8306-027

# MECHANICAL PROPERTIES AND PHYSICAL METALLURGY OF HSLA STEEL LASER BEAM WELDMENTS

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## ABSTRACT

Laser beam weldments of High Strength Low Alloy (HSLA) Steels, (12 mm (0.5 in.) thick), were fabricated as autogeneous butt welds and with 0.025 mm (0.001 in.) thick Inconel 600 inserts. Their mechanical properties, solidification structure, and microstructure were evaluated. The HSLA steels examined were ASTM A633, A710, A736, and A737. The mechanical properties (YS, UTS, Elong., RA, and Fracture Toughness) of the base plates and weldments were measured. The fracture toughness was determined by the Charpy V notch test. Hardness traverses were made across the base plates, heat affected and fusion zones. The solidification structure and microstructure of the autogeneous and Inconel 600 insert welds were identified by optical microscopy. Fractographic analysis was carried out by scanning electron microscopy. A discussion of the differences in structures and mechanical properties of the weldments will be presented.

## INTRODUCTION

THE INCREASED USE of high strength low alloy (HSLA) steels in structures is due in part to their high strength, good low temperature toughness, and weldability. Many of these structures require extensive and repetitive welding sequences which are easily automated. The use of a high power laser beam welding system in such an automated system is logical because of the simple joint preparation, high welding speed, ability to be completely computer controlled, and low distortion of the resulting weldment. Also as a result of its low heat input and fast welding speed, the laser beam welding process has rapid solidification and high cooling rates which affect the mechanical properties of the heat-affected zone (HAZ) and fusion zone (1,2). This paper reports on the mechanical properties of laser beam weldments of three HSLA steels (A633, A737, and A710/736).

## LASER WELDING

The laser or light amplification by stimulated emission of radiation, has existed for only a little over twenty years but has already found its way into manufacturing (3). In many situations the lasers are low power continuous-wave (CW) or pulsed lasers which are used to weld thin sheet metal. However, a high power $CO_2$ CW laser rated at 25 kilowatts is presently producing thick section (16 mm(5/8 in) thick) welds in a production line environment (4).

Laser beam welding occurs when the collimated, monochromatic laser beam is focused to a small diameter spot (1.0 mm (.04 in)). This results in a very high power density which impinges on and interacts with the workpiece. This interaction can be considered a combination of reflected and absorbed energy. If the absorbed energy is sufficient, a column or "keyhole" is produced consisting of vaporized metal surrounded by a molten pool both of which extend through the thickness of the material. The vaporized metal, or plasma, that is produced in the keyhole also exist above the interaction site and is a very good absorber of the laser radiation. This results in a decrease in the amount of energy going into the keyhole. A helium gas jet is used to move the plasma away from the top of the keyhole. Helium is also used to blanket the weld area in an attempt to minimize the amount of detrimental gas absorbtion. The depth to which the keyhole will penetrate is determined by the power of the laser beam, the weld speed, and the amount of plasma suppression (5,6). A proper laser beam weldment will have a depth-to-width ratio of 4 to 1 or greater.