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EVALUATION OF LOCAL MECHANICAL PROPERTIES AND CORRELATION WITH TENSILE PROPERTIES OF AA7075-T6 FRICTION STIR WELDS VIA SHEAR PUNCH TESTING

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ABSTRACT

Friction stir welding, used for joining light alloys in the aeronautics industry, generates an asymmetric thermomechanical cycle along the weld line, leading to uneven heat input and significant variations in mechanical properties. To evaluate these variations, the shear punch test offers an effective solution, especially when sample size or constraints limit traditional tensile testing. This test, based on the blanking process, accommodates various grain sizes and sample thicknesses, making it versatile for diverse microstructures. Additionally, it produces mechanical curves similar to tensile tests, enabling a reliable correlation between local and global mechanical properties in welded joints. The aim of this work is to establish a correlation between local mechanical properties obtained through shear punch testing and global properties derived from tensile testing in different zones of a welded joint. A correlation between σ_{ys}, τ_{ys}, and σ_{us} with τ_{us} was derived based on the von Mises criterion and the Power Law Strain Hardening (PLSH). The yield strength σ_{ys} is expressed as $1.73\tau_{ys}$, determined at a 0.2% offset. For the ultimate tensile strength, the relationship $\sigma_{us} = (1/S_f).\tau_{us}$ is applied, where S_f depends on the hardening exponent n obtains from tensile test. In this study, n_τ values derived from the shear punch test data were used to calculate S_f allowing the correlation to be extended to regions where tensile testing strength coefficients, such as strain hardening exponents n, were unavailable. This approach highlights the value of shear punch testing as a tool for evaluating local mechanical properties in welded joints. In conclusion, the strain hardening exponent from the shear punch test is approximately 1.3 times that from tensile testing. The highest n_τ value (0.14099) was in the TMAZ retreating side, The maximum ultimate strength (441.77 MPa) was found in the nugget zone, while the lowest value, 278.90 MPa, occurred in the HAZ advancing side. The (τ_{us}/τ_{ys}) ratio peaked at 1.82 in the TMAZ retreating side, exceeding the nugget zone by over 20%.