ACOUSTIC EMISSION IN ANALYSIS OF FRICTION STIR WELDED JOINTS

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Abstract: Most materials and structures emit energy in the form of mechanical vibrations (Acoustic Emission (AE)) as a result of sudden change or movement of which is due to defect-related phenomena such as cracking or plastic deformation. These acoustic emissions propagate from the source, throughout the structure. The technique of electronically "listening" to the acoustic emission is used worldwide in detecting and locating defects as they occur across the entire monitored area providing early warning of pending failure, in a timely and cost effective manner. Friction Stir Welding (FSW) process proves to be one of the novel fusion welding processes and suitable to weld wide range of similar and dissimilar material combinations. In this context it has been proposed to study the applicability of AE technique in the analysis of FSW joints. Also a conceptual model has been developed to correlate the FSW process parameters, tool profile, material flow pattern, microstructures, mechanical properties, etc with AE signals to assist in monitoring and control of the weld quality.

I. Introduction:

AE is defined in E 1316 the terminology for Non-destructive Examinations, as "the class of phenomena whereby transient elastic waves are generated by the rapid release of energy from localized sources within a material." The actual cracking process emits acoustic waves that emanate in an omni-directional manner from the source. An acoustic emission sensor (usually piezo-electric based) in contact with the material being monitored, detects the mechanical shock wave and converts the very low displacement, & high frequency mechanical wave, into an electronic signal that is amplified by a preamplifier and processed by the AE instrument. Stress plays an important role in the AE generation process. In many AE applications, stress is automatically applied by the process itself, and in others, the stress is applied by an externally induced force. The key however, is that the stresses being applied are non-destructive, i.e. they are well below the expected defect tolerance of the material. Typically, AE systems operate in a range of 1 KHz to 2 MHz or greater frequency. The lower frequency limit is imposed by background noises such as friction, outside impacts, or process generated signals that tend to mask acoustic emission. The upper frequency limit is imposed by attenuation, which tends to limit the range of detection of acoustic emission signals. A critical part of the AE application process is the selection of a suitable frequency range for AE detection and signal processing. It must be above the non-AE related background noises, while providing the necessary detection range (distance/frequency) and sensitivity to AE related signals. This is accomplished through the selection of AE sensors (that operate in various narrow-band or wide-band frequency ranges) and electronic signal filtering. Acoustic emission is generally transient in nature, occurring in discrete bursts. AE systems process these bursts as AE "hits" by analysing various aspects of the waveforms associated with each hit, one at a time. The "Time of hit," "rise time," "AE amplitude," "AE counts," "duration," "frequency content," and even the waveform itself are key AE features that can be analysed to help and identify the source of AE as noise- or defect-related. AE has been used successfully in Crack Detection, Weld Analysis, Vessel Inspection, Leak Detection, Pulp and Paper Industry [1].

II Friction Stir Welding:

Friction Stir Welding (FSW) process involves the joining of metals without fusion or filler material. FSW can regard as a solid state autogenous key hole joining technique. The weld metal is thus free from defects typically found in fusion welding, consumable filler material or profiled edge preparation is normally not necessary [2]. In FSW the welds are made below the melting point in the solid phase which has excellent mechanical properties and low distortion is attributed to the low heat input and the absence of melting [3]. Defect free welds up to 2.5 K.M long can be produced with 71% reduction in weld time, 81% reduction in labour with reduced costs compared with conventional fusion welding process [4].

III Application of AE in FSW

One of the major concerns of applying friction Stir Welding is the reliability of the weld quality. No reliable non destructive test method is available at present to determine the weld quality, particularly during production. From the studies of OH Sae-Kyoo et.al it was confirmed, through initial energy effects, that AE techniques can be reliably applied to in-process strength monitoring in any type of friction welding, as the cumulative AE counts occurring during welding and cooling periods were quantitatively correlated with reliability at 95 % confidence level to the joint strength of welds, bar-to-bar (AISI 4140 to 1117 & 12L14) and tube-to-tube (AISI 1020 to 304 stainless steels) [5]. Studies of WM Zeng et.al showed that tool wear occurs during FSW, acoustic emission (AE) sensing, metallographic sectioning and tensile testing are employed to evaluate the weld quality in various tool wear conditions. AE signatures recorded during welding reveal that the AE hits concentrate on the higher amplitudes with increasing tool wear and show that the AE sensing provides a potentially effective method for the on-line monitoring of tool wear [6].

IV Conclusions

It is evident from literature survey that FSW process is an innovative solid state joining technique which finds grater uses in space systems, aircrafts, ship building, rail carriages, automotive etc. in welding wide range of materials i.e. aluminium alloys, castings, extrusions and magnesium and copper alloys, stainless steel , titanium alloys, thermoplastics and range of dissimilar combinations. Acoustic Emission technique has proved to be a fast, accurate and cost effective method of structural monitoring that has shown to be very reliable, and can inspect both "locally" and "globally". AE technique is also helps in detecting defect growth in real time as it is occurring. It has been observed from the literature that there is no complete model to analyse the process parameters of FSW and its effects on the weld quality with the use of AE technique.

An experimental examination and quantitative analysis for the effects of initial energy on AE relating to weld strength is proposed as a new approach which attempts finally to develop an on-line quality monitoring system design for friction welded joints using AE techniques. In this context it is proposed to develop a conceptual model as shown in Fig. 1. The model helps in establishing relationship between welding process parameters, tool profile parameters, material flow patterns and mechanical and microstructural properties of welds with AE signals. Further the model is intended to help in producing defect free welds using different materials for different applications and detect and locate flaws as early as possible. As a result, the welded structure can be repaired or replaced well before a catastrophe can occur there by preventing loss of life, environmental damage and costly repairs.

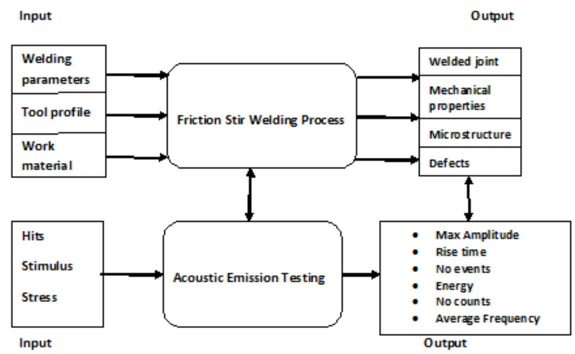

Figure 1 Conceptual Model

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