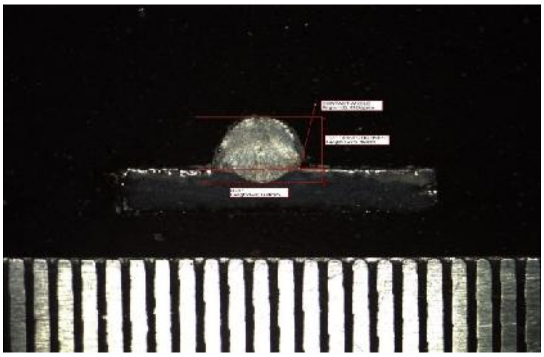


Trial no. 5

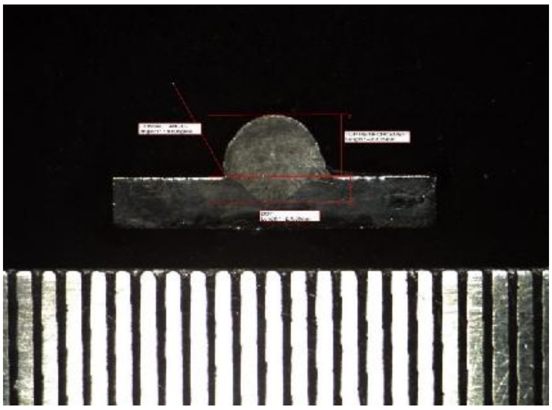


Trial no. 6

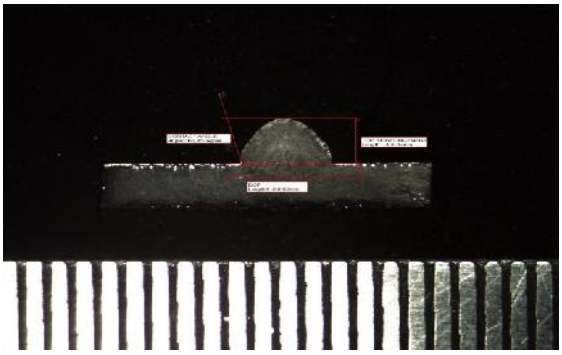
To check the parameter in microscopic View.



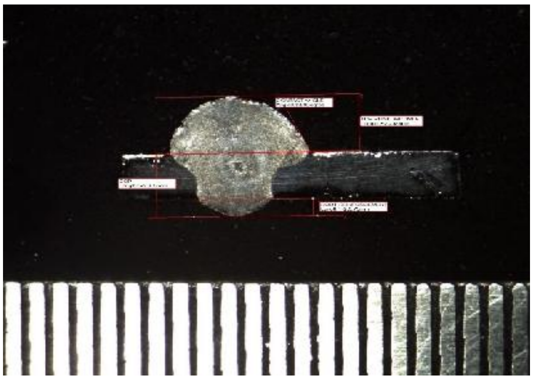
Trial no. 7



Trial no. 8



Trial no. 9



Sample no. 10 (butt-joint configuration)

Inference from the results:

The complete reinforcement is achieved with the last macro photograph analysis. The parameter with complete penetration is the desirable output required for the present study. This implies that the parameter for the last macro photograph is the best parameter.

MICROHARDNESS

LOAD=500G
VICKER'S HARNESS
DURATION TIME:10 SEC

I.

1) 234.9HV0.5
2)226.6HV0.5
3)234.1HV0.5 (INTERFACE)
4)243.7HV0.5

II.

1)235.6HV0.5
2)227.1HV0.5
3)235.7HV0.5
4)241.1HV0.5

III.

1)231.1HV0.5
2)228.5HV0.5
3)239.2HV0.5
4)241.1HV0.5

IV.

1)232.1HV0.5
2)229.1HV0.5
3)238.1HV0.5
4)240.1HV0.5

V.

1)230.1HV0.5
2)218.1HV0.5
3)229.1HV0.5
4)239.5HV0.5

REFERENCES

[1] Ramkumar, K. Devendranath & K, Gokul & N, Arivazhagan. (2014). Characterization of metallurgical and mechanical properties on the multi-pass welding of

Inconel 625 and AISI 316L. Journal of Mechanical Science and Technology. 29. 10.1007/s12206-014-1112-4.

[2] Kolahan, Farhad & Heidari, Mehdi. (2010). A New Approach for Predicting andOptimizing Weld Bead Geometry in GMAW.

[3] N. Pravin Kumar, N. Siva Shanmugam,Somestudies on nickel based Inconel 625 hard overlays on AISI 316L plate by gas metal arc welding based hardfacing process, Wear, Volumes 456–457, 2020,

[4] IzzatulAini Ibrahim, Syarul Asraf Mohamat, Amalina Amir, Abdul Ghalib, The Effect of Gas Metal Arc Welding (GMAW) Processes on Different Welding Parameters, Volume 41, 2012,

[5] Erdal Karadeniz, Ugur Ozsarac, Ceyhan Yildiz, The effect of process parameters on penetration in gas metal arc welding processes, Materials & Design, Volume 28, Issue 2, 2007,

[6] Mohan Kumar, S., Rajesh Kannan, A., Pravin Kumar, N. et al. Microstructural Features and Mechanical Integrity of Wire Arc Additive Manufactured SS321/Inconel 625 Functionally Gradient Material. J. of Materi Eng and Perform 30, 5692–5703 (2021)