IRJMETS

e-ISSN: 2582-5208

International Research Journal of Modernization in Engineering Technology and Science

(Peer-Reviewed, Open Access, Fully Refereed International Journal)

Volume:04/Issue:12/December-2022 Impact Factor- 6.752 www.irjmets.com

DETERMINATION OF IMPACT STRENGTH, HARDNESS AND COMPRESSIVE STRENGTH OF FRICTION STIR WELDED ALUMINIUM ALLOY 6061 JOINTS

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DOI : https://www.doi.org/10.56726/IRJMETS31976

ABSTRACT

Welding is the most economical and efficient way to join metals permanently. It is the only way of joining two or more pieces of metal to make them act as a single piece. Friction stir welding (FSW) is a most versatile mechanical joining process. This joining Technique welds by using a rotating and non-consumable welding tool to locally soften a work piece, through heat produced by friction and plastic work, thereby allowing the tool to stir the joint surfaces. In this welding process, a rotating welding tool is driven into the material at the interface such as two adjoining plates, and then translated along the interface. The mechanical properties of aluminium alloy 6061 welded joints need to study before going to processing and preparing various mechanical components. Aluminium alloy 6061 welded specimens with suitable dimensions are prepared and these specimens are tested through various mechanical tests. These specimens are welded through friction stir welding process. FSW is an ideal process for producing low cost and high performance joints. This joining technique is energy efficient, environment friendly, and versatile. In particular, it can be used to join high-strength aerospace aluminium alloys and other metallic alloys that are hard to weld by conventional fusion welding. In this paper the evaluation of mechanical properties of aluminium alloy 6061(AA 6061) welded joints such as impact strength, hardness and compressive strength and also studied.

Keywords: Friction Stir Welding , Impact Strength, Aluminium Alloy.

I. INTRODUCTION

The welding is vital to our economy. It is often said that 50 % of the gross national product is related to welding in one way or the other. Welding ranks high among industrial processes and involves more sciences and variables than those involved in any other industrial process. Welding is a joining process coalescence of materials (typically metals or thermo plastics) by heating them to welding temperature, with or without the application of pressure or by the application of pressure alone, with or without use of filler material(1-2). There are many ways to make a weld and many different kinds of welds. Some processes cause sparks and others do not even require extra heat. Welding can be done anywhere. Outdoor or indoor, under water and in outer space. Nearly everything we use in our daily life is welded or made by equipment that is welded. Welders help to build metal products from coffeepots to Skyscrapers. They help to build space vehicles and millions of other products ranging from oil drilling rigs to automobiles. In construction, welders are virtually rebuilding the world, extending subways, building bridges, and helping to improve the environment by building pollution control devices (3-5). The use of welding is practically unlimited; there is no lack of variety of the type of work that is done. Variation was the use of inert gas with small amounts of oxygen that provided the spray-type arc transfer.

Recent developments in friction welding which uses rotational speed and upset pressure to provide friction heat was developed in the Soviet Union. It is a specialized process and has applications only where a sufficient volume of similar parts is to be welded because of the initial expense for equipment and tooling (6-9). This process is called inertia welding. Laser welding is one of the newest processes. The laser was originally developed at the bell telephone laboratories as a communications device, as it possess tremendous concentration of energy in small space. It is proved to be a power full source. It has been used for cutting metals and non-metals. The laser is finding welding applications in automotive metal working operations.

II. EXPERIMETAL METHODOLOGY

2.1 Friction Stir Welding

It is a solid-state joining process that involves joining of metals without fusion or filler materials. The frictional heat is produced from a rapidly rotating non-consumable high strength tool pin that extends from a cylindrical shoulder. The process is particularly applicable for aluminium alloys but can be extended to other products also. Plates, sheets and hollow pipes can be welded by this method. The process is also suitable for automation. The weld produced is of finer microstructure and superior in characteristics to that parent metal. Its cost effectiveness and ability to weld dissimilar metals makes it a commonly used welding process in recent times. In friction stir welding (FSW) a cylindrical, shouldered tool with a profiled probe is rotated and slowly plunged into the joint line between two pieces butted together. The parts have to be clamped onto a backing bar in a manner that prevents the abutting joint faces from being forced apart. Frictional heat is generated between the wear resistant welding tool and the material of the work pieces.

The working Principle of Friction Stir Welding is becoming an important joining process because it makes high quality welds for number of materials as compared to the conventional welding techniques. In FSW process, a non-consumable welding tool is used to generate the frictional heat between the tool and the work piece. This facilitates the tool movement along the joint line. As a result, the plasticized material is transformed from the leading edge of the tool to trailing side. Subsequently, it produces a high quality joint between the two plates by the translation movement of the work piece along with applied pressure of the tool. Terminology of friction stir welding process is shown in fig.1.

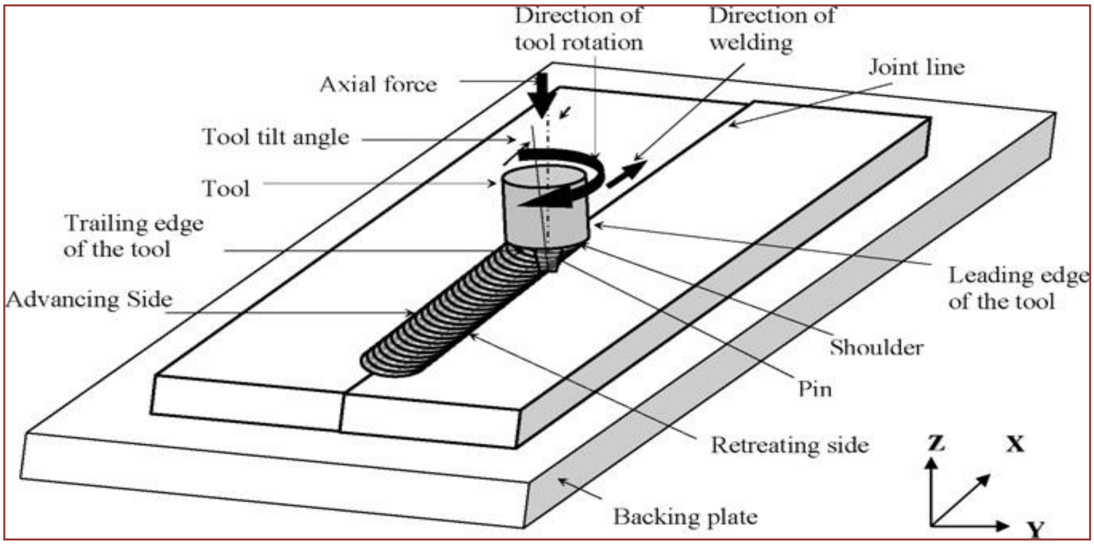

Fig 1: Terminology of friction stir welding process

2.2 Impact Test-Charpy Test

The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply. A disadvantage is that some results are only comparative. The apparatus consists of a pendulum of known mass and length that is dropped from a known height to impact a notched specimen of material. The energy transferred to the material can be inferred by comparing the difference in the height of the hammer before and after the fracture (energy absorbed by the fracture event).

Impact test specimen prepared to see impact energy of the friction stir welded joint of aluminium alloy 6061 using Charpy impact testing machine.

2.3 Brinell hardness Test

The Brinell hardness test method as used to determine Brinell hardness, is defined in ASTM E10. Most commonly it is used to test materials that have a structure that is too coarse or that have a surface that is too rough to be tested using another test method, e.g., castings and forgings. Brinell testing often use a very high test load (3000 kgf) and a 10mm diameter indenter. Brinell hardness number evaluated for aluminium alloy 6061 friction stir welded joint through this test.

2.4 Compression Test

Operation of the machine is by hydraulic transmission of load from the test specimen to a separately housed load indicator. The hydraulic system is ideal since it replaces transmission of load through levers and knife edges, which are prone to wear and damage due to shock on rupture of test pieces. Compressive strength evaluated for aluminium alloy 6061 friction stir welded joint through this test. These above three tests, results are discussed in results and discussion section.

III. RESULTS AND DISCUSSION

3.1 Impact Test - Charpy test

Impact test specimen of friction stir welded aluminum alloy 6061 joint is prepared as per ASTM standard, the test is performed in impact testing machine.The fig.2 shows Impact test specimen before the test fig.3 shows specimen after the test.

Fig 2: Impact test specimen of welded joint of aluminium alloy 6061 before test

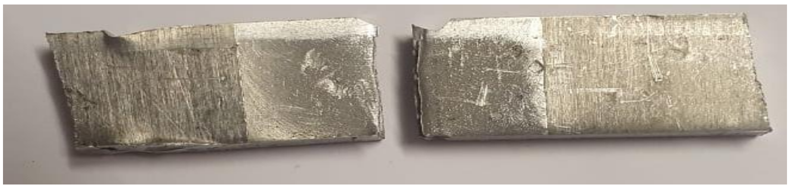

Fig 3: Impact test specimen of welded joint of aluminium alloy 6061 after test

Maximum impact load absorbed for test specimen obtained for FSW Aluminium alloy 6061 joint is 92 Joules. It indicates toughness of Aluminium alloy 6061 welded joint.

3.2 Brinell Hardness Test Results

Brinell hardness test specimen of friction stir welded aluminum alloy 6061 joint is prepared as per ASTM standard, the test is performed in. Brinell hardness testing machine. The fig.4 shows Brinell test specimen before the test, fig.5 shows specimen after the test.

Fig 4: Brinell hardness test specimen of welded joint of aluminium alloy 6061 before test

Fig 5: Brinell hardness test specimen of welded joint of aluminium alloy 6061 after test

Brinell hardness number is evaluated for welded joint of aluminium alloy 6061 through following methodology. Hardness is measured at base metal and weld joint region. Brinell hardness number represented by BHN.

$$\mathrm{BHN} = \frac{2P}{\pi D\left(D - \sqrt{D^2 - d^2}\right)}$$

Load on specimen, P = 500 kgf

Indenter diameter, D = 10 mm

Indentation diameter at weld d = 2.8 mm , Indentation diameter at base metal d_1 = 3.1 mm

Brinell hardness number at weld zone BHN = $\frac{2\times500}{\Pi\times10(10-\sqrt{10^2-2.8^2})} = 79.57BHN$

Brinell hardness number at base metal BHN_1 = $\frac{2\times500}{\Pi\times10(10-\sqrt{10^2-3.1^2})} = 64.5BHN$

Brinell hardness Number : 79.57 BHN (On weld zone)

Brinell hardness Number : 64.5 BHN (On base metal)

3.3 Compression Test

Compression test specimen is prepared as per ASTM standard the test is performed in Compression testing machine The fig.6 shows Compression test specimen.

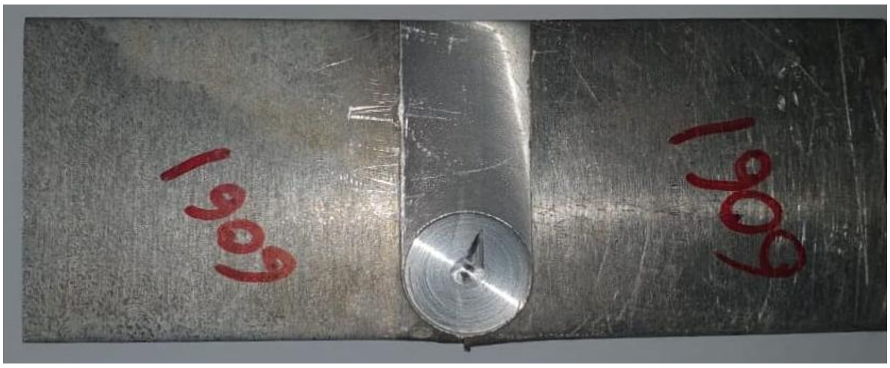

Fig 6: Compression test specimen of welded joint of aluminium alloy 6061

Compression strength is obtained for friction stir welded joint of aluminium alloy 6061 test specimen is 490 kN

The above Results are summarised are in table.1

Table 1. Results of welded joints of Aluminium alloy 6061

Parameter	Friction stir welded joint of aluminum alloy 6061 test specimen
Maximum impact strength	92 Joules
Brinell hardness number - weld zone	79.57 BHN
Brinell hardness number -base metal	64.5 BHN
Compression strength	490 kN

IV. CONCLUSION

The conclusions are drawn from present research work of Friction stir welded joints of Aluminium alloy 6061 as follows.

- Defect free welds has been welded.
- Pin profile in friction stir welding is cylindrical shape.
- The properties obtained through cylindrical pin profile in friction stir welding
- The maximum impact strength absorbed for welded joint is 92 Joules.
- The hardness strength is 79.57 BHN on weld joint place and 64.5 BHN on base metal
- The maximum compression strength is 490kN
- Highest hardness value obtained on weld line/zone of joint of aluminum alloy 6061
- Lowest hardness value obtained on base metal of joint of aluminum alloy 6061

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