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A brief introduction of dissimilar welding techniques for Ti alloy to NiTi alloy

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Introduction

TiNi alloy has shape memory and pseudo-elastic properties, excellent corrosion resistance and good biocompatibility, it provides promising solutions to solve the problems in various applications such as aerospace, atomic energy, microelectronics, and medical equipment [1-2]. Ti alloy has excellent comprehensive properties, such as high specific strength, high specific modulus, hardness, corrosion resistance and high damage resistance [2,3]. Therefore, it will be widely used in aerospace, instrumentation, electronics, chemical industry and other fields. Compared with single material property, this material can use the performance and cost advantages of each material to select the best material for each structural component [4]. However, the weldability of dissimilar materials also limits the wide application of these alloys. This leads to the formation of brittle-like intermetallic compounds (IMCs) in the weld zone. For example, Ti_2Ni, NiTi, Ni_3Ti [5]. The formation of Ti-Ni IMCs in the weld makes the weld brittle, and the mismatch of the thermal expansion coefficient of the two materials, it will lead to the formation of transverse cracks in the weld and the deterioration of mechanical properties [6-8].

At present, the most commonly used method is to insert an intermediate layer to improve the microstructure of the joint, which can improve the mechanical stability between TiNi alloy and Ti alloy and lead to the formation of other phases except for Ti-Ni IMCs [9]. This is because the addition of intermediate layer can reduce the fusion ratio of TiNi alloy and Ti alloy in the joint. This effect reduces the content of Ti and Ni in the weld metal, thus reducing the probability of the formation of Ti-Ni IMCs in the weld metal [10-12]. Elements such as niobium, zirconium, molybdenum, tantalum, and vanadium are recommended interlayers for dissimilar welding of Ti-based alloys, since they do not react with titanium [13]. However, due to the high price and unavailability of these elements, Ag, Cu and Ni are usually used as the interlayer for the welding of these two materials, among which Cu is the most widely used interlayer in the field of dissimilar materials welding [14]. These elements will react with Ti and may form new IMCs, but in a case that the hardness of the new phases is less than that of the primary intermetallic phases formed between base metals elements (Ti-Ni IMCs in here), so it is reasonable to use these metals as the interlayer. Compared with TiNi alloy and Ti alloy, Cu has higher ductility and lower melting point, so it can reduce the influence of thermal stress mismatch caused by solidification of welding pool during welding [15]. In addition, copper is much cheaper than Zr, Ta, Mo, Ni, V and other elements, and is easy to obtain. On the other hand, according to the research of Bricknell et al. [16] on ternary shape memory alloys of Ti-Cu-Ni, nickel atoms can be substituted with copper atoms in lattice structure of NiTi. This substitution leads to the formation of Ti (Ni, Cu) ternary shape alloy at different transition temperatures. Therefore, Cu has a good compatibility with NiTi.

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