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THERMAL BEHAVIOUR AND MATERIAL FLOW ANALYSIS OF UNDERWATER FRICTION STIR WELDED ALUMINIUM ALLOYS

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Abstract -Underwater friction-stir welding (UWFSW), method die solidstate joining, is used widely in both similar and dissimilar combining of Aluminium, Magnesium, Copper and their alloys. Its applications are in a different field such as aeronautics, automobiles, shipbuilding, etc. The paper compares mechanical properties such as tensile and compressive strength, micro-grain structure, Impact strength, and hardness of the materials on different aluminium alloys AA5052 and AA6082. These properties are compared under certain selected variables such as continual tool rotational speed, rate of welding using underwater friction-stir welding process. In underwater friction-stir welding, parameters of the tool impact a important role in determining joint strength of weld joint. H13 tool steel has been used as a tool material for a variety of pin profiles, including cylindrical, cylindrical threads, and tapered hexagons. The Taguchi L9 method was used for statistical analysis. This experiment helps to identify the main factors that affect the hardness, bending, impact and joint's tensile stress.

1.INTRODUCTION

Underwater Friction-Stir Welding (UFSW) is a welding process of solidstate. Submerged friction-stir Welding which is a underwater stir-welding happens at temperatures below the material's melting point. This welding is recommended because of the defects-free weld joints. In this method, Rotating tool which is non consumable is used to run over the material under the water, causing heat to be generated due to friction. Substrates near the tool area. so, the material subjected to Plastic deformation results in softening can be easily joined. It also eliminates shrinking, embrittlement, splattering, solidification, porosity, and crack, among other welding faults. underwater friction stirs welding achieved maximum or good tensile strength and elongation compared to typical friction stir welding. This method uses less energy and is less harmful to the environment than traditional friction welding. The underwater friction stir welding process does not require filler metal or shield gas, thus avoiding environmental pollution. For this reason, it can be called green welding. UFSW minimizes the residual stress and causes minimal deformation compared to Friction Stir Welding. It uses little energy and has better mechanical characteristics. It also gives for a defined grain size variation across multiple zones of a high-quality weld joint. The application of UFSW can be found in trains, shipbuilding and aerospace applications. underwater friction stir welding is highly flexible because it can be applied to 1D, 2D, and 3D joints and can be applied to butt, lap weld, and spot weld geometries. Welding can be done in any position UFSW is an improved process for improving joint strength compared to FSW. In underwater friction stir welding (UFSW), heat being more concentrated under tool, the cooling rate is higher due to the water environment, and finally welded joint's welding properties are improved. Underwater friction Stir Welding is suitable for aluminium alloys which are heat treatable because it lowers the effect of softening.

Aluminium alloys are divided into wrought & casting-alloys. Wrought alloys and casting alloys are classified into two, such as 1.heat-treatable 2.non-heat-treatable. Around 85% of aluminium is used in wrought alloys. Cast alloys seem to have a very low melting temperature and can be manufactured at a relatively low cost, but they tend to have lower tensile strength than their wrought counterparts.

Aluminium alloy 5052 with hardness H32 has excellent corrosion resistance to marine and industrial conditions. It has excellent weld quality and excellent cold workability. Alloy 5052 with hardness H32 has a wide range of advantageous properties such as tough wearing, anti-Slipping, resistant to corrosion, Maintenance is minimal, anti Static, and weightless. Uses of aluminium 5052 are boiler, containers, vehicle nameplates, road Signboard, architectural Panels, weld Tubes, chemical Industries, irrigation, saltwater units, pressure vessels, and nails.

Aluminium alloy of series 6082 is a moderate strength alloy with very exceptional corrosion resistance. In the form of plates, 6082 is the most widely used alloy for process of machining. The newer alloy 6082 has displaced 6061 in many applications due to its great strength. The inclusion of significant amounts of Mg modifies the structure of grain, resulting Alloy which is

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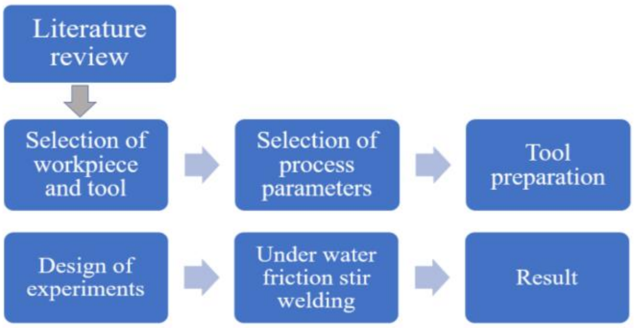
stronger. Aluminium 6082 is used typically in applications which are highly stressed, bridges, elevators, transportation, barrels, and containers of milk.

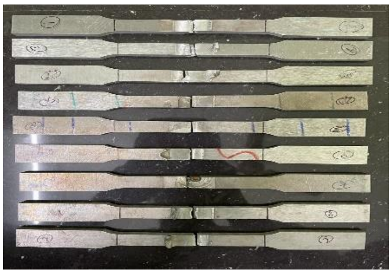
2.Methodology

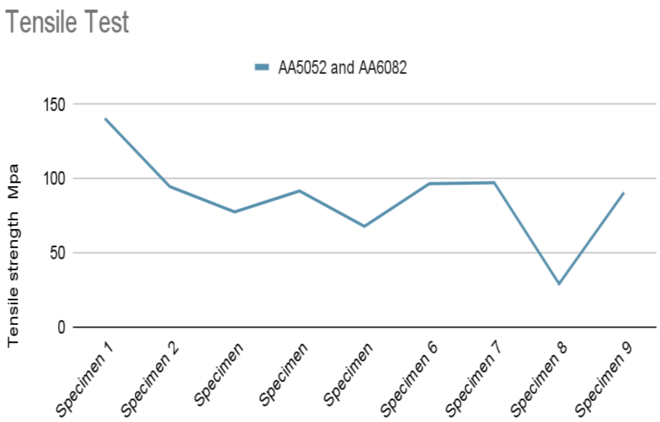


3. RESULT AND DISCUSSION

TENSILE TEST

The corresponding American Standard ASTM E8 was used to design and produce the tensile strength test specimens. Tensile strength of materials is defined as the measurement of tension/elongation when a single piece of material is pulled from one end to the other until it breaks into two sections. The Two clamps hold the object in place, and pressures are released gradually or quickly depending on load capacity criteria. The value of the load application and the resulting displacement are provided by UTM. The tensile test of any object involves slowly pulling the object from two ends while the machine measures the object's elongation strength. A digital indicator records a reading that includes all compression and tensile strength metrics. The universal testing machine was employed to perform the tensile strength test.

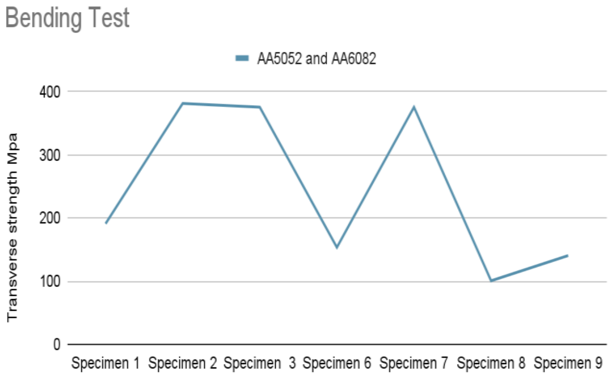




From the graph, it is studied that the tensile strength of the nine samples are compared to the following the underwater Friction Stir Welding procedure. In Al5052 and Al6082, specimen number 1 has a high tensile strength of 140.649 Mega pascal when the cylinder tool profile is employed for the UWFSW process with speed of Spindle given 1120 rotation per minute and traverse speed given 1.8cm/min. Furthermore, specimen number 8 obtained a lower tensile strength of 29.095 Mpa when a Tapered hexagon pin tool profile was utilised for the UWFSW process with a spindle speed of 1500 rotation per minute and a transverse speed of 20 mm/min.

BENDING TEST

Bend testing is a technique for examining how materials respond to simple beam loads. A test for bend is performed on a universal machine for testing to determine the characteristics of a specimen by setting it on anvils two support and bending it with one or two loading anvils with force applied. The major advantage of the three-point bending test preparation and testing of the test piece. The ASTM-E290-08 standard was used to create the bending test samples. To begin, use a vernier calliper to measure the width and thickness of a specimen and mark all of the spots where the load will be applied. Place the sample carefully on the UTM stage during the 3-point bending process so that the loading point is established at the stated spot. Following that, the bending load is applied until the specimen fails. The load-deflection curve, which is produced using the data obtained from the experiment, is then used to compute the specimen's flexural bend strength and elastic modulus



The joint strength of the weld samples was satisfactorily assessed using a bending test. The bending force was applied in the weld joint's centre, and the rear surface of the test sample was inspected. There were no surface cracks at the end of the bend test, suggesting that the weld joint was ductile. However, a few weld samples were found to have defects on the bottom side, resulting in poor bending strength of the joints. Sample numbers 2,3,7 in Al5052 and Al6082, where the cylinder pin, cylinder pin, and tapered hexagon tool profiles are used for the UWFSW process with spindle speeds of 1120,1120,1500 rpm and traverse speeds of 2 0,24,18mm/min, have higher flexural strengths of 381.579 Mpa, 375.696 Mpa, and 661.432 Mpa, respectively. Then there's sample number 8, which has a poor flexural strength of 100.674Mpa due to the use of a tapered hexagonal tool profile for the UWFSW process with a speed of spindle of 1500 rotation per minute and a transverse speed of 2.0 cm/min.

Table -1: Sample Table format

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
OVERALL	1	148	11.4971	1.43917	.11830
	2	52	11.9973	1.58739	.22013

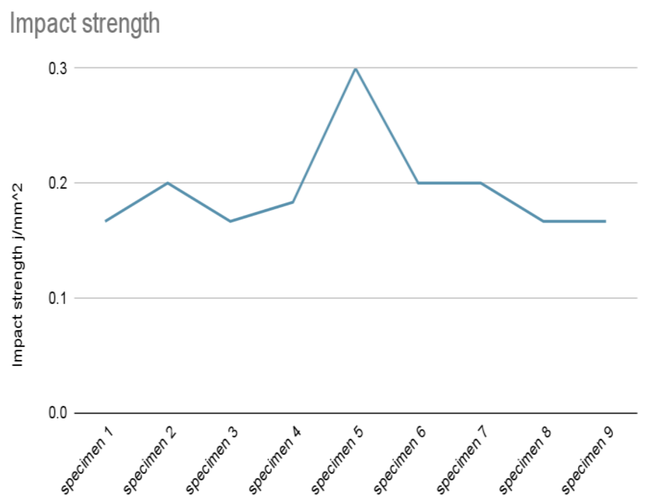
Independent Samples Test

		t-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
OVERALL	Equal variances assumed	-2.098	198	.037	-.50015	.23839
	Equal variances not assumed	-2.001	82.329	.049	-.50015	.24990

IJSREM sample template format ,Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

IMPACT TEST

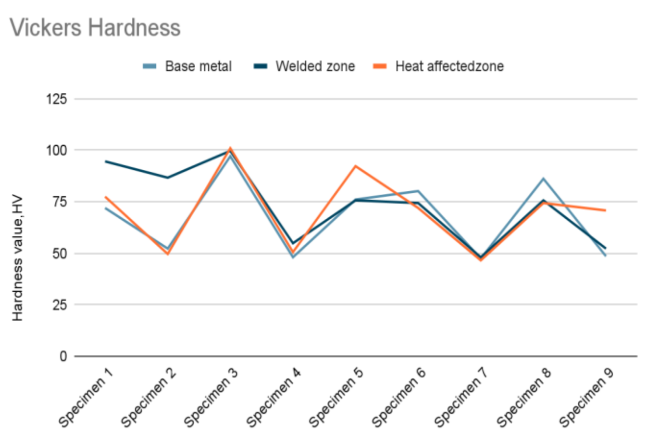
A Charpy impact test is the type of impact test that we employed in our project. The Charpy impact test is a way of measuring a material's toughness. A material specimen is machined and put into a Charpy impact-test machine. The Required amount of force for a material to fracture using a pendulum’s swinging measures its toughness. The impact testing machine we utilised is the Impact AIT 300N, which can be used for both Charpy and Izod impact testing with some small adjustments. The machine and workpiece setup is depicted below. According to ASTM A370, the standard size of the specimen for Charpy impact testing is 10 mm x 10 mm x 55 mm, which we have chosen.



This graph is used to execute the Charpy test on the 09 samples. Sample number 5 with threaded tool pin profile at 1300 rotation per minute and traverse speed of 1.8cm/min has the highest Value of Charpy, whereas specimen numbers 8 and 9 of tapered hexagonal tool pin profile at 1500 rpm and tool rotating speed of 20,24mm/min have the lowest Charpy value

Hardness Test

Vickers hardness is a type of hardness measuring machine that was used to conduct the tests. To acquire an indentation, a diamond indenter is being used to apply force or load to the material used for test. The indentation depth on the material determines hardness of the specimen. Harder the object, the smaller the indentation. The indenter used here is smaller, which minimizes the chances of damaging the test material. The hardness testing was carried out by ISO 6507-1 and ASTM E384 standards



The graph is used to examine and analyse Vickers hardness levels for nine samples. Sample number 3 has a maximum hardness of 100 HV, with a speed of spindle of 1120 RPM and a speed of transverse of 2.4 cm/min with a cylinder profile pin. Whereas Sample numbers 4,7,9 had the lowest hardness values of 48.5,47.4,49.8 HV with a speed of spindle of 1300RPM,1500 RPM,1500 RPM and a transverse speed of 1.8cm/min ,1.8cm/min,2.4cm/min with a threaded, tapered hexagon, tapered hexagon pin profile.

4. CONCLUSIONS

1. The joint's surface and strength are affected by plunge depth, tool rotating speed, and traverse speed.
2. Various welding parameters for UFSW between Al alloy 5052 and Al alloy 6082 were determined, and experiments utilising these parameters resulted in not only good welds but also the strongest welds for 6mm thickness of the alloy plates.
3. It is observed that cylindrical tool of 1120rpm spindle speed, and 18mm/min transverse speed have acquired ultimate tensile strength. In addition, specimen number 3 with the cylindrical tool of 1120 rotation per minute and a transverse speed of 24 mm/min has great hardness. Furthermore, sample number 5 with threaded tool pin profile at 1300 Rotation Per Minute and traverse speed of 18mm/min have the highest Value of Charpy.
4. Temperature was measured for each tool while welding. whereas every tool pin profile shows similar results while welding at higher rpm.

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