Precipitation Behaviour and Corrosion Properties of AISI 436 Ti Stabilized Weld Zone

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Abstract: In this study, Precipitation behaviour and their corrosion properties about three types of weld metals adjusted the Ti content of AISI 436 stainless steel welding wire flux were evaluated by examining the microstructure of the welding metal and by conducting an anodic polarisation test after two hours of heat treatment at 850°C were produced. Microstructural examinations revealed that the sigma phase in the Ti-free specimen was formed by the segregation of Cr-Mo. However, in the Ti-added specimens, the sigma phase did not precipitate instead, TiN formed within the grain matrix. Ti expanded the ferrite region and delayed the formation of the sigma phase. EDS and mapping analyses revealed that the segregation of Cr-Mo occurred where the sigma phase precipitated. Anodic polarisation revealed that the potentials of passive film formation were nearly identical for all samples, but the pitting potential increased as Ti was added, improving the corrosion resistance. Examination of the starting point of pitting corrosion revealed that pitting in the Ti-free specimen began around the Cr-deficient area that surrounded the sigma phase, whereas in the Ti-added specimens, pitting began in the vicinity of the Ti precipitates that were formed within the grain matrix.

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1. INTRODUCTION

Global warming and environmental issues have recently been topics of increased interest. For this reason, studies on the development of environment friendly materials, high fuel efficiency, and exhaust purification are actively pursued in the auto industry [1]. The exhaust pipe of a car is exposed to high-temperature environment during use because it is positioned close to the engine. Spheroidal graphite cast iron and cast steel had been used as materials for automobile exhaust systems in the past, but cast iron and cast steel are disadvantageous because of heavy weight and not capable to withstand the high heat input. On the other hand, stainless steels have extended life span with capability to withstand high temperature which is the focus of current research. The stainless steels is 40% lighter than cast iron and cast steel. Additionally, because of their low thermal capacity, the catalyst-induced temperature increase of stainless steels can be improved, leading to reduced methane gas emission [4]. In particular, the low coefficient of expansion of ferritic stainless steels makes them appropriate for automobile exhaust pipes that are used in a high-temperature environment. Ferritic stainless steels are cheap and highly resistant to corrosion at high temperatures; however, intergranular corrosion reduces corrosion resistance, strength, and ductility, making it the single most problematic factor for these steels [2-7]. Intergranular corrosion arises from the difference in electrochemical potentials between the grain matrix and the Cr-deficient area between the Cr-carbide and Cr-carbonitride that contains Cr precipitate along the grain boundary. The sigma and chi phases have also been reported to induce intergranular corrosion [7-9]. As a result, to prevent the formation of intermetallic compounds that reduce corrosion resistance, the content of C or N is lowered. Alternatively, in the case of AISI 409 or 439, a stabilising element, such as Ti or Nb, is added. However, ferritic stainless steels are sensitive to intergranular corrosion because the stabilising element content is very low as 0.001 wt%. Therefore, to increase the intergranular corrosion preventing effects of
2. EXPERIMENTAL PROCEDURES

2.1. Welding consumables and welding

The materials used in this study were prepared in the form of test plates with the following dimensions: 150 mm width × 200 mm length × 20 mm thickness. The flux-cored arc welding (FCAW) process was carried out by placing a backing material identical to the welding material over the adjacent plates, and 100% Ar was used as the shielding gas. The shape of the material is shown in Fig. 1, and the welding conditions are shown in Table 2. PWHT cycle was shown in Fig. 2.

2.2. Chemical composition

For the materials used, three types of weld metals were produced by adjusting the amount of Ti added to the flux component of the existing AISI 436 stainless steel welding wire flux and evaluated their corrosion properties by examining the microstructure of the welding metal and by conducting an anodic polarisation test after two hours of heat treatment at 850 °C.

TiC or TiN precipitation, these elements must be added. Ti, a commonly used stabilising element, is a potent carbide-forming element that has been reported to refine grain size and improve metallic characteristics, as well as to enhance high-temperature strength, weldability, and corrosion properties [3]. In this study, we produced three types of weld metals by adjusting the Ti content of AISI 436 stainless steel welding wire flux and evaluated their corrosion properties by examining the microstructure of the welding metal and by conducting an anodic polarisation test after two hours of heat treatment at 850 °C.