Effect of Structural Conditions on Fatigue Performance of Ti-6Al-4V Welds

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The new 155-mm Howitzer has been designed using Ti-6Al-4V for reduced weight and air portability. The welded structure is required to withstand stresses induced by transport and firing cycles. This project was initiated to study the fatigue resistance of titanium alloy welded structures, particularly those with minor welding imperfections.

Fatigue testing in 4-point bending was performed on butt welds with 3 different treatments after welding: no heat treatment, heat treatment in vacuum, and heat treatment in air. Air and vacuum heat treatment had very similar fatigue performance, while the performance of the pieces without heat treatment was slightly improved. All subsequent tests were done on welds after heat treatment in air.

The fatigue performance of both butt welds and tang and slot welds was found to differ noticeably between testing in tension and testing in 4-point bending. Lifetimes averaged 4 to 5 times longer in bending.

Internal flaws in butt welds, corner joints, and T-joints were all found to cause very little change in the fatigue performance. Surface imperfections and shape had a greater effect on fatigue performance than internal flaws. Root linear indications were noted to be particularly detrimental when located on the tensile face of bend specimens.

The data from this project and the literature has shown that the fatigue life need only be reduced by 20% compared to steel on stress range compared to an initial prediction of 44%. By relating this data to IIW recommendations for steel structures, new fatigue guidance has been derived for a wide array of weld joint configurations. The newly developed fatigue guidance, based on a fatigue classes with a slope exponent of 3.5 for Ti-6Al-4V alloy, will be more accurate and less conservative for life cycles greater than 100,000.