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Short Communication

Influence of ageing on wear resistance of an Fe–Mn–Si–Cr–Ni–Ti–C shape memory alloy

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ABSTRACT

To further improve the wear resistance of Fe–Mn–Si–Cr–Ni based shape memory alloys, the effects of ageing at 1123 K with and without pre-deformation at room temperature on the precipitation of second-phase particles and their effects on wear resistance were investigated in an Fe–Mn–Si–Cr–Ni–Ti–C alloy. Results showed that the solution treated Fe–Mn–Si–Cr–Ni–Ti–C alloy exhibited much better wear resistance than the solution treated AISI 321 stainless steel; ageing with pre-deformation improved the wear resistance of Fe–Mn–Si–Cr–Ni–Ti–C alloy more effectively than ageing without pre-deformation, especially under the heavy load condition.

1. Introduction

Austenitic stainless steels usually exhibit the excellent corrosion resistance, high toughness, and good weldability. Therefore, they are applied widely in the chemical, aerospace, and energy industries. However, their relatively low yield strength and hardness limit their applications in the structures that require good wear resistance. To improve the wear resistance, various surface modification methods, such as carburizing [1], nitriding [2,3], and surface laser cladding [4–6], are used. However, their modification methods not only decreased the corrosion resistance, but also increased the costs. In addition, it was difficult to modify components of large sizes [1,7,8].

Recent studies showed that austenitic Fe–Mn–Si–Cr–Ni based shape memory alloys (SMAs) exhibited comparable corrosion resistance in alkaline environment compared with austenitic stainless steels besides their unique shape memory effect [9–11]. Recently, Lin et al. showed that the solution treated Fe–17Mn–5Si–10Cr–4Ni SMA exhibited better wear resistance than AISI 321 stainless steel in oil lubricated friction [12]. More recently, Ye et al. showed that in both dry and oil lubricated friction, the wear resistance of the solution treated Fe–13.95Mn–5.67Si–11.54Cr–5.36Ni–0.11C SMA was better than that of AISI 321 stainless steel [11]. Therefore, austenitic Fe–Mn–Si–Cr–Ni based SMAs have potential as a new kind of austenitic stainless steels with better wear resistance. Note that the past studies focused only on the wear resistance of single phase austenite.

It is well known that if lots of second-phase particles can be dispersed in austenite matrix of Fe–Mn–Si–Cr–Ni based SMA, their wear resistance can be further enhanced due to the strengthening of second-phase particles. The recent studies by Wen et al. showed that ageing after the pre-deformation at room temperature promoted the precipitation of more and smaller $Cr_{23}C_6$ particles inside the grains in an Fe–13.53Mn–4.86Si–8.16Cr–3.82Ni–0.16C alloy, as compared to the ageing without the pre-deformation [13,14]. In the present paper, the effects of ageing with and without the pre-deformation at room temperature on the precipitation of particles and their effects on the wear resistance were studied in a new Fe–14.51Mn–6.02Si–9.10Cr–5.06Ni–1.49Ti–0.16C alloy. The results showed that the wear resistance of the solution treated experimental alloy was much better than that of solution treated AISI 321 stainless steel; its wear resistance was remarkably improved by ageing with the pre-deformation, especially under the heavy load condition.

2. Experimental procedures

2.1. Preparation of specimens

The experimental Fe–Mn–Si–Cr–Ni–Ti–C alloy (A) was prepared by induction melting under an argon atmosphere. High purity iron, manganese, silicon, chromium, nickel, titanium and graphite were used as raw materials. After being homogenized at 1423 K for 15 h, the ingot was forged into the bars with 15 mm in diameter at 1373 K. Then, the bars were solution treated (treatment 1), followed by a water-quenching. Some of the bars subjected to treatment 1 were aged, which was considered ageing without pre-deformation (treatment 2). Some were first subjected to tensile deformation and subsequent ageing treatment, which was considered ageing with pre-deformation (treatment 3). AISI 321 stainless steel subjected to the treatment 1 was used as a reference alloy (B). The chemical compositions of the two alloys were listed in Table 1. Details of the different heat treatments were also listed in Table 2.

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