DEVELOPMENT OF A MODEL FOR ONLINE MONITORING OF FRICTION STIR WELDING USING ACOUSTIC EMISSION TECHNIQUE

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Introduction

Friction Stir Welding (FSW) is an innovative solid state welding technique, which uses frictional heat and pressure from a rotating non – consumable tool to join sheet and plate materials, without melting the base material. This technology is capable of joining a range of similar as well as dissimilar materials. Current state of the art of this technology in the domain of low melting point materials such as aluminum alloys has matured up to the point where this technology is well-suited for commercial and military aircrafts application [1].

The field of Non -Destructive Testing (NDT) is very broad and plays a critical role in assuring the structural components and systems to perform their function in a reliable and cost effective manner. NDT implement tests that locate and characterize material conditions and flaws that might otherwise cause serious accidents. It provides an excellent balance between quality control and cost effectiveness [2]. Among the NDT methods, Acoustic Emission (AE) testing is a powerful method of examining the behavior of materials deforming under stress. AE refers to the generation of transient elastic waves produced by a sudden redistribution of stress in a material. When a structure is subjected to an external stimulus (change in pressure, load, or temperature), localized sources trigger the release of energy in the form of stress waves, which propagate to the surface and can be recorded by sensors. AE unlike in most other NDT techniques differs in two regards. The first pertains to the origin of the signal. Wherein instead of supplying energy to the object under examination, the AE technique simply listens for the energy released by the object. Second deals with dynamic processes, or changes in a material. This is particularly meaningful because only active features (e.g. crack growth) are highlighted. Materials "talk" when they are in trouble: using A E equipment one can "listen" to the sound of growing, of cracks, breaking of fibers and many other modes of active damage in stressed material. The ability to discern between developing and stagnant defects is significant. Typical AE system contains a sensor, preamplifier, filter, and amplifier, along with measurement, display, storage equipment like personal computers. Furthermore, AE testing usually provides an immediate indication relating to the strength or risk of failure of a component [3]. From studies of Sae-Kyoo et.al it was confirmed, that through initial energy effects, AE techniques can be reliably applied to in-process strength monitoring in any type of friction welding [4]. Han-Ki et.al have showed experimentally that real time quality evaluation of welded joints can be done by AE technique [5]. Zeng et.al showed that tool wear during FSW can be noticed by AE technique [6].

Experimental Details

Materials

Aluminum plates of grade AA7075 and AA7072 were cut to the size 70 mm X 300 mm to prepare welds using FSW machine. In this study tools made of HCHCR (High Carbon, High Chromium) steel having conical and cylindrical tools with grooves were used to prepare the welds.

Apparatus and Procedures

Welding was carried out on FSW machine (Make: ETA Technologies, Bangalore-INDIA, and Type: Horizontal, Capacity: 10 Ton). During welding, AE signals were recorded by AE tester, (Make: Physical Acoustic Corporation-USA, Model: WD Wide band, Sensor element:

Piezoelectric Transducer). Welded samples were subjected to Radiography tests as per ASME Sec IX to study the weld quality. Tensile test was carried out on Electronic Tensometer (Make: Kudale Instruments-INDIA, Model: PC 2000, Capacity: 20 KN).

Results and Discussion

AE signals were acquired during FSW process. Important among many AE parameters are Amplitude v/s Time, Energy v/s T time and RMS v/s Time. AE signal patterns acquired are shown in Fig. 1 to Fig. 3. It can be observed that (circled area) there is an increase in Amplitude (Fig 1), RMS (Fig 2) and Energy (Fig 3) at 40 sec. Radiography tests reveal that there is some defect at that point. It can be observed that the relationship between AE parameters and weld quality exists. Based on the threshold values of AE signals a model (Fig 4) has been proposed to monitor online the FSW process to produce quality welds. This will in help assessing the weld quality and modify the welding process parameters accordingly to get quality welds only based on AE signal pattern obtained.

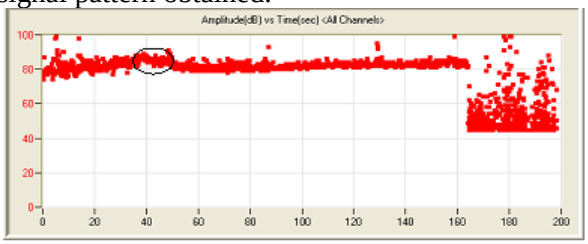

Fig. 1 AE signals apmlitude vs Time

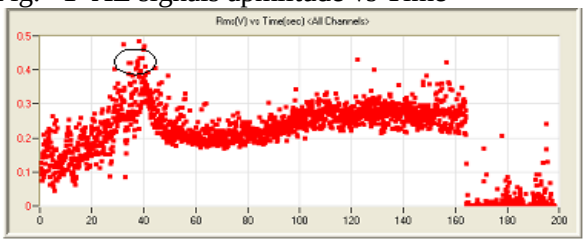

Fig. 2 AE signals RMS vs Time

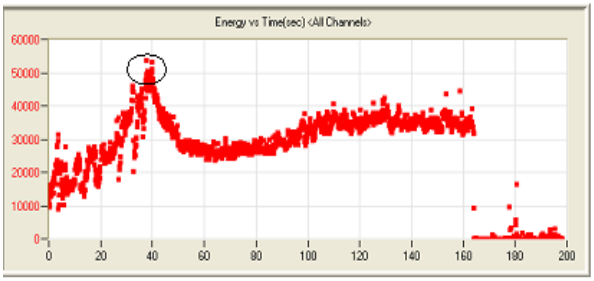

Fig. 3 AE signals energy vs Time

Conclusion

AE is a technique which can be efffectievely utilised for monitoring the quality of welded joints. Model developed proves to be more reliable in producing quality welds. AE technique along with the model proposed will improve the reliability and quality of monitoring process during welding.

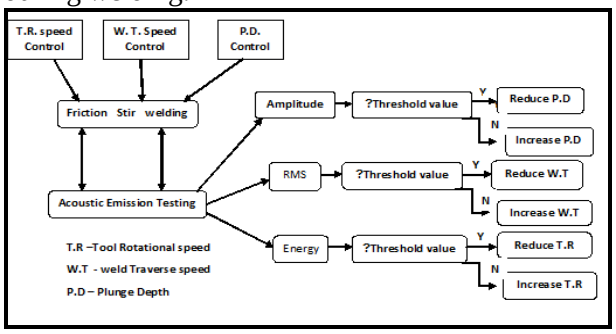

Fig. 4 Online monitoring model of FSW using AE

Acknowledgment

Authors are thankful to Prof. Satish V Kailas, Professor, Department of Mechanical Engineering, IIsc, Bangalore for extending facilities of FSW setup to carry out this investigation. The authors wish to express sincere thanks to Aeronautical Research & Development Board (ARDB), New Delhi, for financial support rendered through R& D project No: DARO/08/2031473/M/I.

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