International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 08 | Aug 2024 www.irjet.net p-ISSN: 2395-0072

Study The Influence of Process Parameters on Weld Quality and Perform Formability Test

Sumer Singh

College of Technology and Engineering, Udaipur

Introduction- In current automotive stamping technology, there are two basic paths that can be followed to arrive at the final panel. The first method is part disintegration. In this technique, each different section of the blank is stamped separately and then spot welded together in the shape of the final part. This method has numerous advantage such as the ability to select the specific properties, i.e. the strength, thickness, corrosion resistance etc of each area of the blanks. This method also gives a higher yield ratio of material used. However, this method has some disadvantage. The major problem is the large number of different forming operations that is required for the disintegration method, which translate to high tooling costs. Also assembly costs would increase (more joining required) and there is possibility of fittability problem between the different stamping. The other possible method is the integration method. In the integration method, the part is stamped out of a single blank. This reduces the number of tools needed; the assemblies cost and eliminate the fittability problem. However, the design engineer is forced to work same grade, thickness, strength and corrosion resistance throughout the entire part; this would increase the cost and weight of the part significantly.

EXPERIMENTAL INVESTIGATION

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

1.1 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.

Table 1.1 FSW tool dimensions.

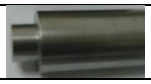
Tool	Tool 1	Tool 2	Tool 3
Tool Figure			
Tool pin Diameter	8 mm	12 mm	16 mm
Tool pin length	10 mm	10 mm	10 mm
Shank Diameter	19.95 mm	19.95 mm	19.95 mm
Shank length	55 mm	Mm	mm

Fig. 1.1 Fixture used in FSW process

2. Backing Plate: A plate of dimensions 200 x 100 x 10 mm was firstly cut by hacksaw machine then machined on shaper in order to reduce the thickness to 8 mm and later the finishing process was carried out on surface grinding machine. The flatness of the backing plate is a crucial factor in order to perform the experiment correctly.

Fig. 1.2 backing plate (200X100X8 mm) used in FSW process

3 Tool: A round bar of diameter 25 mm and length 75 mm of **EN31 [**is a high carbon alloy steel which achieves a high degree of hardness with compressive strength and abrasion resistance.] was machined on lathe to produce a tool. The final dimensions of the tool were

4.Specimen: Aluminium alloy sheets of thickness 1.7 mm were cut into strips of dimension 170 x 52 mm in shearing machine. Firstly, 30 strips of above dimensions were cut and later machined on shaper on the edge to be welded in order to get co-aligning of specimens.

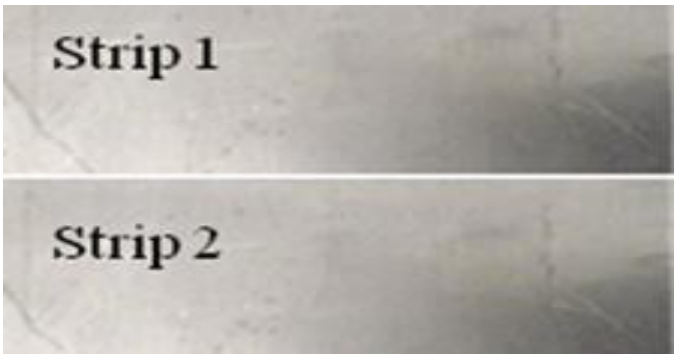


Fig. 3.3 Specimen (170X50X1.7 mm)

1.2 Welding procedure

In trail experiment four different speeds with constant shoulder diameter, weld speed and depth of plunging were selected for the study as shown in table 3.2. The rolling direction of the sheet was in parallel with the welding. Prior to the welding, the edge of the strips was machined in shaper machine. Firstly, the finished edges of two specimens were brought into contact and specimens were placed on the backing plate. Then they were clamped using fixtures

Table 1.2 Process parameters taken for trail experiment

Sample No.	Rotational speed (in rpm)	Shoulder diameter (in mm)	Welding feed (In mm/min.)	Depth of plunging (in mm)
1	355	8	160	0.35
2	450	8	160	0.35
3	560	8	160	0.35
4	710	8	160	0.35

The welding was carried out by using the selected variations as shown in table 3.2. By continuous visual inspection evaluate the quality of welds. Three welds of each variation were prepared. All weld specimen shown below fig.3.5

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.

1.3 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 2.2 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

2.4 Mechanical Properties

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

2.4.1 Microhardness tests

Metallographic sample were cut from the transverse direction of weld and mounting were prepared by epoxy resign. Samples were polished with different grade of emery paper starting from 200 to 2000 and then soft polishing on cloth with alumina Powder (Al_2O_3) with I, II and III grades having particle size 5, 3 and 1 µm respectively. Subsequently samples were etched with Killer's reagent having 2.5 % HNO_3, 1.5 % HCl and 1 % HF and 95 % water (by volume). Vicker's hardness test was performed in each sample in transverse direction of weld covering advancing side, weld and retreating side. The hardness of a material usually is considered resistance to permanent indentation. The indentation load was taken100 grams for a 10 sec dwell time. Microhardness test samples will be prepared in each weld run which are taken from weld specimen across the weld, which is cover the entire weld region (i.e. weld nugget zone and heat affected zone) as shown in fig 3.6.

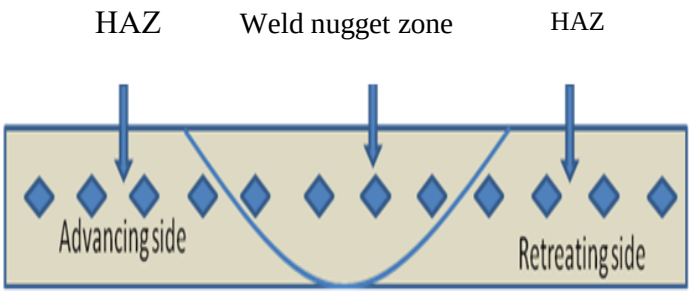


Fig 3.6 Top view of micro hardness sample

2.4.2 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.

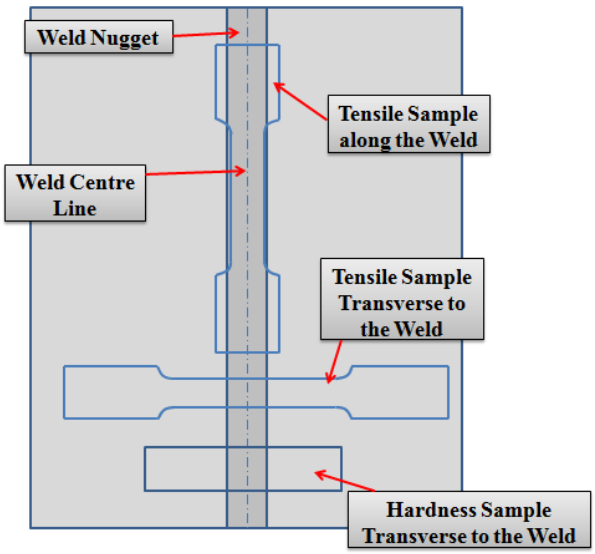


Fig.2.7 Tensile tests and microhardness test samples

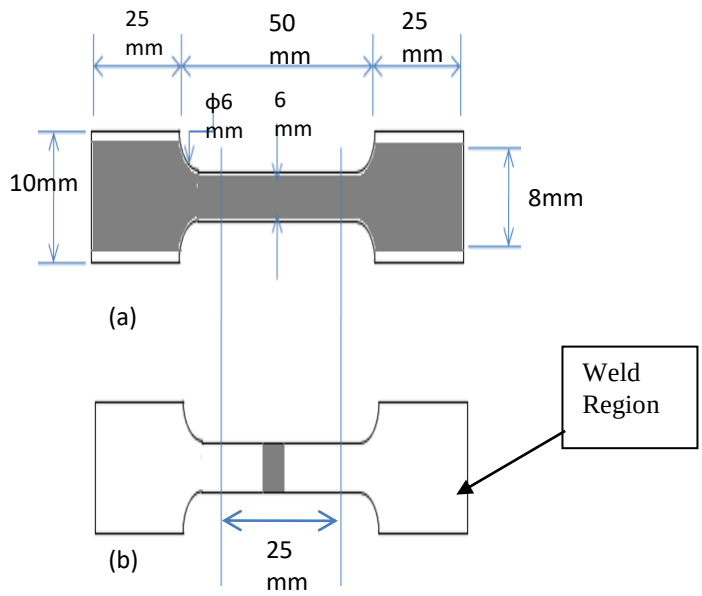


Fig 2.8 Sub size specimens used in tensile tests of TWBs (a) longitudinal specimen (b) transverse specimen

2.4.2.1 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).

3.1 Microhardness

The microhardness analysis revealed that the average width of weld zone (weld nugget zone and heat affected zone) is approximately 3 to 4 mm both side higher than the weld nugget zone (i.e. 14 mm for 8mm diameter tool). The hardness profiles of all weld configurations are shown in Fig 4.1. Clearly shown is that welding has created a highly heterogeneous hardness distribution. From the literature, it has been widely accepted that the softening effect of FSW is due to dissolution and/or coarsening of the precipitates. Furthermore, the hardness profile is asymmetric for all configurations. Generally, the sheet at the advancing side has a higher hardness compared to the one at the retreating side, which has been observed in other studies as well, resulting from different deformations at both sides. The material at the advancing side is influenced more and for a longer time by the vortex velocity field because they have different directions on the retreating side but the same direction on the advancing side. Therefore, the straining and grain refinement is more severe on the advancing side.

Table 3.1 Vickers Hardness values of all samples with respect to weld region

Distance from Centre Line / Sample no.	R1 (450/80/8)	R4 (560/160/8)	R7 (710/250/8)
-25	48.7	47.4	47.9
-24	47.6	47.2	45.7
-23	44.3	46.2	46.2
-22	46.2	44.2	46.8
-21	46.7	45.3	47.1
-20	45.8	46.6	45.5
-19	45.2	43.8	43.9
-18	44.1	43.6	42.8
-17	45.1	42.1	42.4
-16	45.6	41.3	42.2
-15	43.6	41.9	43.1
-14	44.1	42.1	43.2
-13	44.7	42.7	41.9
-12	43.6	41.8	43.6
-11	44.2	42.2	40.6
-10	45.5	41.5	42.5
-9	43.5	39.8	41.9
-8	42.7	41.5	41.8
-7	44.9	39.5	43
-6	40.8	41.2	40.8
-5	41.5	38.8	40.1
-4	40.5	38.7	39
-3	39.5	37.5	38
-2	40.2	37.4	37.4
-1	38.5	35.7	37.8
1	39.3	36.6	37.7
2	39.9	38.1	39
3	40.5	36.5	36.5
4	42.3	37.8	35.7
5	40.3	36.5	37.6
6	41.8	36.7	37.5
7	43.3	37.4	38.3
8	44.9	36.8	41.5
9	46.6	38.9	43.4
10	45.6	39.6	43.8
11	44.9	42.4	42.1
12	46.9	44.2	44.2
13	46.5	44.2	43.4

14	44.1	43.2	42.6
15	45.7	44.3	43.4
16	45.7	43.7	43.6
17	46.2	43.4	42.5
18	47.6	42.5	44.3
19	47	43.2	44.7
20	45.7	43.2	44.1
21	46.4	41.3	43.2
22	48.4	44.2	42.2
23	47.7	46.1	45.4
24	47.4	48.6	45.8
25	48.3	47.4	48.8

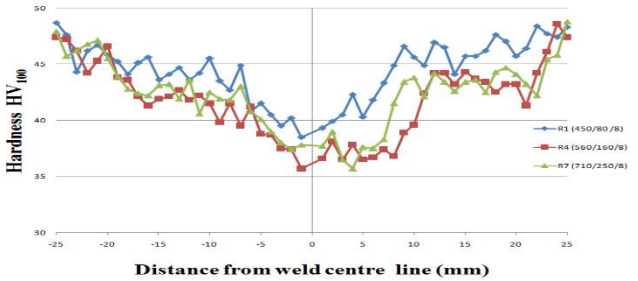
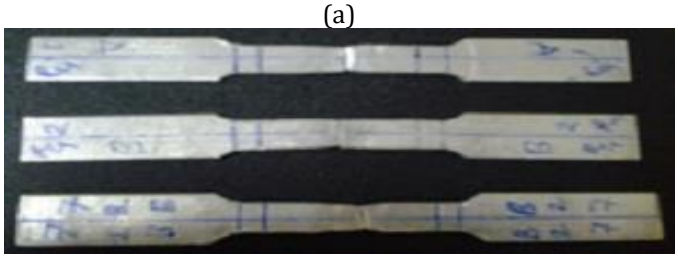


Fig. 3.1 Microhardness profile across the weld in TWBs samples

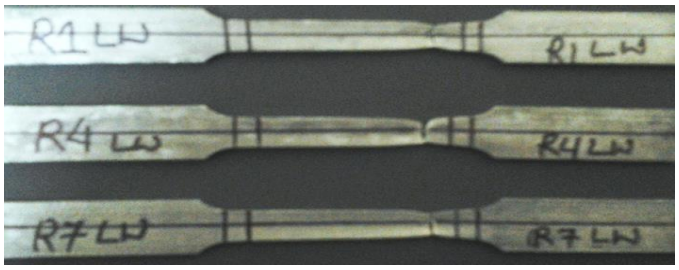
3.2 Tensile tests

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)

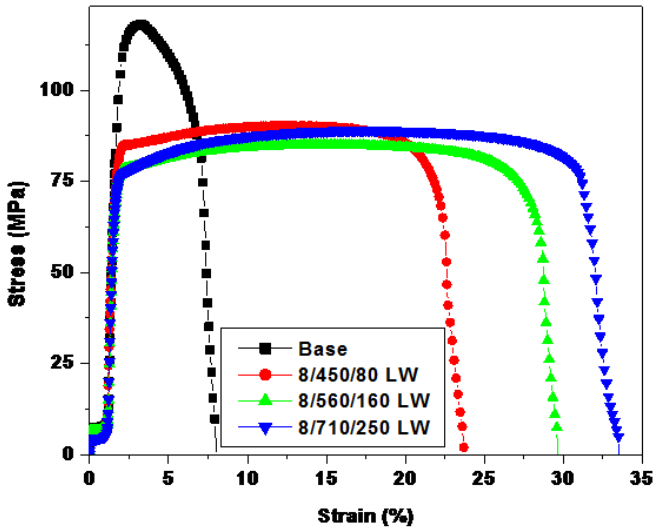
Fig 4.1 Fracture specimen in tensile tests (a) base material (b) across/ transverse to the weld (c) along/ longitudinal to the weld

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

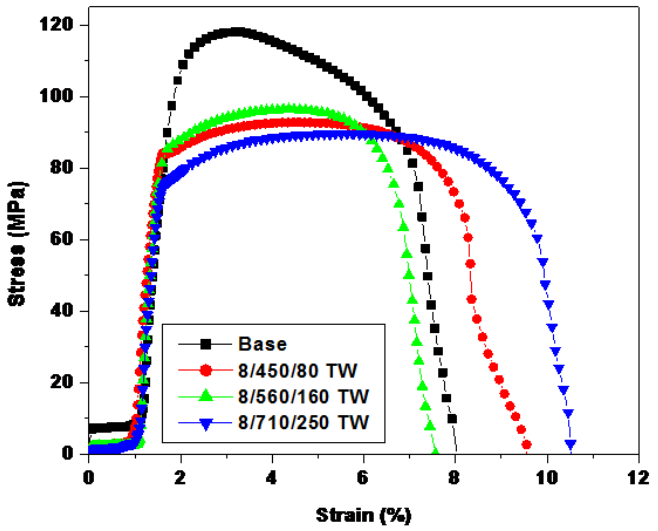


Fig 4.3 (b) Stress *v/s* strain diagram of transverse direction for each run along with base metal

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.

REFERENCES

1. R. Nandan ,T. DebRoy ,H.K.D.H. Bhadeshia, Recent advances in friction-stir welding – Process, weldment structure and properties, Progress in Materials Science 53 (2008) 980–1023.

2. J. Jeswiet, M. Geiger, U. Engel, M. Kleiner, M. Schikorra, J. Duflou, R. Neugebauer, P. Bariani, S. Bruschi, Metal forming progress since 2000, CIRP Journal of Manufacturing Science and Technology 1 (2008) 2–17.

3. Amir Abbas Zadpoor, Jos Sinke, Rinze Benedictus, Raph Pieters, Mechanical properties and microstructure of friction stir welded tailor-made blanks, Materials Science and Engineering A 494 (2008) 281290.

4. Sushanta Kumar Panda, D. Ravi Kumar, Improvement in formability of tailor welded blanks by application of counter pressure in biaxial stretch forming, journal of materials processing technology 2 0 4 (2 0 0 8) 70–79.

5. R Ganesh Narayanan1 and K Narasimhan, Predicting the forming limit strains of tailor-welded blanks, The manuscript was received on 17

April 2008 and was accepted after revision for publication on 20 June 2008.

6. M.Sivashanmugam, S.Ravikumar, T.Kumar, V.Seshagiri Rao, D.MuruganandamA Review on Friction Stir Welding for Aluminium Alloys, 978-1-4244-9082-0/10/$26.00 ©2010 IEEE

7. D.M. Rodrigues, A. Loureiro, C. Leitao, R.M. Leal, B.M. Chaparro, P. Vilaça, Influence of friction stir welding parameters on the microstructural and mechanical properties of AA