THERMAL MODIFICATIONS OF WELDING RESIDUAL STRESSES

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ABSTRACT

Significant changes can be made in welding residual stresses by proper welding and post-weld thermal techniques. In particular, the axial ID stresses in butt welded schedule 80 austenitic stainless steel pipes are usually tensile in the weld heat affected zone. Compressive stresses can be induced instead by heat sink welding, whereby the ID is water cooled after the second welding layer while the rest of the weld is completed. The tensile stresses in pipes already welded can be changed to compressive stresses by heating the pipe OD near the weld while simultaneously cooling the ID with water, so that plastic deformation occurs. Then the heating is removed. One method of heating the OD is induction heating. Examples will be given of the stresses induced by normal welding procedures, heat sink welding, and the induction heating process.
INTRODUCTION

The residual stresses induced by conventional welding techniques can have adverse effects when the welded materials are placed in actual service. As an example, welded austenitic stainless steel pipes occasionally crack via an intergranular stress corrosion cracking (IGSCC) mechanism. This IGSCC is generally attributed to three factors that must be present at the same location: a sensitized microstructure, a detrimental environmental condition, and a critical stress or strain condition. The degree to which any one factor must be present for the IGSCC to occur depends on the intensity of the other two factors. The stress factor will be considered here.

The stress to which a material is subjected while in use is a combination of the applied stress and the residual stress. The applied stress can usually be calculated with reasonable accuracy, but this is not always true for the residual stress. The residual stresses present in austenitic stainless steel pipes joined by conventional welding practices will be described as well as two techniques that can significantly change these welding stresses and drastically reduce the possibility of IGSCC. These two techniques have been named heat sink welding and induction heating stress improvement.

The stresses that will be described are those in the axial direction (the stresses in the direction perpendicular to the weld) on the inside surface near the welds. The reason for emphasizing these stresses is that the stress corrosion cracking that does occasionally occur is circumferential and starts on the inside surfaces of the pipes.

Most of the residual stress measurements were made using x-ray diffraction techniques with strain gauges being used to obtain stress relief corrections. A brief description will also be given of some through-wall residual stress results obtained from a strain gauge dissection method.

EXPERIMENTAL

The residual stress measurements reported here were made on schedule 80 type 304 stainless steel pipes with wall thickness to pipe diameter ratios in the range 1/12 to 1/20. All of the pipes were machined in the counterbore region prior to welding, and the butt welds were made with a double J weld preparation configuration.

For the conventional welds, the consumable insert fusion and the second layer, consisting of two passes, were made using the gas tungsten arc welding (GTAW) process. The remaining groove was