DIFFUSION BONDING BY HOT EXTRUSION OF INCOLOY 825 AND DUPLEX 2205 TO A LOW ALLOY STEEL

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AISI 4130 low alloy steel has been diffusion bonded to an Incoloy 825 and a Duplex 2205 stainless steel by an industrial hot extrusion process, the final product being a seamless clad tube with an internal lining of these corrosion resistant alloys. The microstructures of the as-extruded products have been analysed using optical metallography, SEM and STEM techniques. The interdiffusion of the different elements through the interface has been determined using EDS microanalysis both in SEM and STEM. For the combinations AISI 4130-Incoloy825 a region close to the original interface on the Incoloy side is observed, where a deformation substructure with subgrains, dislocations and an important amount of carbides $M_{23}C_6$ type are found. Different layers of austenite, martensite and ferrite-pearlite are observed on the steel side. In the case of the combinations AISI 4130-Duplex 2205 and close to the interface, a region with a low amount of ferrite with a big profusion of $M_{23}C_6$ carbides precipitated at the grain boundaries is observed, followed by regions with a higher amount of ferrite at grain boundaries to reach the original structure of the Duplex. The influence of several heat treatments consisting in quenching plus tempering in the region around the bonding have also been analysed.
INTRODUCTION

Surveys carried out by some oil companies have shown a clear trend at the near future for drilling wells at deeper depths. As well depth increases, the requirements of materials for tubing become more stringent. Due to the rise in temperature and pressure and because the tubings used have to sustain their own weight a high strength is required. An additional problem with deep oil and gas wells is the corrosion due to $\text{H}_2\text{S}$, HCl and CO$_2$.

Thus, the combination of these two factors: strength-corrosion resistance together with economical requirements have encouraged the development of bimetallic tubes, that is, a high strength low alloy steel with a thin metallurgically bonded, corrosion resistant clad alloy, produced in an economical way. These products could be also used in other applications like, pipe lines for oil transport, heat exchangers, in the chemical industry and cryogenic applications among others.

The present work describes the microstructures developed during diffusion bonding by hot industrial extrusion of inside linings of a Duplex 2205 stainless steel and an Incoloy 825 to an AISI 4130 low alloy steel

EXPERIMENTAL PROCEDURE

The bimetallic tubes were produced using 230mm AISI 4130 billets. These were perforated so that Duplex 2250 and Incoloy 825 bars could be alocated inside the holes and subsequently sealed following the procedure patented by TUBACEX S.A.(1). The assemblies were heated by low frequency induction heating to temperatures between 1170 and 1240°C, pierced in a vertical 1200 Tn capacity hydraulic press. After reheating the pearced assemblies were extruded in a 3100 Tn capacity hydraulic press to 138 mm diameter tubes with a 10.5 mm total wall thickness. Finally they were hot rolled to 88.9 mm diameter tubes of 9.52 mm total wall thickness and air cooled. Metallographic specimen were cut from the tubes and prepared by conventional techniques to be observed optically and by SEM. Thin foils perforated at the interface for TEM observation were prepared using a combination of electropolishing and ion beam etching.