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40

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Title : FATIGUE LIFE ENHANCEMENT FOR FRICTION STIR WELDED AA6061 BUTT JOINT THROUGH HIGH FREQUENCY MECHANICAL IMPACT (HFMI) OF PNEUMATIC IMPACT TREATMENT (PIT)

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The welding and joining industry in the past few decades has witnessed a huge growth in pursuit of process optimization and design minimization due to the continued escalation of prices. A relatively typical new welding process that requires wide attention in process optimization for an ideal low defect joint and life cycle improvement is friction stir welding due to its advantage of having minimal parameters to be controlled during the process. However, despite its many advantages tensile residual stress in friction stir welded joints remains to be a significant concern due to its extensive clamping and stirring process causing a lower fatigue resistance particularly in structures subjected to fluctuating loads triggering a need for improvement by utilizing modern post-weld treatment processes. Aiming to apply the HFMI method of pneumatic impact treatment (PIT) to enhance the fatigue performance of a 6 mm thick AA6061-T651 FSW butt joint, this research consisted of three main phases. The initial phase focused on the optimization of the rotational and traverse speed based on multiple mechanical properties and quality features, which emphasized on the tensile strength, hardness and the weld quality class using the Multi-objective Taguchi Method (MTM). Furthermore, the first order model for predicting the mechanical properties and weld quality class was derived by applying Response Surface Methodology (RSM). The second phase dealt with determining the best governing process parameters of HFMI technique using a similar optimization approach for varied parameters centered on indenter diameter, air pressure and impact frequency. In the final phase, the nominal stress approach was employed to determine the fatigue class (FAT) enhancement values as well as S-N curves of HFMI/PIT treated, post weld heat treated (PHWT), as-welded and in-service HFMI/PIT treated FSW AA6061 joints. Subsequent sub-surface hardness measurements and static test evaluation with microstructure analysis was conducted to gain a better understanding of the fatigue behavior for each condition. Further analyses and measurements of the longitudinal and transverse residual stress for FSW AA6061 joints using the hole-drilling method with electronic speckle pattern interferometry (ESPI) for various conditions was conducted to establish the vicissitudes of residual stress with each as-welded and post weld treatment. It was found that the PIT treatment imparted significant amount of compressive residual stress to the FSW joint resulting in an enhanced fatigue life of FSW PIT treated condition. The FSW in-service PIT treated joints achieved marginally higher fatigue strength than the as-welded conditions although being pre-fatigued, thus giving a whole new meaning to asset integrity and management for in-service FSW aluminum alloy joints and structures.