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ANALYSIS OF MECHANICAL PROPERTIES OF SS304L AND SS308L IN HYBRID MANUFACTURING PROCESS WITH VARIABLE HEAT INPUTS

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ABSTRACT: Produced bimetallic additive Surfaces take the place of traditionally made surfaces. By combining metal forming technology with wire arc additive manufacturing technology, a hybrid technology employing layer wise variable heat inputs is created and a bimetallic additive manufactured surface is prepared. Utilizing pulse mode WAAM technology, SS308L was deposited on this SS304L hot-forged component. Mechanical properties such as Tensile Strength and Hardness were examined at various zones and the analysis concludes that implementation of layer wise variable heat inputs in WAAM enhances the mechanical properties.

KEYWORDS: WAAM, Metal Forming, Hybrid manufacturing, SS304L, SS308L, Mechanical Properties, Heat Input.

1.INTRODUCTION

[1] The process of layer-by-layer object production is referred to as additive manufacturing. It is the opposite of subtractive manufacturing, which involves producing an item by gradually removing little amounts of a solid block of material.

[2] By layering materials to create objects, additive manufacturing is a revolutionary industrial technology that enables the fabrication of custom components with previously unheard-of levels of freedom. Unique hierarchical microstructures are created for metallic materials during additive manufacturing, providing them a variety of amazing properties.

[3] In present days additive manufacturing (AM) has become a busy area of research and technology transfer because of the expanding demand for effective and environmentally friendly practises in the concrete construction industry.

[4] Dual wire arc additive manufacturing was used in the current work to create functionally graded material (FGM) with a seamless composition transition from 100% Inconel 625 (IN625) to 100% stainless steel 308L. Due to the ability to identify the location clearly and easily in the composition's gradient path with every weakest mechanical property, every issue may be completely highlighted with this composition transition. During manufacturing, cracks close to the position with IN625 of 20 wt% were found. They were identified as liquation fractures, which are hot cracks, based on the fracture's shape and tract.

[5] In this chapter heavy weight and low material on HSLA steel (T-WAAM) is used another material cu is mixed with that WAA material then processed on arc additive manufacturing making is used to functionally graded material part is created. Because copper and steel components combine excellent mechanical properties with robust thermal and electrical conductivity, a variety of sectors are interested in using them.

Multi-energy microgrids (MEMs) have increased significantly in recent years in order to attain zero net emissions. New possibilities for reducing carbon emissions in MEMs are provided by hydrogen-based technologies and energy conversion systems. This study uses hybrid demand response (DR) technology, integrated energy sources, and promoted energy conversion facilities to try to schedule these resources as efficiently as possible.

[6] Researchers worked to determine thermal behaviour in WAAM and concentrated on analysing it.

[7] In this experiment, deposits were created using wire-arc additive manufacturing (WAAM) with a

variety of heat inputs utilizing an Al-Cu-Sn alloy as the starting material. It has been investigated how heat input affects the microstructure and mechanical characteristics of Al-Cu-Sn alloy deposits. by examining the mechanical properties, metallography, energy dispersive spectroscopy, transmission electron microscopy, and scanning electron microscopy. The findings demonstrate that deposits' thickness and layer height grew as heat input increased.

1. MATERIALS AND METHODOLOGY

2.1 MATERIALS:

STAINLESS STEEL 304L (BASE PLATE)

Stainless steel alloy 304L, a T-300 series austenitic contains a minimum of 8% nickel and 18% chromium. The maximum amount of carbon in type 304L is 0.030. It is the typical "18/8 stainless" that is frequently discovered in cookware and kitchen appliances. The most adaptable and popular alloy in the stainless-steel family is alloy 304L. Alloy 304L has superb formability, high ease of fabrication, and strong corrosion resistance, making it perfect for a variety of domestic and professional purposes. Austenitic stainless steels can be joined using any fusion or resistance welding technique, making them the most weldable high-alloy steels.

STAINLESS STEEL 308L:

A low carbon version of grade 308 stainless steel is grade 308L. It is specifically used to weld grade 304 stainless steel using a submerged arc. In non-corrosive environments, it can also be utilised for welding stabilised grades 321 and 347.

Table 1 and 2 shows SS304L and SS308L mechanical and physical properties respectively.

GRADE	TENSILE STRENGTH KSI (MPA)	HARD NESS (BRINELL) MAXI	HARD NESS (ROCKWELL B) MAXI
304L	70 (485)	201	92
308L	88 (593)	170	87

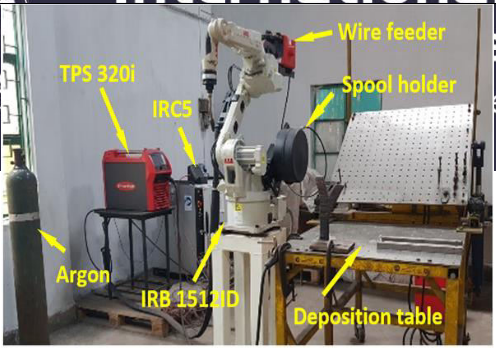
Table 1: **Mechanical Properties:**

GRADE	DENSITY G/CM3	THERMAL CONDUCTIVITY (W/M-K)	ELECTRICAL RESISTIVITY (IN X 10-6)	COEFFICIENT OF THERMAL EXPANSION (IN/IN) / °F X 10-6	SPECIFIC HEAT (BTU/LB/ °F)	MELTING RANGE (°F)
304L	7.93	16.2 at 100°C 21.5 at 500°C	28.3 at 68°F	9.4 at 32 – 212°F	0.1200 at 68°F to 212°F	2500 to 2590
308L	7.8	15 at 100°C 20.2 at 500°C	26.2 at 68°F	9.6 at 32 – 212°F	0.11 at 68°F to 212°F	1380 to 2510

Table 2: **Physical Properties:**

2.2 METHODOLOGY:

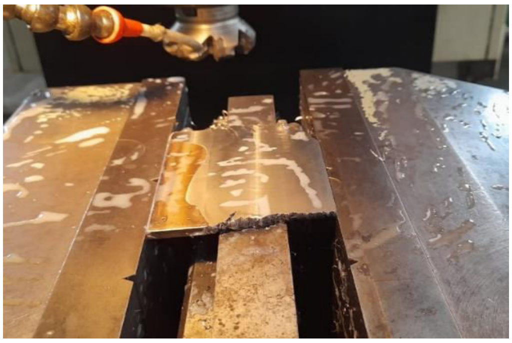
A hybrid manufacturing process forging, and Wire Arc Additive Manufacturing was used in this experiment. A forged plate of SS 304L was taken and SS308L MIG wire with 1.2mm diameter was used for deposition using GMAW-WAAM. While deposition, pulse mode was used in GMAW-WAAM which give better results. This deposition was done until a dimension of 100x50x5mm was achieved. While depositing the heat input for deposition was varied layer by layer to study the thermal effects on mechanical properties in Wire and Arc Additive Manufacturing process. Researchers proved the two-tier input system yields better results in WAAM



(a)

(b)

(c)



(d)

deposition process, two tier heat input system for layer by layer was employed in this experiment while depositing on a forged plate.

Fig 1: (a) Experimental set up (b) Deposition on forged plate (c) Final specimen (d) Post processing of plat

Parameters mentioned in the following table 3 are used in the experiment. These parameters are varied from layer by layer. First layer was started with high heat input and a time gap of 10 seconds was given for solidification; second layer deposition was started with low heat input. Likewise, all the layers were deposited. A total of 36 layers were deposited to attain the required height on the forged plate. Heat input calculations was based on $Q=(\eta*V*I)/v$

LAYER	I_M (AMP)	V_M (VOLT)	F (HZ)	T S (MM/SEC)	H I (J/MM)	I_P (AMP)	I_B (AMP)	T_P (SEC)	T_B (SEC)
1	147	20.3	0.5	6	422.74	250	78.3	0.8	1.2
2	119	11	0.4	5	222.136	204	64	0.7	1.0

Table 3: Process parameters in the Experimentation

2.3 TENSILE TEST:

Three miniature size tensile samples were taken from the walls for the tensile test analysis, at three different zones: one horizontal piece at the forged and deposition interface, a second vertical specimen at the interface, and a third at the deposition zone. [8] Tensile test specimen was extracted based on ASTM E8M standards using Wire EDM Then micro tensile test was done and the tensile strength of three specimens were mentioned in the table 3.

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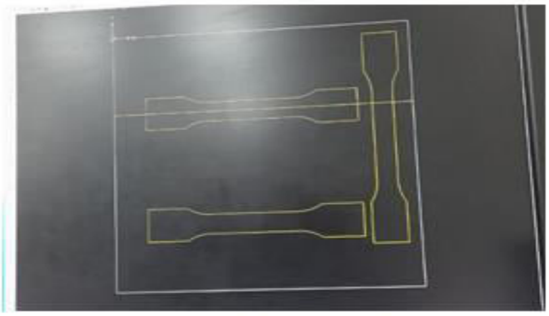


Fig. 3 AutoCAD image for Tensile Testing

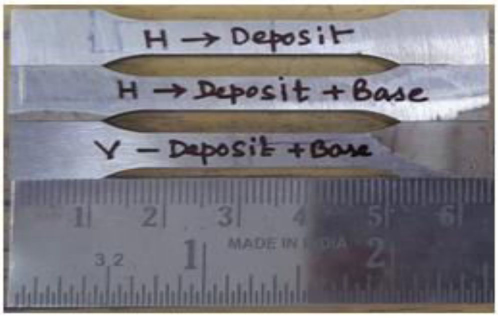


Fig. 4 Test Specimens as per ASTM standard

2.4 HARDNESS TEST:

Micro-Hardness test was done using Hardness testing machine as per ASTM E18 standards with 1.2 kgf with dwell time 10 seconds. Hardness of the deposited zone taken with reference to interface mentioned in the table 4.

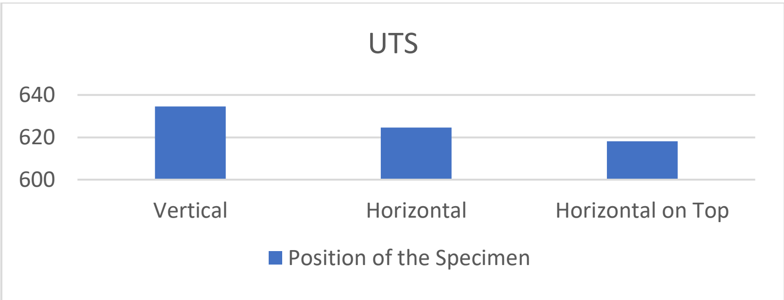
2. RESULTS :

2.1 TENSILE STRENGTH:

FORGED PLATE	635.890MPA
POSITION OF SPECIMEN	ULTIMATE TENSILE STRESS (MPA)
Vertical	634.583MPa
Horizontal	624.629MPa
Horizontal from top	618.174MPa

Table 5

The Tensile test was done and found that tensile strength of the three sample pieces from three different zones were having very small difference in their values as mentioned in the table 5 and the values are graphically represented as shown in the graph 1.



Graph 1

And the Load vs Displacement and the Stress vs Strain values are represented graphically in the Graph 2 and 3 respectively.

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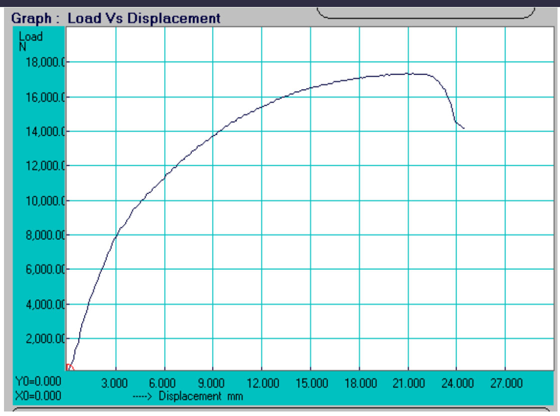
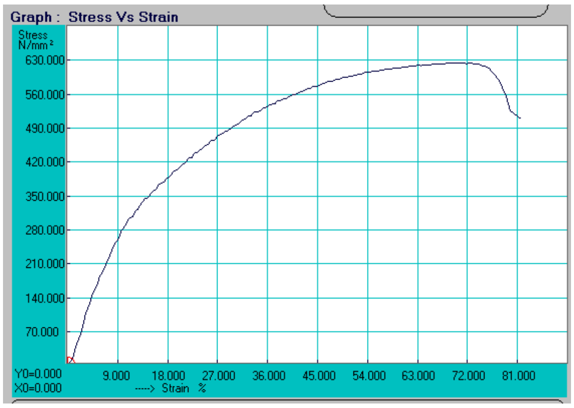


Graph 2



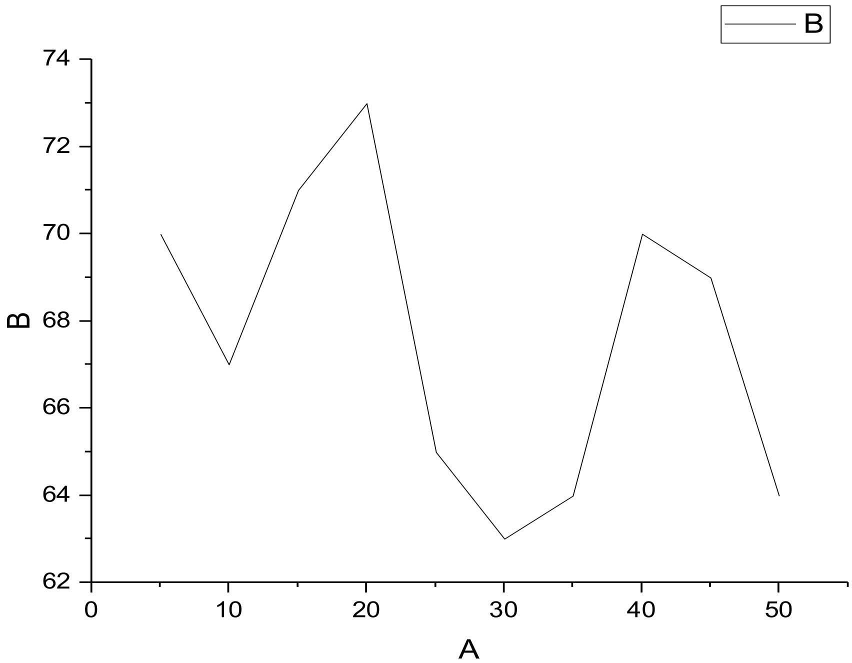
Graph 3

2.2 HARDNESS:

DISTANCE IN BUILD-UP DIRECTION(MM)	5	10	15	20	25	30	35	40	45	50
HARDNESS (RHN)	70	67	71	73	65	63	64	70	69	64

Table 4

In the Hardness testing using UTS we found that the Rockwell Hardness of the build-up distance of the deposition from the interface has been observed that all the values are near to the maximum hardness. These values are mentioned in the Table 4 and these values are represented graphically in the Graph 4.



Graph 4

4. CONCLUSION:

Hybrid Manufacturing was successfully implemented in SS300 Series by deposition of layer by layer with variable Heat inputs for this experiment and it was concluded that:

- The deposition of successive layers with various heat input is sufficiently melts the previous. As a result, it produces strong metallurgical bonding between the layers, fulfilling the GMAW-WAAM process requirement for inter-layer bonding.
- The implementation of viable heat input reduces the anisotropy in all directions of the specimen and further enhances in the better results of Tensile strength and Hardness

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