Study The effect of Process Parameters on Weld Quality and Perform Uniaxial Tensile Test

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Abstract -With the changing attitude of society towards the environment, the use of laser welded blanks could be very beneficial to the automotive industries. This includes reducing scrap from manufacturing and making their product more energy efficient. Along with the reduction of scrap, the automotive industry is subjected to more and more stringent government regulation for fuel efficiency. There is currently a large interest in developing lightweight alloys that can be used in an automobile to replace heavier steel parts, resulting in weight reductions of the vehicle without sacrificing strength. Metallic material such as aluminium and magnesium, high-strength steels, carbon-carbon composites as well as a number of novel metallic composites is all under investigation in terms of viability and practicality for use in high production in automobile.

A unique combination of properties puts aluminium and its alloys amongst our most versatile engineering and construction materials. All alloys are light in weight, yet some have strengths greater than that of structural steel. For automotive applications aluminium alloy sheets have the advantages of corrosion resistance, high strength to weight ratio, and recyclability.

Laser, electron beam, tungsten inert gas, metal inert gas and friction stir welding processes have been used for creating tailor welded blanks. However, due to the small heat effected zone (HAZ) and fusion zone, the laser and electron beam welding process produce less impact on material properties than others. Laser welding has been the most frequently used process for producing TWBs due to the lower cost and greater flexibility compared to those of electron beam welding. However, there are several difficulties to develop TWB particularly for aluminum and magnesium alloys because of their high reflectivity, low molten viscosity and inherent oxide layer, conventional laser welding leads to hot cracking in the fusion zone and the poor coupling during welding process. Therefore, as a newly emerging welding technology for TWB, friction stir welding (FSW) was developed primarily for aluminum alloys. Friction stir welding was invented by Wayne Thomas at TWI (The Welding Institute), and the first patent applications were filed in the UK in December 1991. Initially, the process was regarded as a "laboratory" curiosity, but it soon became clear that FSW offers numerous benefits in the fabrication of Aluminum products.

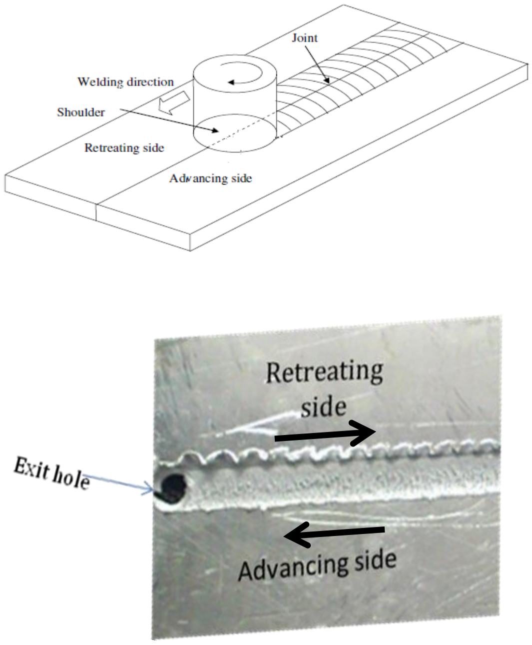


Fig 1.1(a) Schematic illustration of the Friction Stir Welding process [1] (b) An FSW weld between Aluminium sheets

Friction stir welding (FSW) is a solid–state, hot–shear joining process in which a rotating tool with a shoulder and a pin, moves along the butting surfaces of two rigidly clamped plates placed on a backing plate as shown in Fig. 1.1 The shoulder makes contact with the top surface of the work–piece. Heat generated by friction at the shoulder surface, softens the material being welded. Severe plastic deformation and flow of this plasticized metal occurs as the tool is translated along the welding direction. Material is transported from the front of the tool to the trailing edge where it is forged into a joint. Although Fig. 1.1 shows a butt joint for illustration, other types of joints such as lap joints and fillet joints can also be fabricated by FSW. The welding technology for tailor welded blank is well established. What is not understood is the forming characteristics of the TWBs. The problem is the prediction of how the process parameters will influence the weld quality and how the location of welds will influence the formability and their mechanical properties. In this project I will perform the friction stir welding process for producing tailor welded blanks and study the influence of process parameters on weld quality and perform formability test along with uniaxial tensile test and microhardness test. Further detailed description mentioned in the literature review which is in the chapter-

EXPERIMENTAL INVESTIGATION

In the present work the TWBs made by FSW process and study the effect of process parameter on weld quality.

3.1 Friction Stir Welding Setup:

The following were used for the Friction Stir Welding Process of Aluminium alloy sheets.

1. Vertical Milling machine
2. Fixture
3. Backing Plate
4. Tool
5. Specimen

1. Fixture: A fixture is a work-holding or support device used in various manufacturing processes. The main purpose of a fixture is to locate and in some cases hold a workpiece during a machining operation.

All weld samples are shown above in fig 3.5. Equation 2.1 shows that at higher rotational speed the heat generation is high which is clearly shown in above figure 3.5 c, d. High heat generation causes more amount of material flash out during welding and less heat generation causes improper bonding between strips, which is undesirable. Therefore optimum range of speed, which was used in this experiment, is in between 450 rpm to 710 rpm. Common defects in friction stir welds include porosity and surface defects [1]. Common defects in friction stir welds include porosity and surface defects [1]. At a constant rotational speed, an increase in the travel speed leads to wormhole initiation near the bottom of the weld. Furthermore, the size of the wormholes increases with the travel speed because of inadequate material flow towards the bottom of the weld. There are indications that the travel speed to rotational speed ratio is an important variable in the formation of the wormhole defect. For the same material and tool geometry, a high ratio tends to favor the formation of wormhole defects. That's why it was restricted f Most of the heat generation occurs at the interface between the tool shoulder and the work–piece. Significant heterogeneity in heat generation at that interface can lead to defect formation in the form of excess flash due to surface overheating.

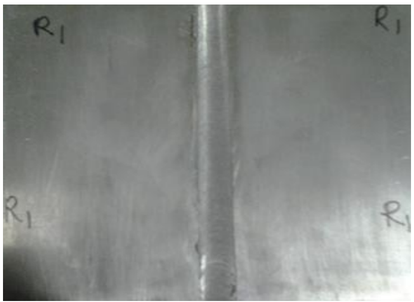
3.3 Selection of process parameters

The quality of FSW welds is greatly dependent on the selection of process parameters such as welding speed (mm/min), rotation speed (rpm) and tool diameter. Since the heat generation [eq. 2.1] in weld nugget zone plays an important role in determining the mechanical properties of the weld. Therefore, it is very important to select the welding process parameters for obtaining optimal heat in the weld nugget zone. In the welding was carried out by using the selected variations of parameters as shown in Table1 which is obtained by Taguchi's orthogonal array method. The Taguchi method involves reducing the variation in a process through robust design of experiments. The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting the process and the levels at which they should be varies. Instead of having to test all possible combinations like the factorial design, the Taguchi method tests pairs of combinations. This allows for the collection of the necessary data to determine which factors most affect product quality with a minimum amount of experimentation, thus saving time and resources. Primarily visual inspection evaluate the good quality of welds were obtains by FSW. Four welds were developing on each set of parameters.

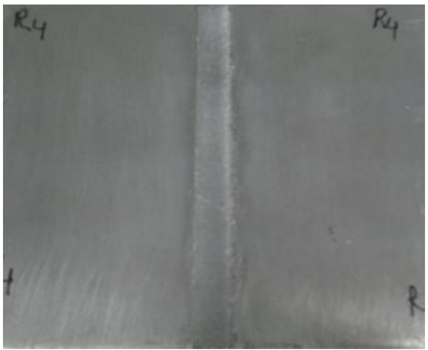
Table 3.2 Process parameters

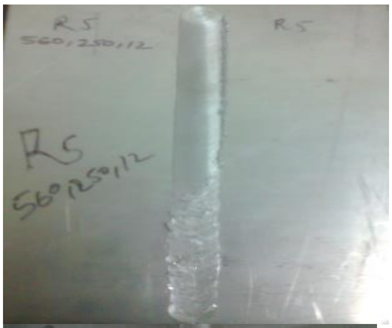
Welding Run No.	Rotational speed (rpm)	Welding speed (mm/min)	Tool diameter (mm)	Depth of plunging (mm)	Result
1	450	80	8	0.35	Good
2	450	160	12	0.35	Poor/ over heating
3	450	250	16	0.35	Not possible due to over heating
4	560	160	8	0.35	Good
5	560	250	12	0.35	Poor/ over heating
6	560	80	16	0.35	Not possible due to over heating
7	710	250	8	0.35	Good
8	710	80	12	0.35	Poor/ over heating
9	710	160	16	0.35	Not possible due to over heating

After performing the welding, only three welding runs [i.e.R1(450-80-8), R4(560-160-8) and R7 (710-225-8)] were produce good quality weld and other then these run generating more heat which causes sticking between specimen and backing plate which is undesirable and shown in figer.3.5 .



R1 (450 -80 - 8) R2 (450 -160 - 12)
R3 (450 -225 – 16)





R4 (450 -160 - 8) R5 (560 -250 - 12)
R7 (560 -80 - 16)

R8 (710 -80 - 12))

Fig. 3.5 Weld samples with different process parameters (R1, R2, R3, R4, R5, R7 and R8)

All weld samples are shown above in fig 3.6. Equation 2.1 shows that at higher tool pin diameter, higher tool rotation and less welding speed causes the heat generation is high which is clearly shown in above figure 3.6 (R2, R3, R5 and R8). High heat generation causes more amount of material flash out during welding and sticking between strips and backing plate, which is undesirable. R6 (560 - 80 - 16) and R9 (710 - 160 - 16) are not possible because of higher tool diameter along with lower welding speed. R1 (450 - 80 - 8), R4 (560 - 160 - 8) and R7 (710 - 250 - 8) were produces good quality welds as shown in figure 3.6(R1, R4 and R7).

3.4 Mechanical Properties

Various tests will be performed on base material as well as weld material such as...

3.4.2 Tensile test

The weld samples were cut by wire EDM along the weld. In this experiment uniaxial tensile test was performed for each sample. In this test mechanical properties i.e. ultimate strength, yield strength and % elongation were obtained. The uniaxial tensile test is known as a basic and universal engineering test to achieve material parameters such as ultimate strength, yield strength, % elongation, % area of reduction and Young's modulus. These important parameters obtained from the standard tensile testing are useful for the selection of engineering materials and welds for any applications required. Tensile test will be carried out in transverse as well as in longitudinal direction to check the weakest region of the weld and the strength of the weld zone. Two tensile test samples will be prepared in each weld run which are taken from weld samples as shown in fig3.7 and 3.8.

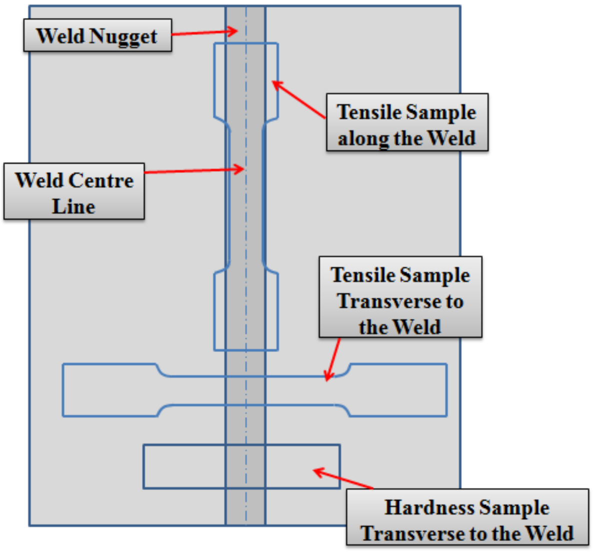


Fig.3.7 Tensile tests and microhardness test samples

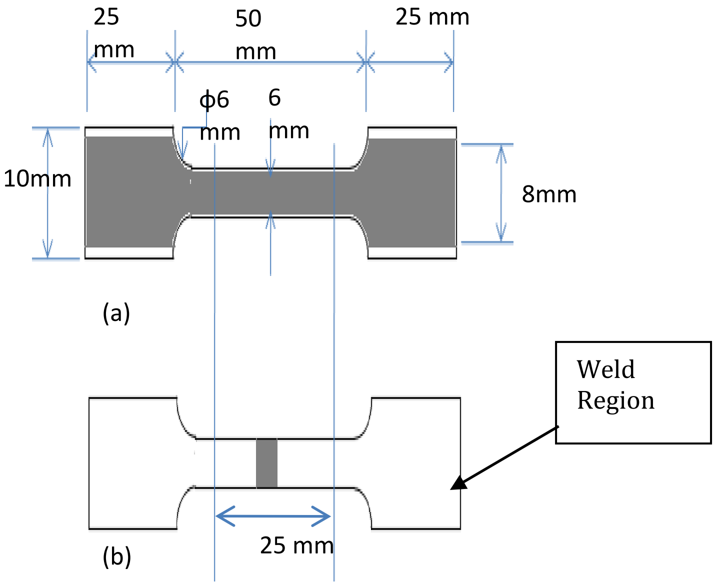


Fig 3.8 Sub size specimens used in tensile tests of TWBs (a) longitudinal specimen (b) transverse specimen

3.4.2.1 Yield Strength (YS), Ultimate tensile Strength (UTS), Ductility

The yield stress was obtained using the 0.2 % offset method. UTS were determined using the maximum load and original cross section area of specimen. The percentage elongation or the reduction in cross section area is used as a measure of ductility of material. Percentage elongation was calculated at the fracture. The elongation was found by measuring the final gauge length after fitting together the fractured specimen.

RESULTS AND DISCUTIONS

The result and observations obtained from various experiment (i.e. uniaxial tensile tests, microhardness tests, formability tests on parents and tailor welded blanks).

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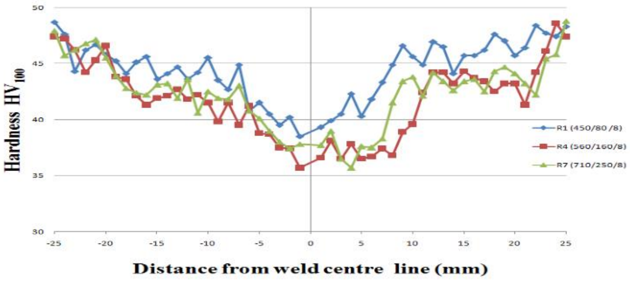
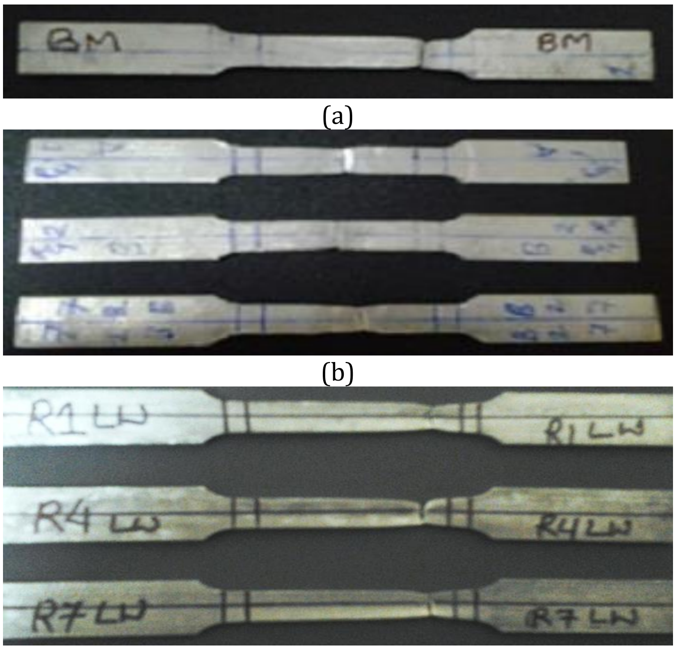


Fig. 4.1 Microhardness profile across the weld in TWBs samples

4.2 Tensile tests

Sub size specimen of TWBs was tested in both longitudinal and transverse direction. Transverse tests were performed to check the strength of the weld region and to ensure that weld parameters chosen in FSW welding are optimum. Failure occurred on the weld nugget zone because in this region thickness of the joint reduces due to plastic flow of metal across the weld movement direction which is known as flash. The fractured specimen of base metal, transverse and longitudinal tensile tests of weld region are shown in fig 4.3.



(a)

(b)

(c)

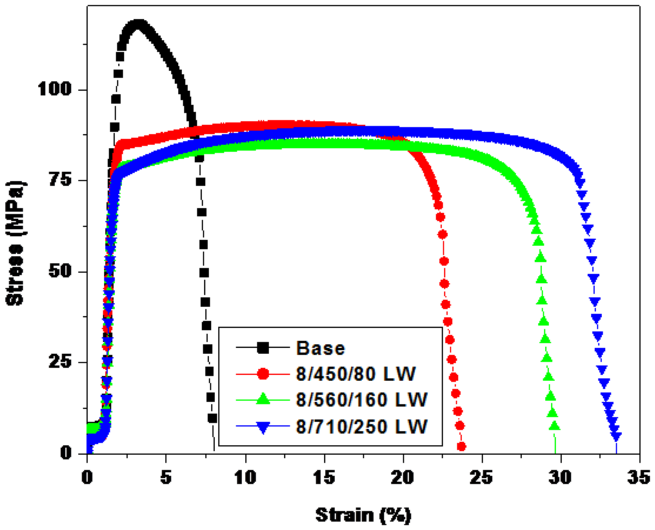
Fig 4.2 Fracture specimen in tensile tests (a) base material (b) across/ transverse to the weld (c) along/ longitudinal to the weld

The standard tensile properties 0.2 % offset yield strength; ultimate strength and % elongation of base metal, transverse to the weld and longitudinal to the weld for each run determined from tensile tests are given in table 4.2.

Table 4.2 Mechanical properties of base metal and weld metal.

Welding Run	YS (MPa)	UTS (MPa)	% Elongation
Base metal	110.512	118.078	8.03
R1 TW	82.872	92.776	12.06
R4 TW	83.503	93.431	9.56
R7 TW	82.870	89.645	10.53
R1 LW	83.047	91.505	23.69
R4 LW	84.751	93.627	33.21
R7 LW	80.281	91.812	27.4

From the above table, it can be observed that yield strength and ultimate tensile strength of weld (i.e. longitudinal direction / along the weld (LW) and transverse direction/ across the weld (TW)) is less than the base metal but percentage elongation of weld metal is greater than base metal in both cases (i.e. longitudinal and transverse direction). It can be also observed that in case of transverse and longitudinal weld, percentage elongation of longitudinal weld is greater than transverse weld but the strength yield strength and ultimate tensile strength of both the weld (i.e. longitudinal and transverse direction) are nearly equal.



4.3 (a) Stress *v/s* strain diagram of longitudinal direction for each run along with base metal

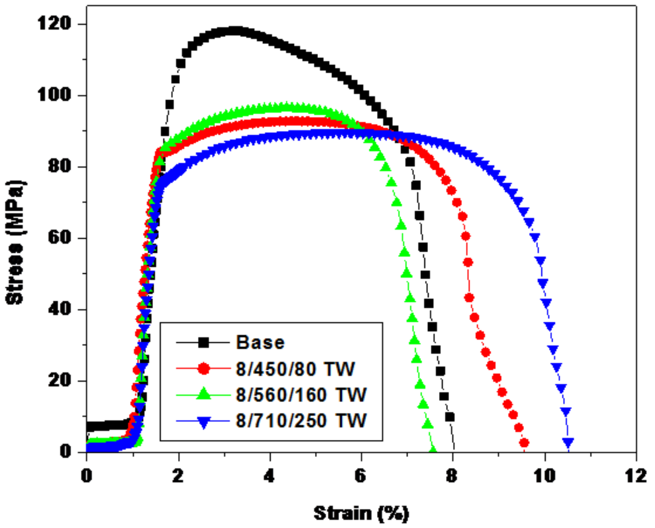


Fig 4.3 (b) Stress *v/s* strain diagram of transverse direction for each run along with base metal

Above result can be verified with the stress – strain curve shown in fig 4.3 (a) and (b). Form the curve it can be also observed that R1 (450/80/8) gives better strength and less percentage elongation but as increase in tool rotation (rpm), the percentage elongation increases. From the above curve R7 (710/250/8) gives good strength and ductility as compare to the others.

CONCLUSION AND SCOPE FOR FUTURE WORK

The following conclusions can be drawn from the results:

(1) Friction stir welding process was used to join the AA-1100 sheets. It is concluded from above result the optimum range of tool rotation (rpm) is 450 rpm to 710 rpm. If it is less than 450rpm, due to less heat generation joint produced by FSW is not good but if it is more than 710 rpm flushing takes place.

(2) At a constant rotational speed, an increase in the travel speed leads to wormhole initiation near the bottom of the weld. Furthermore, the size of the wormholes increases with the travel speed because of inadequate material flow towards the bottom of the weld.

(3) Tensile tests were performed to find out the mechanical properties of the AA 1100 sheets as well as weld region (i.e. longitudinal and transverse direction) of TWBs. It was observed that the % elongation of weld in longitudinal direction is very high as compare to base metal.

(4) Hardness in advancing side is more than the retreating side in HAZ because the grain refinement is more in advancing side than retreating side.

SCOPE FOR FUTURE WORK

(1) FSW tool with pin can also be used for further study.

(2) Microstructure of the weld can also be seen for better understanding and analyzed them for better welding characteristics.

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