SPB7. Feasibility Study Of FSW Penetration Control VIS Eddy Current Sensing

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Introduction

The external tank (ET) is the primary fuel supply for the space shuttle. Lockheed Martin Space Systems uses friction stir welding (FSW) to lower the cost, speed of fabrication and especially the weight of the ET while maintaining or increasing the integrity. FSW can also provide weight savings by the elimination of filler metal, a much lower defect rework time and a reduction in joint preparation as compared to the current joining process. Currently, FSW is employed in the joining of the barrel sections. To ensure uniformity, Lockheed Martin proposes to use eddy current (EC) to measure FSW weld penetration.

Technical Approach & Results

The initial objectives of this project were to determine feasibility of real-time penetration monitoring of friction stir welding of aluminum substrate via eddy current sensing techniques. Welding experiments with initial sensor designs showed that both performed inadequately due to insufficient sensor cap strength and excessive deflection during welding. However, using a 2219 aluminum calibration standard, excellent correlation was established between the voltage and the penetration ligament thickness. Thus, feasibility was proven, demonstrating that eddy current could be a viable sensing technique for FSW. More analysis was needed to determine if a material could be found which could withstand the necessary welding loads and temperatures, while allowing adequate eddy current resolution. FEM analysis showed that an 301 stainless steel cap thickness of 0.14” would allow a minimal loaded deflection of 0.001” and an unloaded permanent deflection of 0.0006”. However, increasing the thickness of the sensor cap will reduce the sensor resolution, reducing the ability to differentiate penetration ligaments that exceed 0.04”. It was decided that materials with increased material strengths should be evaluated. Further analysis showed that a 0.1” tungsten cap had a loaded deflection of 0.0009” and an unloaded deflection of zero (the yield stress was not reached while loaded).

Conclusions

It is concluded that a sensor can possibly be developed that utilizes high strength materials to reduce sensor cap deflection. FEM analysis shows that high strength, non-ferritic materials such as tungsten can provide increased resolution through a decreased sensor thickness as compared to stainless steel or aluminum. However, the effects of high strength materials on sensor resolution are unknown and will require testing.