# Evaluation of Impact Strength of Wire And Arc Additive Manufacturing 70S6 Plate

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***Abstract-*** *Additive Manufacturing (AM) is a technique where structures are produced by adding and depositing material in a layer upon layer manner. WAAM (Wire and Arc Additive Manufacturing) is a technology which has been investigated in the last 30 years, although the first patent dates from almost 100 years ago. It became interesting for scientists and manufacturers due to its ability to produce fully dense metal parts and large near-net-shape products. WAAM is mostly used in modern industries like the aerospace industry. It uses existing welding equipment, electric arc as energy source and welding wire as feedstock. Because of this, it is cheaper than other AM technologies, which usually need specific equipment and materials. The process consists of a few steps (designing CAD model, slicing into layers, tool-path generating, choosing welding parameters, material deposition and post-processing.*

***Keywords***- 70S 6PLATE, Rockwell Hardness, Arc Welding, Stainless Steel.

## I. INTRODUCTION

Additive manufacturing was first used to develop prototypes in the 1980s these objects were not usually functional. This process was known as rapid prototyping because it allowed people to create a scale model of the final object quickly, without the typical setup process and costs involved in creating a prototype. As additive manufacturing improved, its uses expanded to rapid tooling, which was used to create molds for final products. By the early 2000s, additive manufacturing was being used to create functional products. More recently, companies like Boeing and General Electric have begun using additive manufacturing as integral parts of their business processes.

The actual process of additive manufacturing can be done in a number of ways, all of which can take several hours to several days, depending on the object's size. One common method uses a nozzle to lay successive layers of material on top of each other until the final product is complete.Another process uses powders, typically made from metal. This works by "filling a bed with powder, and melting the parts of the powder that you want to form a solid part layer by layer.TheworkaimstodevelopapolymercompositewithProsopisjulifloraandmangotreeasreinforcements of a natural composite epoxy resin matrix. Composite plates were produced using a compression mold method with a composition ratio of 60:40, 65:35and70:30.Theresinandhardenerproportionswere10:1respectively.

**Advantages of additive manufacturing**

Additive manufacturing has some distinct benefits. With traditional manufacturing, the entire supply chain can take months and require an investment sometimes millions or billions of dollars that can only be recouped by high-volume production.

**4D-Printing**

With typical additive manufacturing, machines build a 3-D object that is fixed. 4-D printing creates 3-D objects that have the ability to change or transform over time, without human interaction.

**Additional design freedom**

WAAM and other additive manufacturing methods allow for the manufacturing of relatively complex shapes. This also means that topological optimization and the production of generative designed parts become more accessible.

**Components of the conventional machining process**
Traditional machining processes are different in their constructional features. However, the following are the basic elements of conventional machines:

Work holding device ● Tool holding device ● Work motion mechanism ● Tool motion mechanism ● Support structure.

## II. EXPERIMENTALDETAILS

### ADDITIVE MANUFACTURING

Additive manufacturing was first used to develop prototypes in the 1980s these objects were not usually functional. This process was known as rapid prototyping because it allowed people to create a scale model of the final object quickly, without the typical setup process and costs involved in creating a prototype. As additive manufacturing improved, its uses expanded to rapid tooling, which was used to create molds for final products. By the early 2000s, additive manufacturing was being used to create functional products. More recently, companies like Boeing and General Electric have begun using additive manufacturing as integral parts of their business processes.

### WAAM

Wire Arc Additive Manufacturing (WAAM) is a production process used to 3D print or repair metal parts. It belongs to the Direct Energy Deposition (DED) family of Additive Manufacturing processes. WAAM is executed by depositing layers of metal on top of each other, until a desired 3d shape is created. It is a combination of two production processes: Gas Metal Arc Welding (GMAW) and additive manufacturing.

### 70s 6 PLATE

### Evolution of ER70S-6

ER70S-6 is a copper coated solid welding wire which may be produced either in the form of welding rods to be suited for GTAW welding or in the form of welding coils to be suited for GMAW welding.

This type of welding wires is used in welding mild steel whether with argon gas shielding or carbon dioxide gas shielding or with a mixture of both in addition to other gases which can be mixed with any of the previously mentioned shielding gasses like helium and oxygen to be used for certain applications.

### ER70S-6 welding wire

is the mild steel welding wire designation as per the American welding society standard specification AWS SFA 5.18 “Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding”. Each part in the welding wire designation stands for certain information as follows:

- ER: stands for welding electrode in the form of rod.
- 70: stands for the minimum ultimate tensile strength of 70,000 psi for the produced weld metal.
- S: stands for the solid welding wire form. This letter may be C in other designations which stand for composite welding wire form.
- 6: stands for the chemical designator which refers to the amount of deoxidizers added to the wire including silicon, manganese, aluminum, zirconium and titanium.


### Rockwell Principle

Rockwell is a method of hardness testing that simply relies on the metal's resistance to indentation using a specific load application and a specific indenter. It has two load systems for measurement, which is light load and major load. The Rockwell hardness test is defined in ASTM E 18 and several other standards.

### Rockwell Hardness

The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test measures the depth of penetration of an indenter under a large load (major load) compared to the penetration made by a preload (minor load).

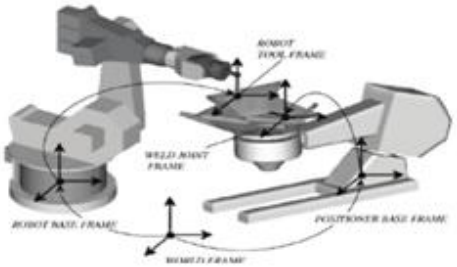
### Empirical mode Decomposition( EMD )

Empirical mode decomposition (EMD) is a data-adaptive multi-resolution technique to decompose a signal into physically meaningful components. EMD can be used to analyze non-linear and non-stationary signals by separating them into components at different resolutions

### Robotic arc welding

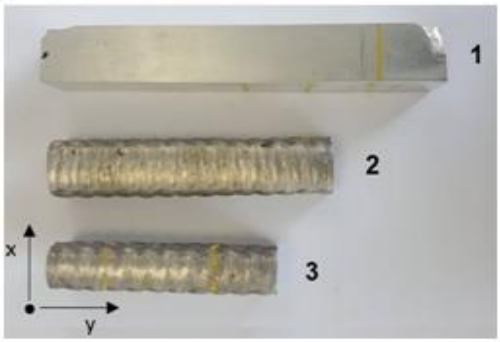
A basic robotic arc welding system is formed by two subsystems: the welding equipment delivering the energy from the welding power source to the work piece, and the robot providing relative positioning of the heat source and the work

piece and the robot providing relative positioning of the heat source and the workplace.



## III. RESULTS & DISCUSSION

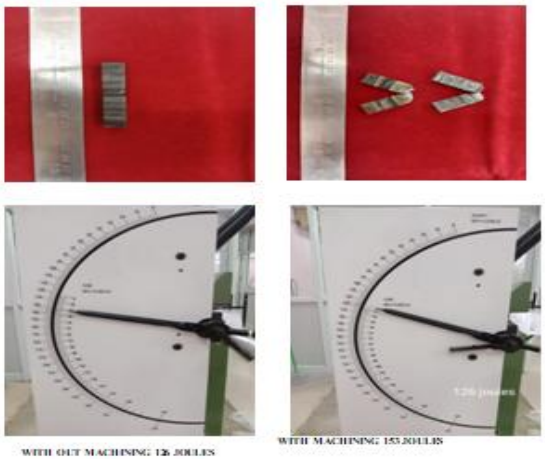
- Additive layers (wire arc additive manufacturing (WAAM)) are made on low carbon steel materials using 70S6 filler wire through Robotic arc welding process.
- The process parameter for additive manufacturing deposition: Welding Current – 130 Amps; Welding Voltage – 15.9 V and Welding Speed – 100 mm/min.
- Shielding gas environment: 95% Argon + 5% CO2; 15 l/min and 15 bar.
- The CAD model. Hence, it is better to input a lower layer height than the actual since this will result in a higher print and gives a safety margin for the post-processing. However, with more testing and experience this should not be a problem.
- Samples for impact strength evaluation are extracted from WAAM specimens using wire cut EDM process. Two different surface conditions (i.e. 1. Un Machined WAAM sample and 2. Machined WAAM sample) are considered for evaluating the impact strength
- WAAM specimens are subjected with hardness test to measure the surface hardness of the specimen
- Rockwell hardness measurements (load of 100kgf with 'B' scale) are carried out on the WAAM samples to find out the mechanical integrity.




UNMACHINED WAAM SAMPLE

MACHINED WAAM SAMPLE

## IV. RESULTS



WITH OUT MACHINING 126 JOULES WITH MACHINING 153 JOULES

**Inference of the present study**

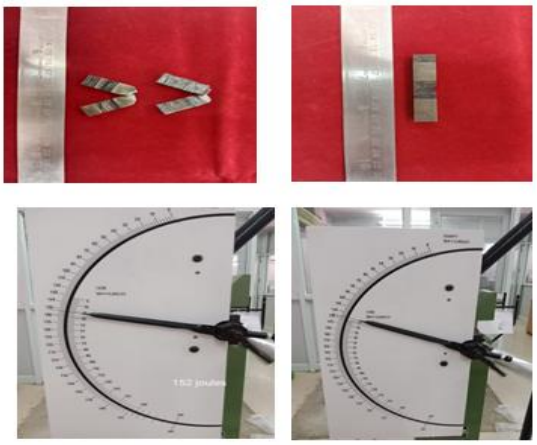
The main drawback with the wire arc additive manufacturing is the surface roughness of the built product. The machining of the surface is essential for the built product and it has a major influence on the properties. The machined component has attained an impact strength of 153 Joules and it is 20% higher than the impact strength of unmachined product.

**ROCKWELL HARDNESS / WAAM 70S6**

LOAD:100 kgf
B-SCALE

**INDENTOR STEEL BALL INDENTOR**

1) HRB58
2) 59 HRB
3) 55 HRB



WITH MACHINING 152 JOULES WITH MACHINING 128 JOULES

## V. CONCLUSION

Among the different AM processes, Wire Arc Additive Manufacturing seems suited to the manufacturing of medium to large scale components, thanks to the relatively high deposition rates, potentially unlimited build volume, low BTF ratios and low capital and feedstock costs. Substantial reductions in material waste and lead time are WAAM's main business drivers. These complement the increased freedom of design, which is a prerogative of powder based processes such as selective laser melting and electron beam melting. Thus, WAAM is a candidate to replace the current method of manufacturing aerospace components from billets or forgings. Its open architecture means that potentially any welding equipment could be used for AM purposes; however, the current lack of a commercially available.

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