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Effect of Process Parameters on Diffusion Bonded Aluminium Alloy Sheets of Grade AA 5083

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ABSTRACT: *Sound joining of aluminum alloys is a fundamental prerequisite for their successful integration into high temperature aerospace applications. It has been well demonstrated that diffusion bonding, a commonly used joining technology in conventional aluminum alloys, can successfully be used in joining similar and dissimilar Al alloys both in thermo mechanically treated conditions. In this study, diffusion bendability of AA5083 alloy using bonding parameters such as bonding temperature, bonding pressure and bonding time using a specially designed experimental die setup will be studied.*

The bonding parameters (i.e., temperature, pressure and time) will be systematically changed to determine the optimum parameters for achieving sound bonds. Short-term tensile test at elevated temperatures will be performed for the DB sheets to determine the material characteristic 'm' and k (material constant) with constant. Hot tensile test will be carried to elevated temperature (up to 550ºC) to obtain the insight of mechanical behavior (uni-axial stress-strain) of AA5083. The basic method and specimen are studied from the literature survey. The whole tensile experimental setup will be designed and fabricated. The flow stress of the material under super plastic condition and room temperature will be determined from the true stress-strain and strain rate sensitivity (m), material constant (k) and strain hardeningexponent.

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I. INTRODUCTION

Diffusion bonding is widely used to produce lightweight structures with honeycomb or corrugated fillers. Diffusion bonding is such a process in which two matched surfaces are held together at a temperature range between 0.5 of the absolute melting temperature of the material and the room temperature under a low pressure without causing a macroscopic plastic deformation in the material. Since diffusion bonding is formed from atomic migration across an interface in a solidstate, there is no metallurgical discontinuity at the interface and hence mechanical properties and microstructure at the bonded region are not different from those of the base metal.

Generally a common diffusion bonding process in airframe manufacture utilizes one or two thin walled sandwich structures with superplastic forming (SPF), so called "thin-sheet diffusion bonding". In combination with SPF, diffusion bonding is a solid-state process that is defined as one in which the components joined undergo no more than a few percent macroscopic deformation without a liquid phase. It is well known that superplastic titanium alloys can be easily joined by diffusion bonding without secondary materials, due to its ability to dissolve its own oxide at high temperatures in vacuum. The main purpose of incorporating "thin-sheet diffusion bonding" process is to fabricate lightweight structures with sophisticated configuration, for instance, like sandwich panels, hollow fan blade, nacelle beam frame, and fuselage frame, etc.

AA5083 is a non-heat treatable alloy that is weldable. It is hardened by cold work. It has good forming characteristics and good corrosion resistance, including resistance to salt water. This alloy has relatively fair machinability

Diffusion bonding of AA5083 and subsequent un-axial testing and its Micro structural and Mechanical properties had been studied for the Bonding and Welding Strength.The selection of diffusion bonding process variables affecting the interfacial structure, compound formation and morphology is critical to attain good quality bonds

The grain size of bonded material is larger than that of the as-received material, due to static grain growth

II. EXPERIMENTAL WORK

The chemical composition of AA5083 used in the investigation is shown in Table 1

Cr	Cu	Mg	Fe	Ti	Si	Zn	Mn	Al
0.212	0.08	4.243	0.382	0.08	0.321	0.13	3.56	91.046

Table 1 Chemical composition of AA 5083

The AA5083 alloy sheets of 1mm thickness were cut into I section of 50 X 19 mm square step projection .The specimen is prepared from the plate by wire cut EDM process. Proper drilling operation is carried out in the specimen in order to hold into the fixture during testing. The faying surfaces were ground using rotary silicon carbide papers from 600 grit down to 1200 grit. All the specimens and interlayers were washed thoroughly in alcohol and rinsed in acetone just before inserting into the diffusion bonding setup is shown in Fig. 1

The polished and chemically treated specimens were stacked in a die made up of HCHCR and the entire diffusion bonding setup is shown in Fig. 2

The die is designed in such a way that the diffusion must not affect the core of void. The bottom plate and top plate is fixed using bolt and nut. specimen is placed over the square step block of the bottom plate and the punch is placed firmly over the specimen. The die is placed inside the muffle furnace with the temperature controller unit. The specimen was then inserted into the cavity of the lower plate of die and tightened using bolt of bore dia 10 mm.

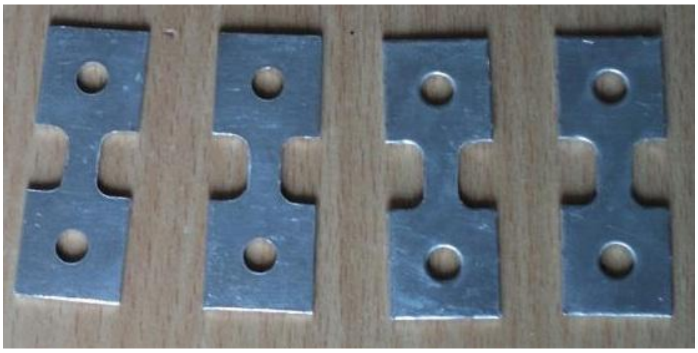

Fig. 1.Specimen with square step projection

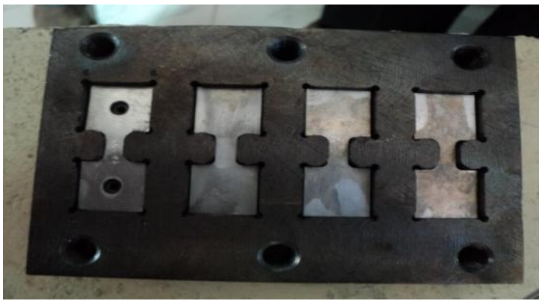

Fig. 2. Configuration of the diffusion bonding setup

After the completion of bonding, the samples
were cooled to room temperature before removal from the chamber
The microstructures of the bond regions of the bonded specimens for the temperature of
540,550,600,650,600,650◦C at 2hours respectively, under a constant pressure of hand pressure at all conditions is shown in Fig. 3

Fig. 3. Bonded specimens

III. MICRO STRUCTURAL ANALYSIS

The grain size of bonded material is larger than that of the as-received material, due to static grain growth during the thermal exposure and slow cooling rate to room temperature Results of microstructure examination of parent material and for diffusion bonded layer is shown in the Fig. 4 (a) &Fig. 4 (b)respectively

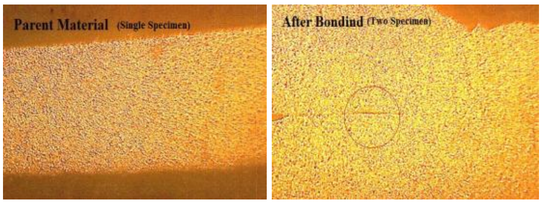

Fig. 4.(a) **Fig. 4.(b)**

Microstructure of parent material **Microstructure of DB sheet**

The oval mark indicates the interface bonding region which has to be disrupted to ensure enhanced bonding and eliminates metallurgical discontinuity.

IV. MICRO HARDNESS MEASUREMENT

Micro hardness along the bonded line is analysed using vicker's micro hardness metallurgical microscope and it was observed that the hardness is increased along the bonded region rather than the parent material. The microhardnessvarations along the bond line has shown in the Fig. 5

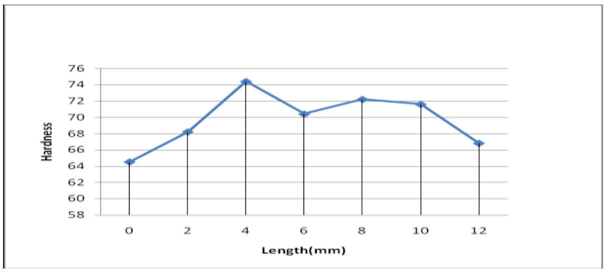

Fig. 5.Micro hardnessvariations of bonded specimens

V. UNIAXIAL HOT TENSILE TEST

A tensile force is applied by the machine, resulting in the gradual elongation and eventual fracture of the test item. During this process, force-extension data, a quantitative measure of how the test item deforms under the applied tensile force, usually are monitored and recorded.

When properly conducted, the tension test provides force-extension data that can quantify several important mechanical properties of a material. AA 5083plateis subjected to uniaxial hot tensile test of diffusion bonded specimens at 530◦C, 550◦C respectively and the results are shown in Fig. 6 (a), Fig. 6 (b), respectively

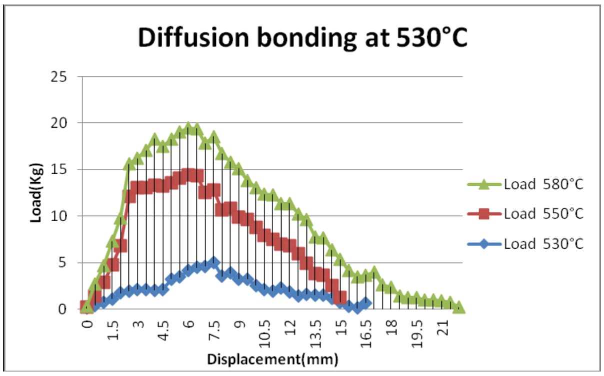

Fig 6 . (a) Load vs Displacement (DB at 530 °C)

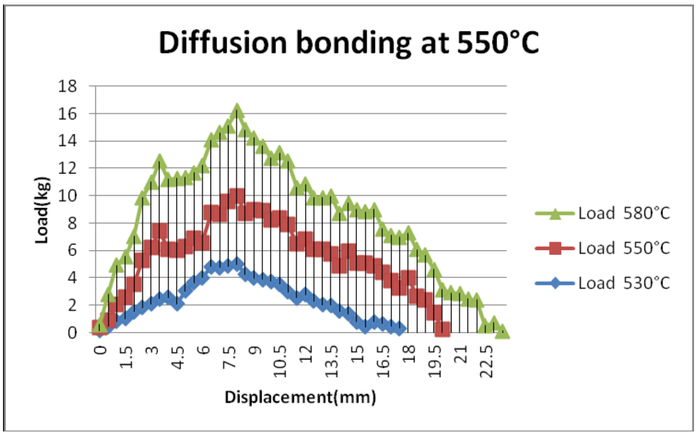

Fig 6 . (b) Load vs Displacement (DB at 550 ℃)

VI. CONCLUSIONS

The diffusion bonding data, presented in this paper, will act as reference maps to design engineers. The material characteristics from tension tests are used for quality control in production, for ranking performance of tructural materials, for evaluation of newly developed alloys, and for dealing with the static-strength requirements of design\

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