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Feasibility Study of Er70s Solidwire for Wire Arc Additive Manufacturing using Mig Welding

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ABSTRACT: Additive manufacturing (AM) using Metal Inert Gas (MIG) welding offers a cost-effective approach for fabricating metal components. This study investigates the feasibility of using ER70S mild steel wire as feedstock in wire arc additive manufacturing (WAAM). Process parameters such as voltage, current, and wire feed rate were optimized through experimentation. Microstructural analysis and mechanical testing, including tensile strength and hardness, were conducted to evaluate the fabricated parts.

The results show that ER70S wire can produce components with satisfactory quality and mechanical properties. However, defects like porosity and cracking were observed, and mitigation strategies are proposed. This study highlights the potential of MIG-based AM for cost-effective and scalable industrial applications.

KEYWORDS: Wire Arc Additive Manufacturing, MIG welding, ER70S solid wire, feasibility study, deposition rate, metallurgical properties, weld bead geometry, mechanical properties, additive manufacturing, process optimization

I. INTRODUCTION

Additive manufacturing (AM) has emerged as a transformative technology for the fabrication of complex components with enhanced design flexibility and reduced material waste. Among the various AM processes, wire arc additive manufacturing (WAAM) using Metal Inert Gas (MIG) welding presents a promising approach due to its cost-effectiveness and compatibility with existing welding equipment and techniques. In this investigation, we explore the application of ER70S MS wire—commonly used in traditional welding—as a feedstock material for additive manufacturing using MIG welding.

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II. ADDITIVE MANUFACTURING (WAAM):

WAAM offers a significant cost saving and a higher deposition rate. However, there are significant challenges associated with WAAM such as undesirable microstructures and mechanical properties, high residual stresses, and distortion. Thus, more research is still needed to handle the above challenges by optimizing the process parameters and post-deposition heat treatment. In line with the above, this paper attempts to fill the gap by presenting a comprehensive review of WAAM literature including stage wise development of WAAM, metals and alloy used, effects of process parameters, methodologies used by various researchers to improve the quality of WAAM component

III. TYPES OF WAAM

1. Gas Metal Arc Welding
2. Gas Tungsten Arc Welding
3. Robot-Assisted

IV. THE APPLIED HARDWARE:

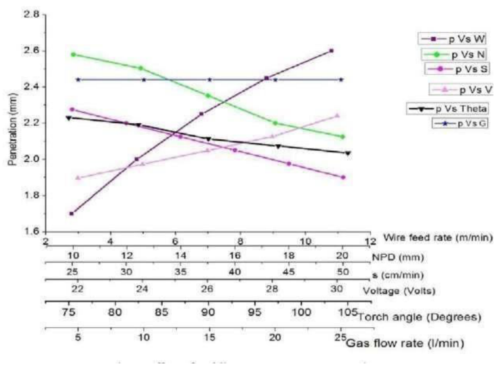
It consists of an IRB 2600 industrial robot with an IRC5 control system and a Fronius TPS 500i welding power source. Attached on the robotic arm is a Fronius WF 60i Robacta Drive CMT weld gun and the worktable consists of a 2-axis positioner called IRBP A250. The positioner can be used for coordinated movements, but is mostly used to change the build direction for parts to prevent building with overhangs**.**

4. Experimental Setup, Results and Bearing Fault Detection

The vibration-based predictive maintenance system was experimentally implemented to evaluate its effectiveness in detecting machine faults, particularly bearing-related failures. The setup consists of a vibration sensor mounted on the machine surface near the bearing housing to capture accurate vibration signals. The sensor output is interfaced with an Arduino Uno, which performs real-time data acquisition, processing, and comparison with predefined threshold values. The system continuously monitors vibration characteristics such as amplitude and pattern variations to assess machine health.

4.1 Welding Wire And Shielding Gas

Tensile test have been made by S. Dahat [26] for a specific wire, ø
ESAB OK Tubrod 14.03 1, 2mm. The shielding gas used was Mison 18. The results from showed a yield strength for the wire to be 720 MPa as worst. This value has been used when developing the torque arm and the same wire have been used through the project. Also the working envelope stated by Dahat have been used. The width depends on the current (I) and travel speed (TS).



MATERIALS PROPERTIES

Chemical Composition:

1. Carbon (C): 0.07-0.15%
2. Manganese (Mn): 1.40-1.85%
3. Silicon (Si): 0.80-1.15%
4. Phosphorus (P): 0.025% max
5. Sulfur (S): 0.035% max

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Mechanical Properties:
1. Tensile Strength: 70,000 psi (480 MPa)
2. Yield Strength: 58,000 psi (400 MPa)
3. Elongation: 22%

Welding Characteristics:
1. Excellent weldability and arc stability
2. Smooth, consistent weld bead
3. Low spatter and fumes
4. Suitable for welding mild steel, low-alloy steel, and some stainless steels

Applications:
1. General fabrication and repair
2. Automotive and construction industries
3. Pipe and tube welding
4. Shipbuilding and structural steelwork
5. Shielding Gas: Typically used with CO2 or Argon-CO2 mix
6. Welding Positions: All positions (flat, horizontal, vertical, overhead)

Some common variants:
1. ER70S-2: Deoxidized wire for welding rusty or dirty steel
2. ER70S-3: General-purpose wire for clean steel
3. ER70S-6: Higher silicon content for improved weldability and appearance

Microstructure of ER70S
1. Ferrite: Primary phase, providing strength and toughness
2. Pearlite: Lamellar structure, contributing to strength and hardness
3. Acicular Ferrite: Needle-like structure, improving toughness

The microstructure can vary depending on factors like:
a. Cooling rate
b. Welding parameters
c. Chemical composition

Common microstructural features:
1. Grain size: Fine grains improve strength and toughness
2. Inclusions: Oxides and sulfides can affect weld quality
3. Porosity: Gas pockets can reduce mechanical properties

V. MAGNETIC PARTICLE TEST

Magnetic particle inspection (MPI) is a nondestructive testing process where a magnetic field is used for detecting surface, and shallow subsurface, discontinuities in ferromagnetic materials. Examples of ferromagnetic materials include iron, nickel, cobalt, and some of their alloys. The process puts a magnetic field into the part. The piece can be magnetized by direct or indirect magnetization. Direct magnetization occurs when the electric current is passed through the test object and a magnetic field is formed in the material. Indirect magnetization occurs when no electric current is passed through the test object, but a magnetic field is applied from an outside source. The magnetic lines of force are perpendicular to the direction of the electric current, which may be either alternating current (AC) or some form of direct current (DC) (rectified AC).

There are several types of electrical currents used in magnetic particle inspection. For a proper current to be selected one needs to consider the part geometry, material, the type of discontinuity one is seeking, and how far the magnetic field needs to penetrate into the part.

past the surface of the test object. This means the magnetic domains will only be aligned equal to the distance AC current penetration into the part. The frequency of the alternating current determines how deep the penetration. Full wave DC[clarification needed – discussion] (FWDC) is used to detect subsurface discontinuities where AC can not penetrate deep enough to magnetize the part at the depth needed. The amount of magnetic pen etration depends on the

VI. CONCLUSION

1. Material Deposition Quality
2. Process Parameters Optimization
3. Microstructural Analysis
4. Mechanical Performance
5. **Defect Analysis and Mitigation**

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