ABSTRACT

The purpose of this paper is to present an introduction to Duplex stainless steels by reviewing their main properties in terms of chemical composition, microstructure, mechanical characteristics and corrosion resistance.

Special attention will be paid to the recent development of a Duplex grade (22% chromium, 5% nickel) with enhanced low-temperature properties. Compared to conventional duplex steels, this new material presents significantly better toughness properties pushing back the limits of use from -50°C (-58°F) to -100°C (-148°F). Toughness results obtained on base materials and welded specimens at various temperatures will be provided. In addition, results of corrosion/cracking tests conducted in H2S-environments will be reported.

KEY WORDS: Stainless Steels; Duplex; Ferrite content; Oil & Gas; Low temperature; Arctic; Weldability

INTRODUCTION

Duplex stainless steels were born and have been actively developed by European companies since 1935. Their features made them very attractive compared to equivalent austenitic grades: higher resistance to Stress Corrosion Cracking, higher mechanical properties and lower alloy cost (Charles and Chemelle, 2010). They present excellent cost/properties ratios particularly in critical applications including: Oil and Gas, chemical industry, pulp and paper industry, water systems, desalination plants, pollution control equipments, chemical tankers...

The Oil & Gas chain involves a large number of highly specific processes. The production units that carry out these manufacturing processes, use reactors and piping systems that must often resist corrosive environments and high pressures (see Tystad, 1997). The demands placed on materials increase steadily in terms of both quality and operating constraints. Duplex grades are commonly used in numerous industries, due to their intrinsic properties.

This paper will describe duplex stainless steels and give an overview of their properties, such as mechanical and corrosion characteristics.

Special attention will be paid to a new duplex grade, a UNS S32205/UNS S31803 (22%Cr, 5%Ni) Low Ferrite Content (LFC), well suited for low temperature and Oil & Gas applications. Its characteristics in terms of ferrite content in Heat Affected Zone will be described in the second part of this paper, suggesting that the values obtained are in line with the standards commonly used in the industry. Data related to the sour corrosion resistance of the material will also be provided. In the last part of this paper, low temperature properties of the material will be discussed showing that it can be an interesting candidate material down to -100°C (-148°F).

OVERVIEW OF DUPLEX PROPERTIES

First duplex grade was produced in the 1930’s. At that time, a significant improvement of mechanical characteristics and intergranular corrosion resistance was highlighted compared to standard austenitic materials. Many developments were performed since then and duplex materials are now widely used in various applications (Charles and Chemelle, 2010) such as storage tanks, pulp and paper industry (Olsson, 1997), chemical tankers and desalination plants (Wallén, 1997). Laboratory studies and service experience have proven that duplex grades exhibit higher stress corrosion cracking (SCC) resistance than standard austenitic materials.

Chemical compositions

UNS designations and typical chemical compositions of duplex stainless steels most commonly used are reported in Table 1. Austenitic grades S30403 and S31603 are given as reference materials. The lean duplex materials UNS S32202 and S32304 contain low levels of molybdenum and are today widely used in the water and pulp & paper industries, i.e. for applications requiring a moderate corrosion resistance. The medium-alloyed grades UNS S31803 and S32205 are 22%Cr steels commonly used in the Oil & Gas industry for piping and topside equipment. Finally, the 25%Cr super-duplex materials UNS S32750, S32550 and S32760 are dedicated to highly aggressive environments.