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Evaluation of Temperature Distribution of Solid State Welded Dissimilar Alluminium Alloy Joints

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Abstract-AA 5059 aluminium alloy is a new grade of high strength aluminium alloy in the non-heat treatable category. This alloy is best suited for military applications because of high strength to weight ratio and high toughness. Also this high magnesium content aluminium alloy is used to make ship hull structure due to its good corrosion resistance and strength. Heat treatable AA6061-T6 aluminium alloy (Al-Mg- Si alloy) has gathered wide acceptance in the fabrication of light weight structures requiring high strength to weight ratio and good corrosion resistance. Friction stir welding is a solid state welding process and it is a suitable method for joining non-ferrous materials such as aluminium alloys. The objective of this work is to analyze the temperature and residual stress distribution in butt welding of dissimilar aluminium alloy of 5 mm thick plates during friction stir welding by using ANSYS. In the present investigation, the high strength AA5059 and medium strength 6061-T6 is aimed to weld by the FSW process; to ascertain the optimal mechanical properties by varying the rotational speed, welding speed and axial force. The optimised parameters used in this friction stir welding process are welding speed 25 mm/min, rotational speed 1000rpm, axial force 5 KN.

Key words: Friction Stirs Welding, Aluminium Alloys (AA), ANSYS

1 INTRODUCTION

Welding is a process of joining metallic parts by heating to a suitable temperature with or without the application of pressure and with or without application of filler material. It is basically a permanent joining process. The process of welding can be classified on the basis of heat generation, barring the process of welding which do not use heat for joining as pressure only is sufficient for the exchange of surface molecules to make the joint. Cold welding process which is completed with the help of pressure applied only. Generally adopted for ductile and malleable metals of less thickness. Friction Stir Welding (FSW) is a relatively new joining process. Since FSW is essentially a solid-state, without melting,

High quality weld can generally be fabricated with absence of solidification cracking, porosity, oxidation, and other defects typical to traditional fusion welding.

FSW can be used to join many types of similar and dissimilar material combinations provided that tool can be developed to operate compatibly in the hot working temperature range of the work pieces. FSW also has potential for bonding many materials that are difficult or impossible to be joined by more conventional methods, including alloys that are susceptible to solidification cracking, high-strength steels, metal-matrix composites, and other advanced alloys. For many conventionally welded aluminium alloys the fusion zones are typically weaker than the base metal.

However, FSW offers a significant quality advantage that it is possible to make welds where the strength of the fusion zone is identical to that of the base metal alloy. Additionally, because the energy input used for FSW is relatively low (no melting occurs), the heat-affected zone (HAZ) or thermo mechanically affected zone (TMAZ) and residual stresses associated with the welds are relatively small. Lower residual stresses mean that distortion associated with FSW is not a large concern as in conventional welding.

2 EXPERIMENTAL PROCEDURE

The two work pieces to be welded, with square mating (faying) edges are clamped on a rigid backing plate. The clamping prevents the any movement of work pieces during welding. The shank, shoulder and pin form a welding tool, and this tool can be rotated to a prescribed speed and may be tilted normal with respect to the work piece.

The tool is slowly plunged into the work piece material at the butt line, until the shoulder of the tool forcibly contacts the upper surface of the material and the pin is at a short distance from the back plate. Either the rotating tool is made to move, along the butt line, to the end by applying an axial force or the work piece is moved to the same effect.

The parent metal was prepared into sizes of 150 × 75 × 5 mm for welding. The pin is withdrawn on reaching the end which leaves a keyhole. The pin is forced or plunged into the work piece until the shoulder contacts the surface of the work piece. As the tool descends further, its shoulder surface touches the top surface of the work piece and creates heat. Table 1,2&3 shows the chemical, Mechanical properties and process parameter.

Table *1.* Chemical composition (wt. %) of base material

Element	Si	Cu	Mn	Mg	Cr	Zn	Ti	Al
AA 6061	21	0.17	0.04	0.95	0.066	0.014	0.022	Remain.
AA 5059	0.041	0.003	0.933	5.21	0.5-0.6	<0.001	0.489	Remain.

Table *2.* Mechanical properties

Element	Ultimate tensile strength (MPa)	0.2% Yield strength (MPa)	Elongation in 50mm gauge length (%)	Hardness (HV 0.05 kg@ 15 sec)
AA 6061	310	276	14	107
AA 5059	385	290	16	123

Table *3.* FSW parameters

Sl.no	Input variables	Values
1	Rotational speed(rpm)	1000
2	*Welding Speed(Mm/Min)*	*25*
3	Axial force(kN)	5

3 NUMERICAL ANALYSIS

The Numerical Analysis technique is a Finite Element Method (FEM) used to perform Finite Element Simulation of any given physical phenomenon and irregular domain. This numerical method used for solve the problems of Engineering and Mathematics. FEM is used particularly for solve the problems involving complicated geometries, loading and material properties which cannot be easily solved by analytical method.

3.1 Finite Element Model

Finite Element Method is a basic analysis technique for resolving and substituting complicated problems by simpler ones. Finite element method being a flexible tool is used in various industries to solve several practical engineering problems. In this simulation I was choose SOLID 70 element for my suitable solution. The FEA MESHED model shown in the fig1.

3.2 Need For Finite Element Method

To predict the behaviour of structure, three tools adopted such as analytical, experimental and numerical methods. The analytical method is used for the rectangular sections of geometri entities or primitives where the component geometry is expressed mathematically. The experimental method is used for finding the unknown parameters of interest. But the experimentation requires testing equipment and a specimen for each behaviour.

The Finite Element Method is used to solve physical problems in engineering analysis and design and used to estimate the approximate solutions to acceptable tolerance.

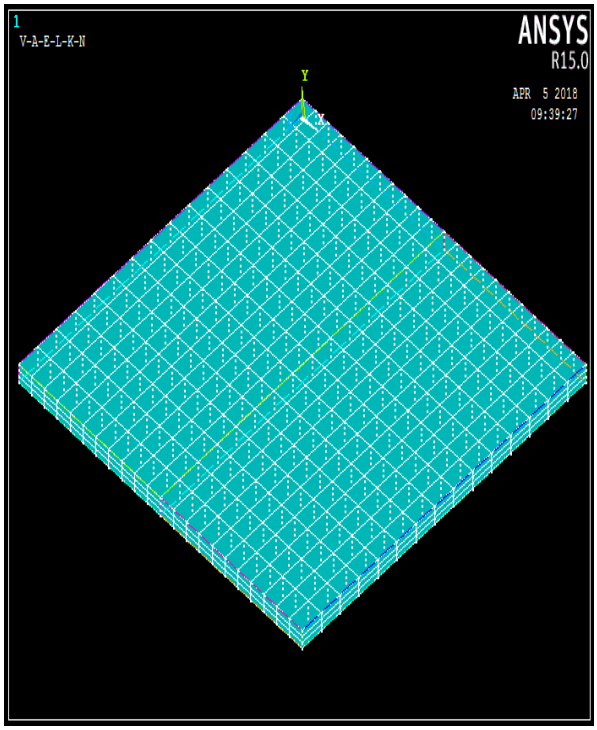

Fig. *1*.Meshed model

4 RESULT AND DISCUSSION

4.1 Temperature Distribution

The temperature distribution was done by using the ANSYS FEA tool by four sub steps by using transient analysis. Because of the thermal analysis was not a static condition, the temperature changes depends upon the time. The FSW welding conducted at the room temperature of 25 degree Celsius. When the welding started the minimum temperature was slightly increased from the room temperature.

The minimum temperature changes during the welding time was 27.35˚c, 41.45˚c, 54.77˚c, 72.1˚c. The temperature distribution **(fig 2,3,4&5)** was used to found how the material distribute the temperature at the time of welding.

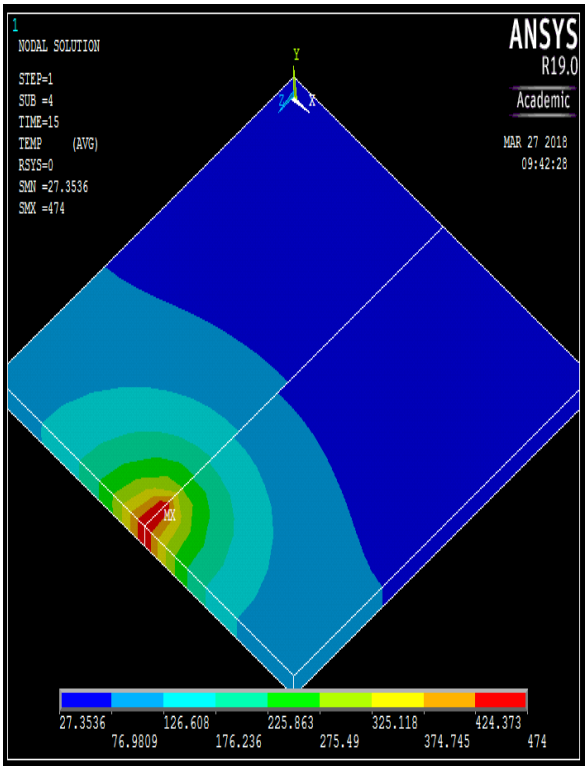

Fig. *2*. thermal profile at 15 sec

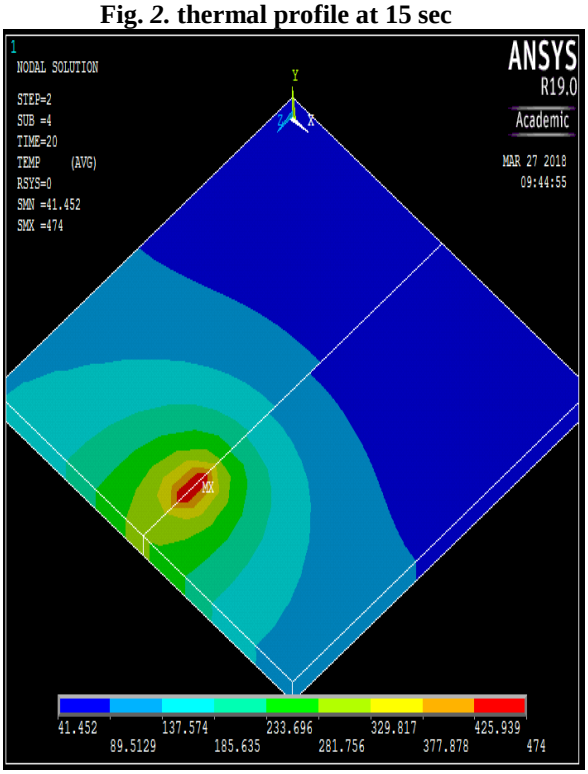

Fig. *3*. thermal profile at 20 sec

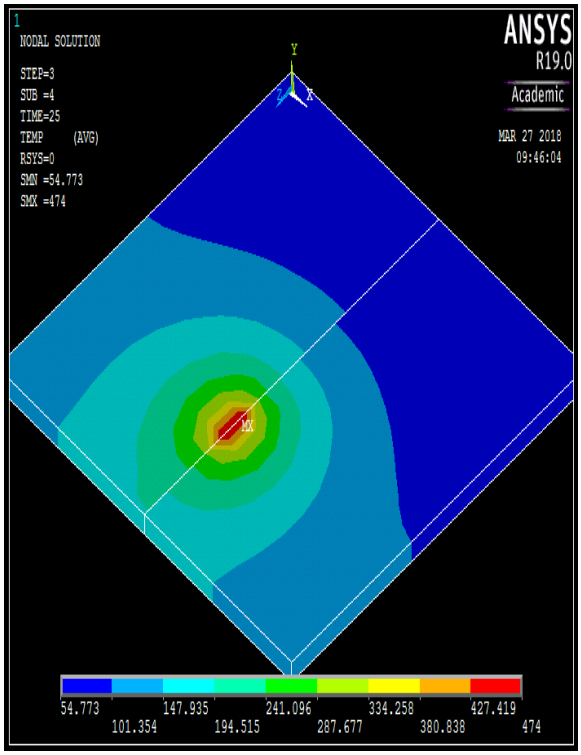

Fig. *4*. thermal profile at 25 sec

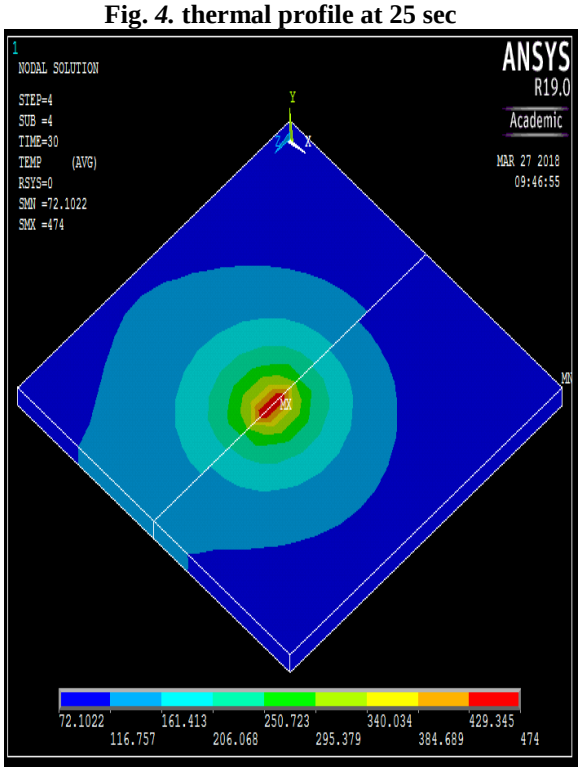

Fig. *5*. thermal profile at 30 sec

4.2 Thermal Stress

The thermal model was developed by FEA simulation. And the thermal result act as the input file to find the residual stress in ANSYS. The temperature distribution was founded by the transient analysis at the same procedure followed for this condition. In this simulation we got the stress distribution value was 67 MPa to 99 MPa at 15 sec to 30 sec. The obtained thermal stress **(fig 6,7,8,9)** value was less than the yield strength of the base materials. It shows given below the figure.

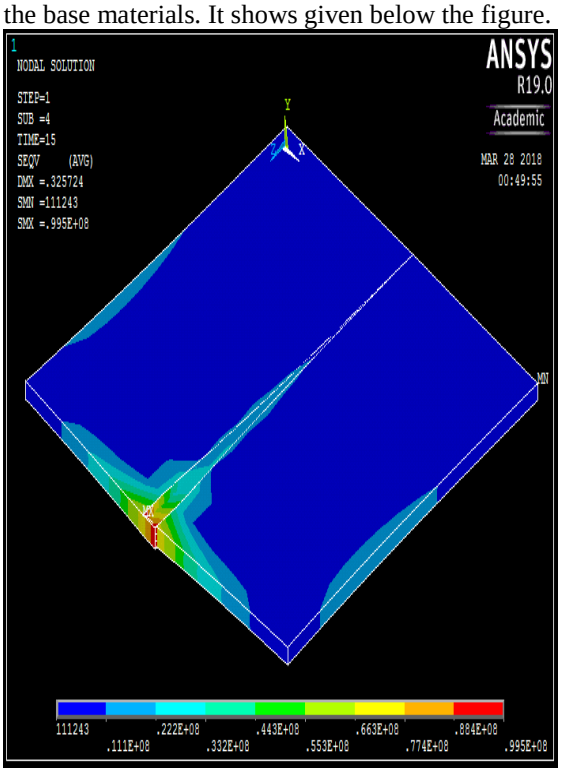

Fig. *6*. thermal stress at 15 sec

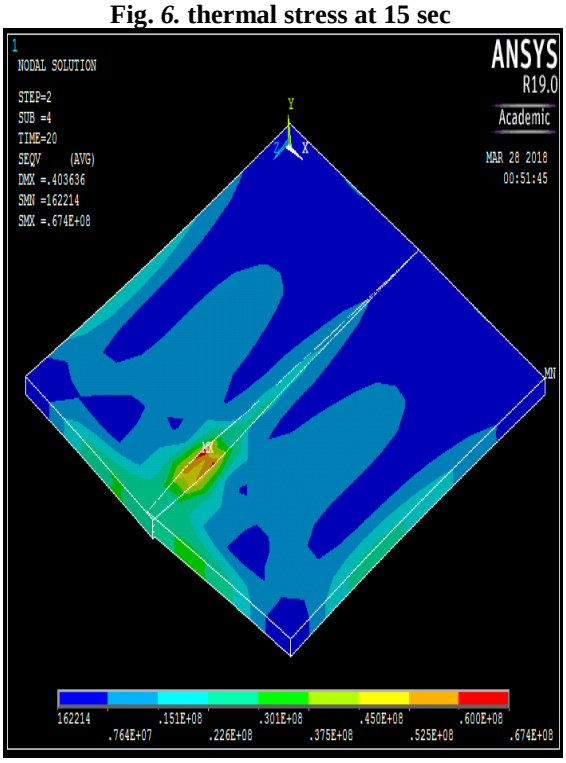

Fig. *7*. thermal stress at 20 sec

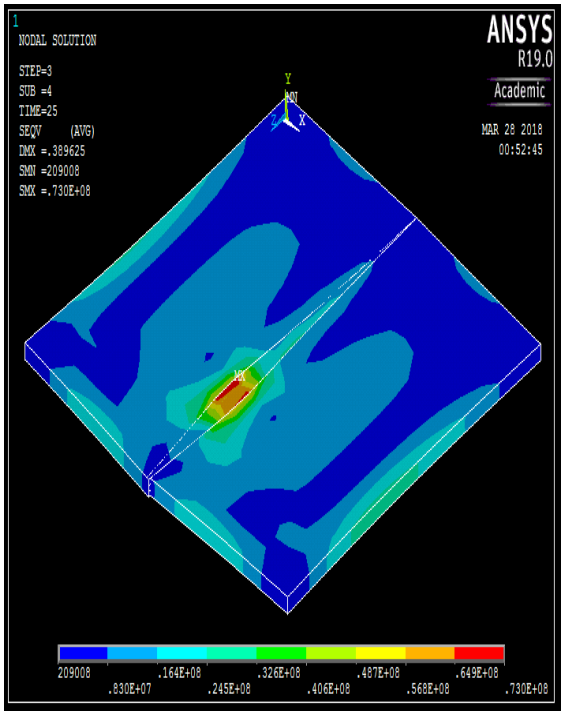

Fig. *8*. thermal stress at 25 sec

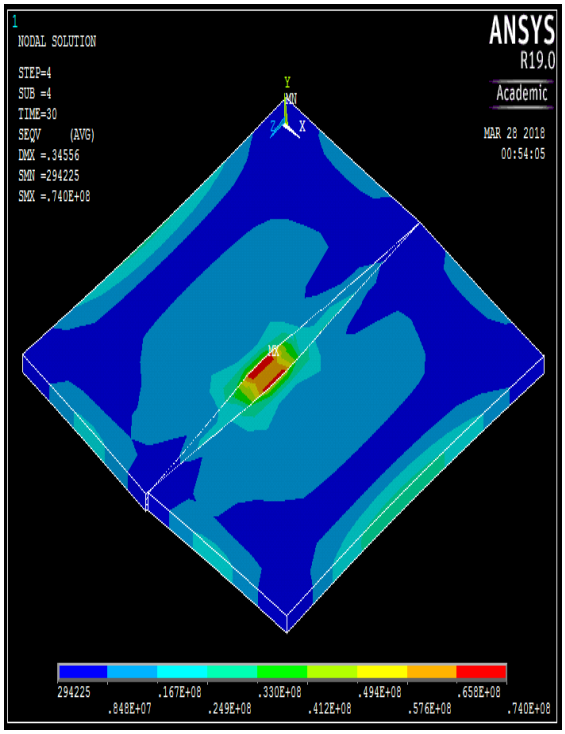

Fig. *9*. thermal stress at 30 sec

5 CONCLUSION

The above investigation was done by the simulating software of ANSYS. In this case the thermal profile and residual stress was done at 15 sec to 30 sec by transient analysis.

- The temperature distribution was founded at the mid-point of the stir zone was 474°c and the minimum temperature was 27°c.
- The residual stress distribution was also less than the base material yield strength(max 99MPa).

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