Materials and Design 32 (2011) 2345–2349

Contents lists available at ScienceDirect

Materials and Design

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

Short Communication

The effect of low temperature annealing on the mechanical behavior of cold rolled dual-phase Twinning-Induced Plasticity steel

V. Torabinejad *, A. Zarei-Hanzaki, M. Sabet, H.R. Abedi

School of Metallurgy and Materials Engineering, University of Tehran, Tehran, Iran

ARTICLE INFO

Article history:
Received 6 September 2010
Accepted 11 December 2010
Available online 21 December 2010

ABSTRACT

In recent years, Twinning-Induced Plasticity (TWIP) steels with high specific strength have been developed to mainly address the unsaturated demands of transportation industries for weight reduction. To achieve the exclusive mechanical properties of TWIP steels, the understanding of their thermomechanical processing (TMP) behavior is highly necessitated. In the present work, the influence of cold rolling and post-annealing treatments on the mechanical behavior of a new dual phase ($\gamma + \alpha$) TWIP steel have been studied. The microstructural studies indicated the presence of deformation twins in the deformed state of material. Annealing the as-rolled experimental alloy could result in the formation of Widmanstätten austenite within the ferrite grains at 500 °C. The nearly constant yield stress at high annealing durations was attributed to the opposite effects of recovery and Widmanstätten austenite formation.

1. Introduction

The characterization of low carbon Fe–Mn–Al TWIP steels have been the target of various investigations. Changing the amount of Mn, Si and Al as the main alloying elements has been resulted in different microstructural characteristics and mechanical properties [1]. In these steels Mn is austenite former, while Al increases the stacking fault energy (SFE) of austenite and stabilizes ferrite [2]. In addition the formation of mechanical twins is recognized as the dominant plastic deformation mechanism in TWIP steels due to their low SFE [1–4]. Recently, a new type of dual phase TWIP steel comprising of austenite and ferrite has been introduced [5]. High Al content in these alloys not only increases the specific strength, but stabilizes the ferrite phase. Furthermore Al improves corrosion resistance of high Mn steels [6]. The single phase Fe–Mn–Al alloys have been extensively investigated by many researchers because of their superior features such as low magnetism, high strength, high ductility and good biocompatibility [7–10]. If these alloys contain rather high concentration of Al and Mn, the ferrite–austenite microstructure could be observed even at room temperature. In the best of author's knowledge, dual phase structure that associated with TWIP effect can be considered as a new candidate to achieve high strength–high ductility applications.

Due to the promising status of aforementioned dual phase TWIP steels, the characterization of proper processing routes to achieve their desired properties is highly necessitated. The cold work-anneal scheme is one of the main industrial processes by which the control of restoration phenomena may lead to the predetermined mechanical properties. In this thermomechanical processing (TMP) cycle, the rate of restoration processes depends on the main processing parameters (i.e., strain, strain rate and temperature) and the material characteristics. The stored energy of cold work is known as the main driving force of restoration mechanisms. Applying the annealing process may result in reducing the dislocation density due to the occurrence of recovery and recrystallization [11]. Furthermore, for BCC to FCC phase transformations in Fe–Mn–Al alloys, Widmanstätten side plate [12], massive [13], DO_3 phase [14] and 18R type martensitic phases [15] have also been observed within the original BCC matrix during high temperature annealing and subsequent quenching treatment. All these may complicate the behavior of dual phase TWIP steels.

Many investigations have been already conducted on the dynamic restoration characteristics of TWIP steels [16–18]. However, there are few studies focusing on the static restoration behavior of these steels. As is well established an excellent combination of yield stress and work-hardening rate could be achieved relying on the concept of twins' thermal stability [19]. This may conduct to exploit the capability of a suitable rolling and annealing cycle. The effect of various annealing duration on the final mechanical properties is yet to be reported in TWIP steels as well as in dual phase TWIP steel. Moreover, it is necessitated to understand the microstructure evolution of the second phase (ferrite) and its effect on the mechanical behavior of dual phase TWIP steels. Accordingly, the present work was programmed to investigate the effect of low temperature annealing on the mechanical response of a group of dual phase TWIP steels after cold rolling.

* Corresponding author. Tel.: +98 21 61114167; fax: +98 21 88006076.
E-mail address: vtorabinejad@ut.ac.ir (V. Torabinejad).

0261-3069/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2010.12.032