Modeling the Effects of Laser Peening on Friction Stir Welding Residual Stresses

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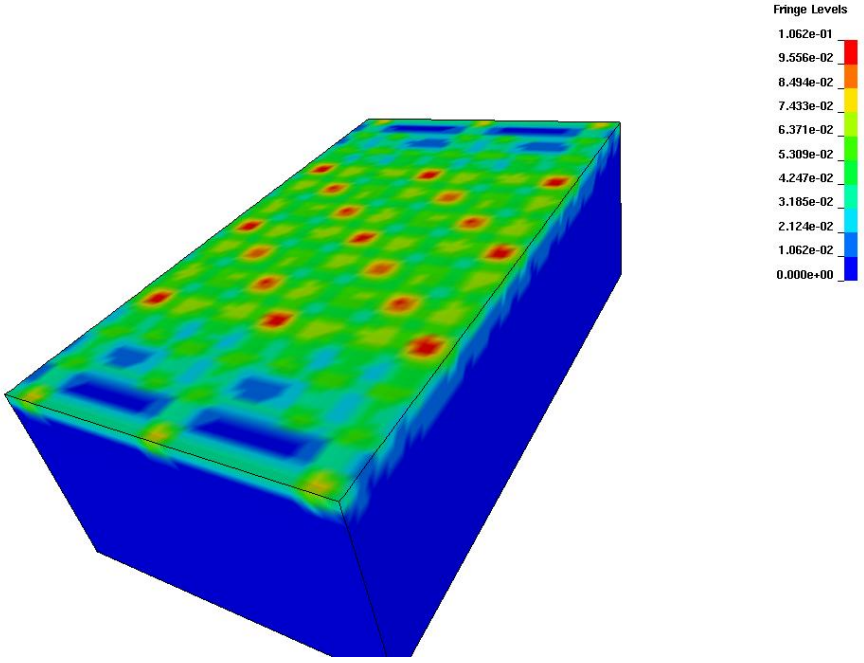
Abstract

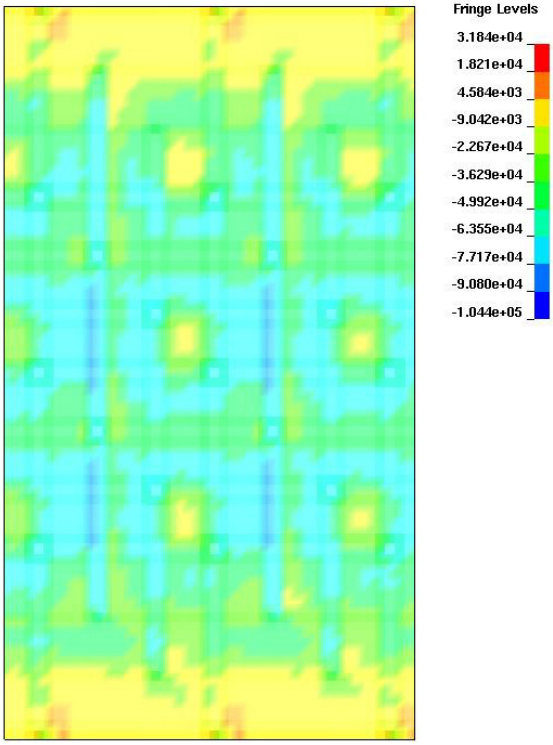
An analytical framework for predicting the residual stresses which result from the laser peening of a friction stir welded sample, using the finite element software LS-DYNA®, is presented, using a 2195 Aluminum alloy as an example. The pressures resulting from the laser peening are directly applied in an explicit transient analysis as forces. At the completion of the transient analysis, an implicit springback analysis is performed to determine the final residual stresses. This cycle is repeated for the appropriate number of peen applications, including the appropriate overlap of application areas. To validate the analytical framework, a comparison of residual stresses between analysis and a test specimen is made using laser peened base material which was not friction stir welded.

Friction stir welding causes residual stresses and material property variations which increase the difficulty of modeling beyond the already complex modeling of the laser peening. In the analysis, the varying material properties regions are somewhat simplified and defined as discrete, separate materials. The residual stresses resulting from the welding are introduced directly as initial conditions in the peening transient analysis and so are combined within the analysis with the residual stresses from the peening.

An additional challenge in the modeling of laser peening is the uncertainty in the yield strength of metals at the very high strain rates (>5000 1/sec) which result from the very short loading pulse duration. The strain rate sensitivity of the example metal, Aluminum 2195, is low at strain rates of less than 5000 1/sec, but its behavior higher than this rate is unknown. The effect of this uncertainty in the very high rate behavior is studied parametrically.



Plastic Strains Resulting from Laser Peening



Residual Surface Stresses Resulting from Laser Peening