

Weld Residual Stress and Distortion Analysis of the ARES I-X Upper Stage Simulator (USS)

F. W. Brust

Engineering Mechanics Corporation of Columbus, Columbus, Ohio

Abstract

An independent assessment was conducted to determine the critical initial flaw size (CIFS) for the flange-to-skin weld in the Ares I-X Upper Stage Simulator (USS). The USS consists of several “tuna can” segments that are approximately 5.5 m in diameter, 2.9 m inches tall, and 12.7 mm thick. A 152 mm wide by 25.4 mm thick flange is welded to the skin and is used to fasten adjacent tuna cans. Gussets are welded to the skin and flange every 10 degrees around the circumference of the “tuna can”. The flange-to-skin weld is a flux core butt weld with a fillet weld on the inside surface. The welding process often creates loss of fusion defects in the weld that could develop into fatigue cracks and jeopardize the structural integrity of the Ares I-X vehicle. This weld represents a rather unique geometry, which cannot be modeled using axis-symmetric assumptions. Moreover, the geometry is quite different from typical ‘pipe or cylinder’ type welds and hence the residual stress distribution is not necessarily intuitive.

The purpose of this set of weld analyses is to model the weld process using a variety of sequences to determine the ‘best’ sequence in terms of weld residual stresses and distortions. The many factors examined in this study include weld design (single-vee, double-vee groove), weld sequence, boundary conditions, and material properties, among others. In addition, mesh refinement studies are included. Full three dimensional weld analyses are performed. The results of this weld analysis are included with service loads (including fit-up stresses) to perform a fatigue and critical initial flaw size evaluation the results of which are presented in a companion paper in this session.