Materials and Design 32 (2011) 433–440

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Technical Report

Mechanical and corrosion behavior of plain low carbon dual-phase steels

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ARTICLE INFO

Article history:
Received 7 April 2010
Accepted 12 June 2010
Available online 18 June 2010

ABSTRACT

Dual-phase steels are being used in automobile industries for last three decades. The mechanical properties of dual-phase steels can be altered by varying its martensite volume fraction. However, the benefits obtained in mechanical properties have to be viewed in light of other properties such as corrosion resistance. In this work, dual-phase steels with different volume fractions of martensite are obtained after thermal processing using different intercritical soaking times. The mechanical properties of dual-phase steels such as Vickers hardness and tensile properties are measured. Corrosion properties are evaluated using potentiodynamic polarization test and immersion test. It was observed that the tensile strength and hardness increased and ductility decreased with increase in martensite volume fraction. The corrosion rate for dual-phase steels is found to be lower than that for subcritically heat treated ferrite–pearlite steel. The higher corrosion resistance of dual-phase steels is explained on the basis of microstructural features.

1. Introduction

In last three decades dual-phase (DP) steels possessing a composite microstructure consisting of hard martensite islands embedded in a soft ferritic matrix have evoked much interest [1,2]. The early investigations have revealed that DP steels possess a number of unique properties making them attractive for applications such as very good quality sheet materials for automotive bodies. Use of DP steels is mainly due to their continuous yielding, low 0.2% offset yield strength, high ratio of ultimate tensile strength (UTS) to yield stress, high work hardening rate, and high uniform and total elongations. Because of above properties, thinner gauge sheets of DP steels can be used while maintaining the required strength levels. This is particularly interesting for the automotive industry that faces the contradictory requirements of decreasing vehicle weight while improving the fuel efficiency of automobiles along with maintaining the safety standards. However, in order to meet other requirements such as durability of sheet metal products over long periods, the corrosion resistance becomes crucial [3].

Investigations in this direction are few. Sarkar et al. [4] have studied electrochemical behavior of microalloyed DP steels and have found that with increase in martensite content and structural refinement, the corrosion resistance decreased. Zhang et al. [5] developed DP microstructure in weathering steel 09CuPCrNi and have found that it has better atmospheric corrosion resistance compared to the weathering steel. However, there is little work on corrosion behavior of plain low carbon DP steels. Further investigations in this direction are necessary to find the effect of martensite volume fraction of DP steel on its corrosion behavior.

The present investigation deals with the study of mechanical properties and corrosion behavior of plain low carbon DP steels with different volume fractions of martensite. Potentiodynamic polarization tests and immersion tests are conducted in 3.5% NaCl solution. These results are also compared with the corrosion behavior of as received steel with ferrite and pearlite as microconstituents.

2. Experimental

Plain low carbon steel in the form of sheet having thickness of 1 mm was used as a starting material. The chemical composition of this steel was obtained through spark emission spectroscopy (Thermo Jarrel Ash, USA) and is shown in Table 1.

2.1. Preparation of dual-phase steels

Plain low carbon steel in the form of a sheet is used to obtain tensile specimens. With the help of punching die the samples for the tensile testing were cut from the sheet with the dimensions as shown in Fig. 1. All these samples were sub critically heated in a muffle furnace at 650 °C for 1 h followed by air cooling. These samples are used for developing the dual-phase steels. After the sub critical heat treatment the samples were soaked at inter critical temperature of 740 °C in a vertical tubular furnace with different soaking times such as 2, 5, and 15 min. The arrangement for this heat treatment is shown in Fig. 2. Dual-phase microstructure

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doi:10.1016/j.matdes.2010.06.025