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Hot workability of 00Cr13Ni5Mo2 supermartensitic stainless steel

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ABSTRACT

The hot workability of 00Cr13Ni5Mo2 supermartensitic stainless steel was investigated by hot compression and hot tension tests conducted over the temperature range of 950–1200 °C and strain rates varying between 0.1 and 50 s^{-1}. The processing map technique was applied on the basis of dynamic materials model and Prasad instability criterion. Microstructure evolutions, Zener–Hollomon parameter as well as hot tensile ductility were examined. The results show that, as for the hot working of 00Cr13Ni5Mo2 supermartensitic stainless steel in the industrial production, the large strain deformation should be carried out in the temperature range 1140–1200 °C and strain rate range 0.1–50 s^{-1}, where the corresponding Zener–Hollomon parameters exhibit low values. Moreover, when deformed under high strain rate range (above 15 s^{-1}), the deformation temperature can be reduced reasonably.

1. Introduction

The supermartensitic stainless steels have attracted substantial attention recently due to their advantages over conventional martensitic stainless steel, such as the unique combination of high strength and high toughness, good weldability and excellent corrosion resistance. Because of these advantages, they have been increasingly used as pipelines in deeper/ultra-deeper oil and gas wells being usually operated at ever higher temperatures and pressures, and also containing hostile gases and ions such as H_2S, CO_2 and Cl^- [1,2]. In addition, they only need simple heat treatment and have advantages in reducing the thickness of pipe wall, pipe weight and cost. So the supermartensitic stainless steels can substitute more expensive duplex stainless steels in some certain conditions, especially in stripper wells [3,4].

Much work has been performed on the balance of chemical composition and thermal history during heat treatment, and corrosion resistance in diverse demanding environments [5–9]. These developments have made a significant contribution to maximize and evaluate the performance of supermartensitic stainless steels. However, in an industrial process, hot forging or rolling is also the main procedure for manufacturing pipelines. The optimum hot working parameters are necessary to improve the properties and product rate of the pipes. However, little literature is available on the theories of hot working technology of these steels in actual production. The hot processing map technique based on dynamic materials model (DMM) in the frame of deformation temperature and logarithm of strain rate is a useful approach to optimize the hot working parameters and control the microstructure and properties of the product [10]. Furthermore, the thermal deformation mechanisms can be reflected by the processing map which has been successfully applied in a wide range of metal materials, such as alloys of magnesium [11], aluminum [12], titanium [13] and Ni-based super alloys [14] as well as stainless steels [15,16].

In the present paper, the hot processing maps of 00Cr13Ni5Mo2 supermartensitic stainless steel were constituted based on the results in hot compression tests. On this basis as well as microstructural analysis and Zener–Hollomon parameter evolution, the hot workability of 00Cr13Ni5Mo2 supermartensitic stainless steel was investigated. Besides, the hot tensile experiments were preformed to check the validity of those maps.

2. Experimental procedures

The chemical composition of 00Cr13Ni5Mo2 supermartensitic stainless steel used in this work is as follows (mass%): 0.013C, 0.18Si, 0.59Mn, 12.97Cr, 4.92Ni, 2.04Mo, 0.06N, 0.024Nb, 0.03W, and balance Fe. The material had been manufactured by Taiyuan Iron and Steel (Group) Co. Ltd. and supplied as hot forged round bars of 130 mm in diameter. Hot compress specimens ($\Phi 8 \times 12$ mm) and hot tensile specimens ($\Phi 10 \times 120$ mm) were machined out of the as-received bars directly. The hot deformation tests were conducted on a Gleeble3800 thermal–mechanical simulator. The heating method involved first heating to 1250 °C and holding for 4 min and then cooling to the deformation temperature at about 5 °C/s was adopted to simulate the practical industrial process. Before

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