# EXPERIMENTAL INVESTIGATION ON THE EFFECT PROCESS PARAMETERS OF FRICTION STIR WELDED AL & MG ALLOYS

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**Abstract -** Friction Stir Welding is done on the Al alloy AA 5083 as well as magnesium alloy AZ31B with dimensions of 150X100X6 mm. The tool profiles used in this work are Square, Conical, Cylindrical threaded, Tapered threaded, and Hexagonal; Tool profiles are made up to certain specifications, and H13 steel is used as a tool material.The FSW tools were hardened to improve their characteristics. Tool profile plays an important role in improving welding. This study explains the essential welding parameters used in the process. Employed characteristics include traverse speed, tool rotational speed, and tool pin profile.Welded joints' mechanical characteristics were examined by conducting various tests such as tensile strength test, Impact test, Microstructure Analysis, and bending test. Following welding, the welded aluminum alloy and magnesium alloy were machined using an EDM machine following ASTM standards.At last, the test results are compared between both the aluminum and magnesium alloys

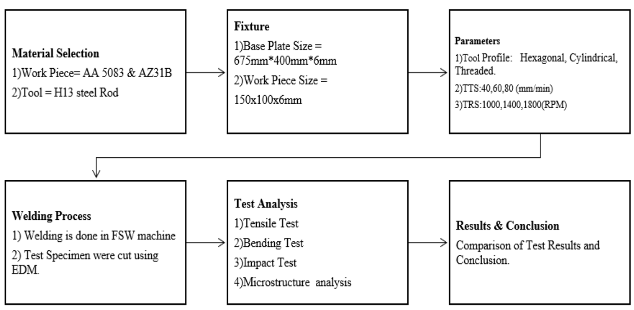
## 1. Introduction

Friction Stir Welding (FSW) is solid-state welding that was developed in 1991 at TWI Ltd.The introduction of FSW is undeniably a major turning point in the evolution of welding technologies.FSW tool is vital to the process's operation. The tool is made up of a rotating round shoulder and a threaded cylindrical pin that heats the workpiece mostly by friction and pushes the softened alloy around it to form the joint.The merits of friction stir welding come from the fact that it produces a unique weld that does not require the use of consumables or shielding elements.This technique is safe and does not cause any big issues like welding fumes or radiation.Since the processing temperature during FSW does not approach the melting temperatures of the alloys, the development of intermetallic compounds in the stir zone is minimized.FSW can weld almost any alloy, even some that are difficult to weld with conventional fusion welding techniques.The variable costs in the FSW are modest, This is due to the non-requirement of filler material or shielding gas. Because oxide removal is typically not necessary, fabrication time is less than that of arc welding, and the speed of the welding is often faster than in fusion welding. The parameters are utilized in the Friction Stir welding technique to achieve a strong weld. The welding parameters such as tool rotational speed, transverse speed, and tool pin profile were used.In this technique, Hexagonal, Cylindrical and Threaded pin profiles were used.The material of the tool profile is H13, and so these tool profiles are made to certain dimensions to get a good weld.

Alloys made of Al and Mg have less density and have a higher specific strength than other alloys. They're widely employed in the automotive, aerospace, and shipbuilding sectors.Commercial magnesium alloys aren't strong enough to be used in structural applications. Magnesium alloys, on the other hand, are appealing for reducing product weight. Aluminum alloys, on the other hand, have been employed in items that demand a lot of strength.

The study aims to compare the mechanical properties of friction stir welded Al and Mg alloys.Aluminum alloy, AA 5083, and Magnesium Alloy, AZ31B are the alloys used in our project which are typical alloys used for shipbuilding, are considered.To prepare the test specimen, FSW is performed between identical alloys. Following the FSW procedure, the specimen is machined in an EDM machine following ASTM standards to perform the following: Tensile, Impact, Bending, Microstructure and hardness. A specific cut is performed in the middle of the welded piece of AA5083 Al and AZ31B Mg alloy to analyze the microstructure.The effect of welding parameters on joint characteristics was also investigated.

## 2. Project Methodology



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## 3. Selection of materials

### 3.1 Workpiece material

The Materials were chosen for the workpiece are AA 5083 Al alloy & AZ31B Mg alloy. The Dimensions for the respective sheet metal are shown in the table below.

| ITEM | DIMENSIONS(mm) |
|---|---|
| AA5083 | 150 (l) × 100 (w) × 6 (t) |
| AZ31B | 150 (l) × 100 (w) × 6 (t) |

- **AA5083 Aluminium Alloy**

The material we have selected is AA5083, as seen in the picture. This is an armor grade alloy with 4.8 percent Mg and excellent corrosion and resistance qualities. Tables following provide the chemical makeup and physical attributes of AA5083:

- **AZ31B Magnesium Alloy**

The Material we have chosen for the comparative study is AZ31B shown in Figure. It consists of 3.5% aluminum, it has excellent corrosion resistance characteristics. Magnesium alloys are very light in weight and have great machinability. The following tables provide information on the chemical content and physical characteristics of AZ31B:

### 3.2 Tool selection

The H13 Steel tool is used in the FSW process. As the tool rotates at given rpms, tool wear is created when the tool and the specimen come into interaction. The tool has been hardened to minimize tool wear improving its hardness.The tool is employed in the material to create high quality welds.Also, Cylindrical, Tapered, and Hexagonal tool profiles are commonly utilized. The tool's rpm, wear, and transverse speed are all examined throughout this operation.The chemical composition of H13 steel are as follows:

| C | Mn | Si | Cr | Mo | V |
|---|---|---|---|---|---|
| 0.50 | 0.50 | 1.1 | 5.25 | 1.35 | 1 |

It contains 5.47 percent chromium(Cr), so it retains its red hardness without losing geometrical forms during welding.

The various tool profiles used are as follows:

- Hexagonal pin profile.
- Conical pin profile.
- Squared pin profile.
- Cylindrical Threaded pin profile.
- Cylindrical Tapered Threaded pin profile.
- Offset Hexagonal pin profile.

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### 3.3 **Welding parameters**

The parameters used in the welding are shown in the below table;

| S/No. | Tool Rotational Speed(RPM)) | Tool Traverse Speed(mm/min) | Tool Pin Profile |
|---|---|---|---|
| I | 1000 | 40 | SH |
| II | 1400 | 60 | SC |
| III | 1800 | 80 | ST |
| IV | 1000 | 40 | SH |
| V | 1400 | 60 | SC |

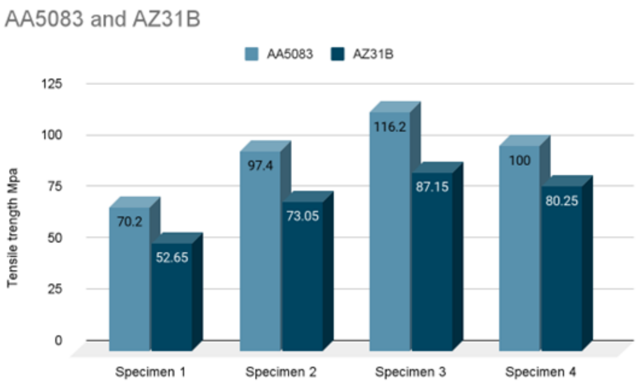
SC - Straight Cylindrical; ST - Straight Threaded; SH - Straight Hexagonal

## 4. RESULTS AND DISCUSSION

### 4.1 Tensile Test

The corresponding American Astm Standards E8 was used to design and produce the tensile test specimens.Tensile strength is described as a material's capacity to withstand a force that tends to rip it apart.The tensile specimen is held in place by the fixed and moveable jaws.The moveable jaw is then moved downwards in the opposite direction to the jaw which is fixed .The tensile sample is expanded at a point, while the tensile sample at other end goes apart and will fracture at one point.The tensile test sample before testing is shown below.

Fig.4.1




In this graph, the eight samples were compared for the tensile strength analysis following the Friction Stir Welding procedure.High spindle speeds (rpm) result in high heat production, whereas high welding speeds (mm/min) result in minimal heat generation. In Al & Mg, specimen 3 where the Hexagonal pin profile is used with tool rotational speed of 1800 RPM and tool travel speed of 80 mm/min has acquired higher tensile strength of (AA5083 =116.2 Mpa & AZ31B = 87.15 MPa) than specimen number 1 where Hexagonal tool profile is used with tool rotational speed of 1000 rpm and transverse speed of 40 mm/min were achieved.

### 4.2 Bending Test

The 3 point bending test gives information about the material's bending modulus of elasticity, its flexural stress, its flexural strain, and its response to flexural stress and strain.A UTM with a 3- or 4 bend fixture is used to do this test.The most important benefit of a 3 flexural test is how easy it is to prepare and test the sample.The figure below shows the Flexural test specimen before it was put through before the test.Following the ASTM-E290-08 standard, the bend test samples were made

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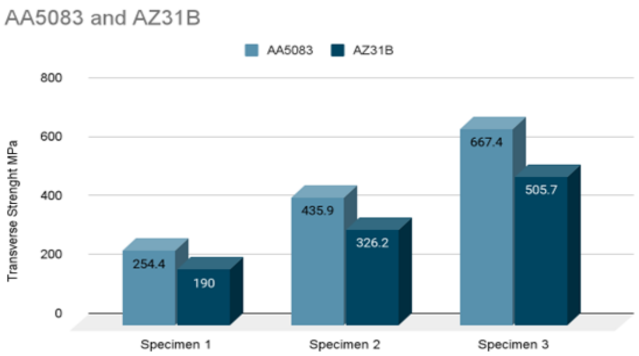
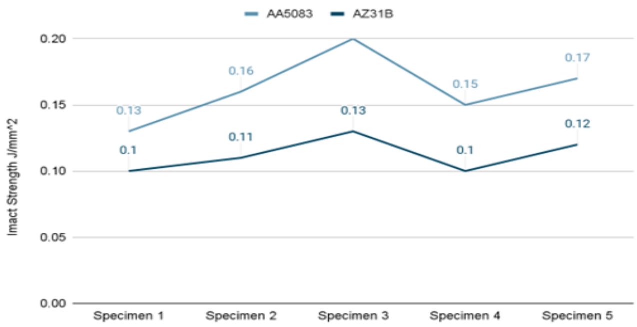
Fig 4.2

Fig 4.3




The strength of the welds was tested by bending the samples, which went well. The flexural force was put on the center point of the weld zone, and the back surface of the test sample was looked at. Now at the end of the bend test, there were no cracks on the surface, which showed that the weld joint was flexible. But a few weld species were analyzed to have imperfections on the bottom side, which made the joints weak when bent. In Al and Mg, sample number 3 with a threaded tool profile and spindle tool speed 1800 rpm and a tool travel speed of 80 mm/min has a higher flexural strength than sample number 1 with a hexagonal tool profile and a spindle tool speed of 1000 rpm and tool travel speed of 40 mm/min.

### 4.3 IMPACT TEST

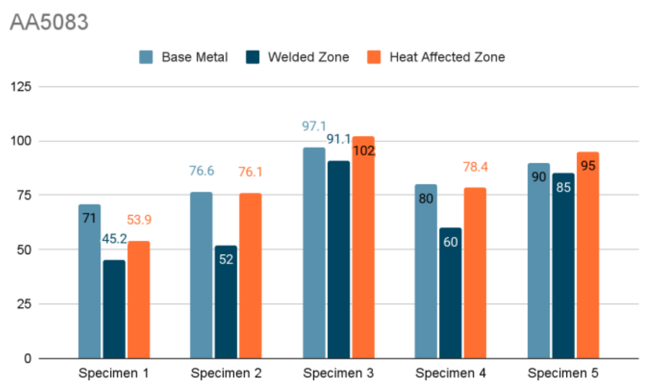
In our project, we did a charpy impact test, which is one of a type of impact test. The Charpy impact test, also known as the Charpy V-notch test, is a standard way to measure how much energy a material absorbs when it breaks.The notch toughness of a material is shown by how much energy it can take in.ASTM A370 says that the standard size for a Charpy impact test specimen is 10 mm by 10 mm by 55 mm. and so that we have chosen it.The specimen for charpy impact test before testing is shown below.

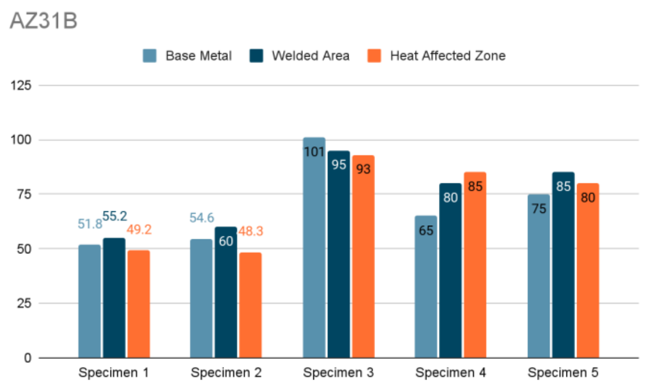
The Charpy test for the 10 specimens is performed using this graph. The greatest Charpy value is found in specimen 5 of threaded tool form at 1400 rpm and travel speed of 60mm/min, while the smallest Charpy value is found in specimen number 1 of hexagonal tool pin profile 1000 rpm and tool rotational speed of 40mm/min.

### 4.4 HARDNESS TEST

Vickers hardness is a type of hardness measuring machine in which the testing was done with a 50kg load which was used to determine the hardness value.Because the material is Al and Mg alloy, a diamond indenter is used. The main advantage of the vicker's testing machine is that the calculations are simple when compared to other hardness measuring machines and the indenter can be utilized irrespective of the materials.The specimen before testing in the hardness tester is shown below

Fig 4.3




The graph above evaluates and analyses Vickers hardness values for ten specimens. Sample number 5 has the greatest hardness reading as 103 HV with such a spindle speed of 1400 rpm and a travel speed of 60 mm/min with the threaded pin profile, while sample number 1 has the smallest hardness reading of 45.2 HV with such a spindle speed of 1000 RPM and a transverse speed of 40 mm/min with a hexagonal pin profile

## 5. CONCLUSIONS

1. Using various welding parameters between Al alloy and Mg alloy the friction stir welding was done and determined and experiments applying these conditions produced not only a satisfactory weld but also the maximum strength weld for alloy plates with a thickness of 6mm.
2. The observed Vickers hardness is in range as follows., Base Metal >Heat Affected Zone >Welded Area in both Al & Mg alloys.
3. The influence of each process parameter on final weld quality and microstructural analysis has also been considered.
4. The Average Grain Size ranges from 13 to 14.
5. When these three tool profiles were compared, the Threaded tool profile had the greatest tensile strength and flexural strength, whereas the Hexagonal tool profile had the highest impact strength.

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