

# Laser Peening of Friction Stir Welds

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Friction stir welding (FSW) was invented by the Welding Institute in England in 1991. Since then, FSW has emerged as a promising, solid-state process with encouraging results, particularly when used on high-strength aerospace aluminum alloys that are generally difficult to weld. FSW transforms metals into a plastic state at a temperature below the melting temperature of the material, and then mechanically stirs the materials together under pressure to produce high-strength bonds.

Residual stresses developed during welding can have a significant effect on the service performance of welded

material with respect to fatigue properties and fatigue crack growth process. Residual tension stresses commonly found in the heat-affected zone of friction stir welds can lead to faster crack initiation and propagation, reducing the advantages of the processes. Therefore, Laser Shock Peening (LSP) was investigated as a mean of moderating the tensile residual welding stresses in components.

LSP is a relatively new surface treatment technique that has been shown to significantly increase the fatigue properties of applications where failure is caused by surface-initiated cracks. Laser peening is a process that

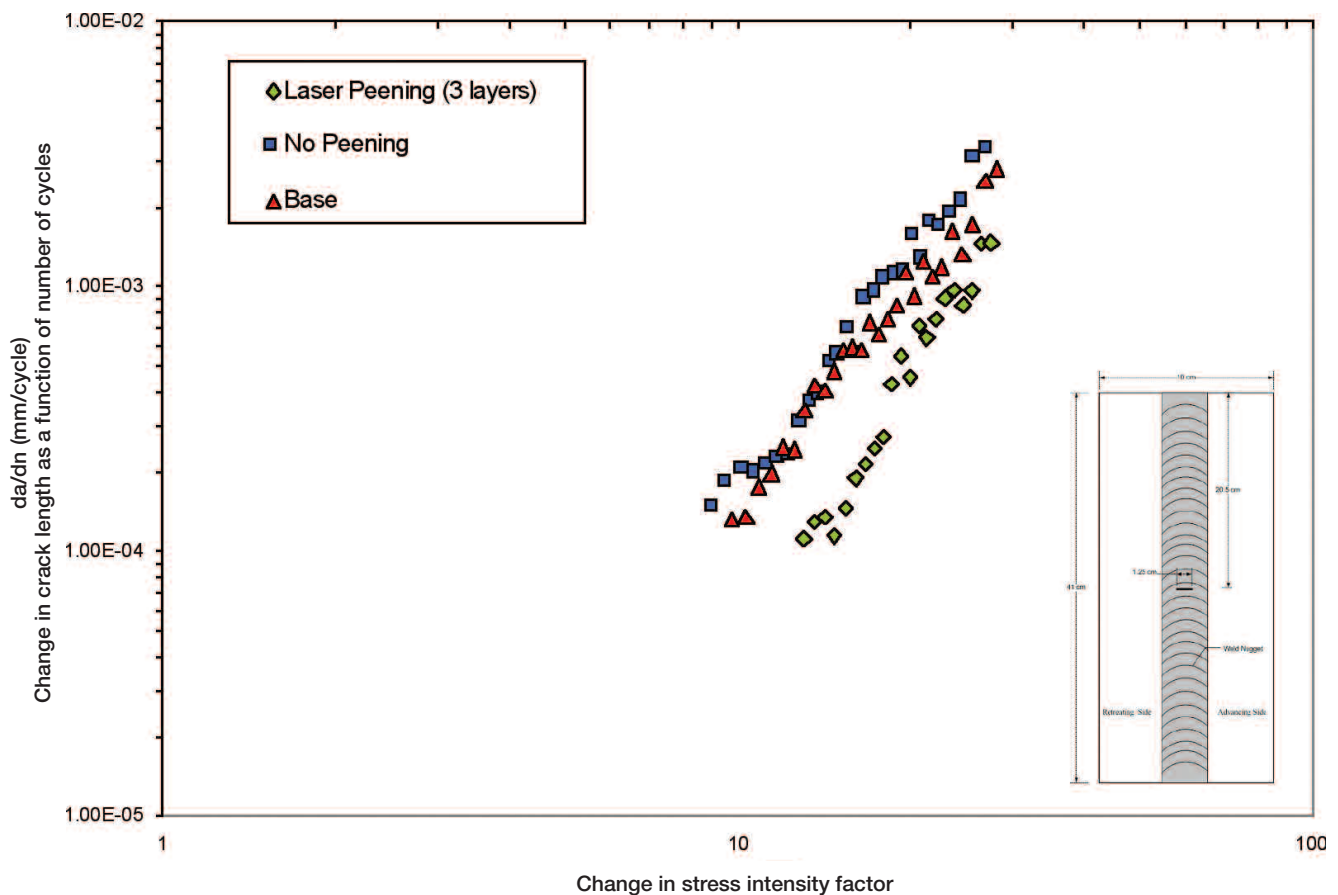


Fig. 1. Crack growth rates for FSW 7075-T7351.

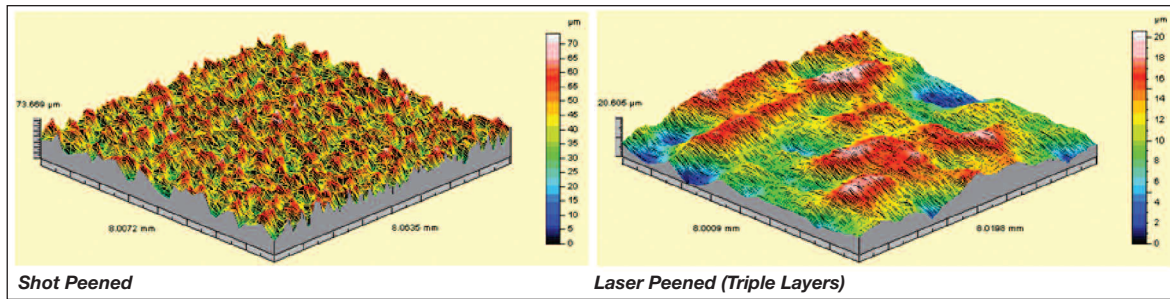


Fig. 2. A three-dimensional contour of the surface roughness resulting from different peening techniques.

provides high-energy laser pulses that are fired at the surface of a metal coated with a dark paint and a thin layer of transparent material (usually water). The interaction of the laser and the paint creates a pressure shock wave that is contained by the layer of water. The shock wave then generates a compressive stress layer directly beneath the focused laser pulse and provides highly compressive residual stress state.

LSP produces a compressive residual stress at the surface that can extend several millimeters or more deep into the material. The residual stress resulting from laser peening can be significantly higher and deeper than for conventional shot peening (SP), resulting in superior fatigue properties (figure 1).

Commonly used SP technique has helped overcome some of the adverse effects caused by tensile residual stress. Nevertheless, SP has many disadvantages; for example, the residual stresses generated by this technique are generally superficial, do not penetrate deep enough into the surface, and effects may be lost after subsequent finishing operations and may result in surface damage. The surface roughness produced by laser peening is also significantly smoother than surface roughness due to SP, as shown in figure 2.

The effects of laser peening on mechanical properties were also investigated (figure 3) and showed an increase in mechanical properties. The increase was mainly attributed to the increase in dislocation density and the high level of compressive residual stresses introduced during the high-energy peening.

In conclusion, the use of this innovative peening technology has the capability to produce substantial benefits. Potential advantages of LSP include the possibility of being used on machined surfaces, the treatment of localized fatigue critical areas without masking, and the possibility to repair cracks that would not be possible using alternative methods. Also, LSP produces a smooth surface and has good process control and repeatability. However,

the application of this novel peening method to airframe alloys may still involve technological risk, which needs to be reduced by careful research and further investigation. Therefore, Johnson Space Center has been extensively researching the ramifications and advantages of applying laser peening to FSW for use on future space vehicles, and is currently optimizing the laser peening parameters to produce optimum fatigue and mechanical properties.

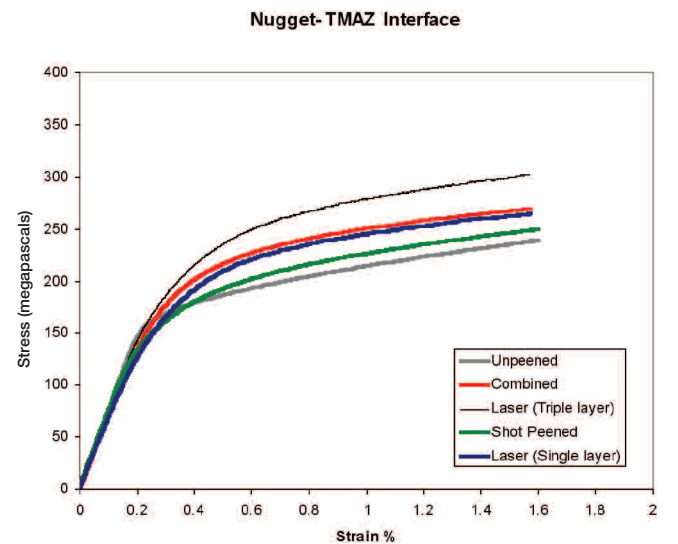


Fig. 3. Tensile behavior at the nugget-thermo mechanical affected zone (TMAZ) interface of an FSW 7075-T7351.