Effect of Ni Interlayer on Cavitation Erosion Resistance of NiTi Cladding by Tungsten Inert Gas (TIG) Surfacing Process

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Received: 17 April 2019 / Revised: 3 July 2019 / Published online: 10 October 2019
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Abstract

The NiTi cladding with/without Ni interlayer was prepared on stainless steel (SS) by tungsten inert gas (TIG) surfacing process, aiming at achieving good cavitation erosion resistance. The ranking according to the cavitation erosion resistance is NiTi plate > NiTi–Ni–TIG cladding > NiTi–TIG cladding > SS. The better cavitation erosion resistance of NiTi–TIG and NiTi–Ni–TIG claddings than SS substrate is due to their higher micro-hardness and superelasticity. Furthermore, the existence of Ni interlayer can decrease the amount of brittle intermetallic compounds, such as Fe₂Ti, and inhibit the crack generation, which results in the higher cavitation erosion resistance of NiTi–Ni–TIG compared with NiTi–TIG cladding. Thus, the cavitation erosion resistance of NiTi cladding prepared by TIG surfacing process can be improved by employing Ni interlayer.

Keywords Cavitation erosion · NiTi · Cladding · Tungsten inert gas surfacing process · Ni interlayer

1 Introduction

Cavitation erosion often occurs in flowing and ultrasonic systems where the static pressure is below the vapor pressure of liquid [1, 2]. In general, the vapor bubbles can form when the pressure is above the vapor pressure, and the subsequent collapse of the unstable bubbles can create shock wave or micro-jet in turbulent flows, which can impact surfaces and induce cavitation erosion damage [1, 3–5]. Therefore, many resources will be used for repairing the damaged components caused by cavitation erosion every year [6, 7].

The near equiatomic NiTi alloy has superior properties, such as superelasticity [8], high corrosion resistance [9], high fatigue strength [10], and biocompatibility [11], in particular excellent cavitation erosion (CE) resistance [9]. These properties correlate with the austenite phase B2 [12, 13]. Cheng et al. [14] found that the cavitation erosion property of NiTi alloy was related to its superelasticity rather than hardness. The superelasticity of the NiTi alloy can mitigate the impact stress induced by cavitation erosion and prevent the crack propagation. Therefore, NiTi alloy is regarded as a promising candidate for cavitation-erosion-resistant material.

However, due to the inferior weldability and high price, NiTi alloy has been limited in the application in cavitation erosion environment [15]. In order to overcome its shortcomings, many preparation technologies have been used to develop NiTi coating against cavitation erosion, such as low-pressure plasma spraying (LPPS) [3], air plasma spraying (APS) [16], high velocity oxy fuel spraying (HVOF) [17], laser spraying [18, 19], sputter depositing [20] and cold spraying [21]. Unfortunately, these coatings do not exhibit excellent cavitation erosion resistance due to the pores in the coatings [22, 23]. The authors [24] investigated the cavitation erosion behavior of NiTi coating produced by APS from the pre-alloyed NiTi powder and found that the pores in NiTi coating would become a cavitation source during

Available online at <http://link.springer.com/journal/40195>

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the cavitation erosion process. Alternatively, the dense NiTi claddings prepared by welding may reduce the pores and acquire the excellent cavitation erosion resistance. Richman et al. [25] reported that both the martensitic and austenitic NiTi alloys explosively welded to steel exhibited excellent cavitation erosion resistance. However, explosive welding is generally used for the components with flat or coaxial cylindrical surfaces, which restricts its application [26]. Cheng et al. [27] found that NiTi cladding prepared by microwave-assisted brazing showed high cavitation erosion resistance but lower corrosion resistance compared with 316L SS. Wu et al. [11] found that the NiTi cladding produced by infrared brazing had high cavitation erosion resistance compared with the SUS304 SS. Similar results were reported by Yang et al. [12], and they found that NiTi thin film produced by filtered arc deposition system (FADS) exhibited superior cavitation erosion resistance compared with 316 SS. Cheng et al. [28] also prepared the NiTi cladding on AISI 316 SS by laser welding. However, the equipment and running costs of laser welding limit its application [29, 30].

The tungsten inert gas (TIG) is a cheap and convenient industrial process, which is applicable in the factories or laboratories [31, 32]. The TIG process needs no chamber and can be used on the surface with more complicated geometry. Nevertheless, some cracks and brittle intermetallic compounds, such as Fe₂Ti, were formed in the joints when NiTi alloy was welded to stainless steel by TIG process [33]. The Ni interlayer was added to improve the weldability, such as laser welding [33, 34] and friction welding [35]. The Ni interlayer can decrease the brittle intermetallic compounds and inhibit the crack generation [33, 34]. However, the work on the influence of Ni interlayer on the TIG processed NiTi cladding is rarely reported. In the present work, NiTi cladding on SS with/without Ni interlayer was prepared by TIG surfacing process. The microstructure and cavitation erosion behavior of NiTi cladding were investigated.

2 Experimental Details

2.1 Materials and Sample Preparation

NiTi wire containing austenite B2 and stainless steel (SS) plate were used in this investigation, whose compositions are listed in Table 1. The dimension of NiTi wire is 100 mm in

length, 2 mm in diameter. The SS was selected as the substrate with 140 mm in length, 50 mm in width and 5 mm in thickness, which was ground by grinding wheel before TIG surfacing process. The pure Ni wire was used as the interlayer material, and its composition is given in Table 1. The dimension of the Ni wire was 90 mm in length and 1.8 mm in diameter. Before TIG surfacing process, the oxides on the surface of NiTi and Ni wires were removed by grinding, and then, the wires were cleaned in an alcohol bath and dried in air. In addition, the NiTi alloy plate containing austenite B2 was used as the comparing material.

2.2 TIG Surfacing Process

In the TIG surfacing process (Master MLS 3500, KEMPMI, Southern Finland, Finland), deposition of NiTi or Ni was carried out manually, with an operating current of 100 A, an operation voltage of 10 V and argon flowing of 10 L/min as the shielding gas. The NiTi claddings with/without Ni interlayer were designated as NiTi–Ni–TIG and NiTi–TIG claddings, respectively. Before the deposition of NiTi on Ni for the NiTi–Ni–TIG cladding, the oxides on the Ni layer were removed by grinding.

2.3 Microstructures

The claddings and NiTi plate were mounted in epoxy, then ground from 120[#] to 2000[#] using a series of silicon carbide abrasive papers and finally polished using 1- and 0.25-μm diamond polishing pastes. The microstructure and morphology of claddings were observed by the optical microscope (OM) (Carl Zeiss Axio Observer Z1 m, ZEISS, Oberkochen, Germany) and the FEI XL30 field emission gun scanning electron microscope (FEG–SEM, FEI, and Hillsboro, USA). Energy-dispersive spectroscopy (EDS) analyses were also performed to clarify the compositions of claddings. X-ray diffraction (XRD) using a Rigaku D/max 2400 diffractometer (Rigaku Corporation, Tokyo, Japan) with monochromated Cu α radiation ($\lambda = 0.1542$ nm) was used to characterize the phase composition.

2.4 Indentation Test

The micro-hardnesses of the NiTi–Ni–TIG cladding, NiTi–TIG cladding, NiTi plate and SS were measured

Table 1 Chemical compositions of Ni wire and SS (wt%)

	C	Si	Mn	P	S	Cr	Ni	Fe	Ti	Al
SS	0.041	0.52	7.93	0.044	0.005	14.69	4.17	Bal.	–	–
Ni wire	≤0.15	≤0.7	≤1.0	≤0.02	≤0.015	–	Bal.	≤1.0	2.0–3.5	≤1.5
NiTi wire	–	–	–	–	–	–	55.57	–	44.43	–
NiTi plate	–	–	–	–	–	–	55.57	–	44.43	–

using a HV-1000 micro-hardness tester (Laizhou hengyi tester equipment co., Ltd, Laizhou city, Shandong province, China). The Vickers micro-hardness on the surface or along the depth of the cross section was measured at a load of 500 g and a loading time of 10 s. Nano-indentation tests were commonly employed to study the superelasticity, a property closely related to the cavitation erosion resistance [36]. The nano-indentation characteristic of the NiTi–Ni–TIG cladding, NiTi–TIG cladding, NiTi plate and SS was acquired using a nano-indentation tester (Tribo-Indenter, Hysitron, USA), with the maximum load of 30 mN and the loading time of 10 s. The surface elastic behavior of the sample can be assessed by the depth recovery ratio η_h defined as:

$$\eta_h = \frac{h_{\max} - h_r}{h_{\max}}, \quad (1)$$

where $h_{\max}$ is the maximum penetration depth and h_r is the residual depth after unloading [14]. The energy recovery ratio η_w is defined as:

$$\eta_w = \frac{W_{rc}}{W_t} = \frac{\int_{h_r}^{h_{\max}} F dh}{\int_0^{h_{\max}} F dh} V \quad (2)$$

where W_{rc} and W_t are the reversible and total work done, respectively. Liu et al. [37] reported that the superelasticity of the sample was evaluated by the ratio η_w . A material with higher η_w exhibits more elasticity/superelasticity has greater capabilities to absorb impact energy and can bear the deformation with less damage.

2.5 Cavitation Erosion Test

The cavitation erosion test was conducted using an ultrasonic vibratory apparatus (53 Church Hill Rd., Newtown, CT, USA) according to the ASTM G32-10 (2010) standard [38]. The schematic diagram of the equipment is shown in Fig. 1. The vibration frequency of the probe was 20 kHz, and the peak-to-peak amplitude was 60 μm . Before the cavitation erosion test, the sample was ground to 1000[#] using a series of silicon carbide abrasive papers, washed in the alcohol, dried in hot air, and weighted using an analytical balance (AUY220, Shimadzu, Japan) with an accuracy of 0.1 mg. During the cavitation erosion test, the sample was submerged into the distilled water and was placed at a distance of 0.5 mm to the lower surface of the probe that was immersed into the test medium to a depth of 15 mm. The temperature of the distilled water was maintained at about 20 ± 1 °C using the cooling water. Each test was repeated at least three times to ensure the reproducibility. The sample was weighed at regular time intervals, and the weight loss was converted to a mean depth of cavitation erosion (MDE) according to [2]:

Fig. 1 Schematic diagram of the cavitation erosion tester

$$\text{MDE } (\mu\text{m}) = \frac{10\Delta W}{\rho A}, \quad (3)$$

$$\Delta W = (\Delta W_1 + \Delta W_2 + \Delta W_3)/3, \quad (4)$$

where ΔW is the mean weight loss in mg, ΔW_i is the weight loss of the sample in mg, A is the eroded area in cm^2 and ρ is the density of the surface layer in g/cm^3 .

3 Results and Discussion

3.1 Composition, Microstructure and Micro-hardness

3.1.1 NiTi–TIG Cladding

The cross-sectional view of NiTi–TIG cladding is shown in Fig. 2. The NiTi–TIG cladding consists of NiTi coating, interface zone and substrate, and the interface is metallurgical bond. Small amounts of pores can be observed, and it is noticed that there are also some through-wall cracks in the NiTi–TIG cladding. This type of crack is frequently observed in the NiTi/SS dissimilar welding joints using plasma [34, 38], laser [39], resistance [40] and friction [35] welding, which can release the residual stress during the TIG process [41].

Figure 3 shows the SEM microstructure, the EDS elements line distribution and the micro-hardness profiles in the cross section of NiTi–TIG cladding. The EDS scanning was performed on the cross section of the sample in Fig. 3a. Three regions of coating, interface and substrate based on

Fig. 2 Cross-sectional view of NiTi-TIG cladding

the chemical composition content are shown in Fig. 3b. The element fluctuation in the interface zone is more evident than both in the coating and substrate. The contents of Cr, Mn

and Fe decrease while those of Ni and Ti increase from the substrate to coating. In Fig. 3c, the micro-hardness of coating is similar to that of interface zone (about 945 HV₅₀₀), and they are both higher than those of the substrate (about 403 HV₅₀₀), NiTi plate (about 307 HV₅₀₀) and NiTi wire (about 281 HV₅₀₀).

The XRD patterns of NiTi-TIG cladding are shown in Fig. 4. The characteristic peaks of Fe₂Ti, B2, γ(Fe, Ni), Ni₃Ti, Ni₄Ti₃ and Ni can be identified. The Fe₂Ti is the brittle phase, the presence of which could deteriorate the cavitation erosion resistance of the cladding.

3.1.2 NiTi-Ni-TIG Cladding

Figure 5 shows a cross-sectional view of NiTi-Ni-TIG cladding. It consists of the NiTi coating, Ni interlayer and substrate, and the interface of each layer is metallurgical bond. There are small pores shown in Fig. 5, which are similar to those in Fig. 2. In fact, the quantities of the pores in NiTi-TIG cladding and NiTi-Ni-TIG cladding are little. In contrast to NiTi-TIG cladding (Fig. 2), there are no cracks

Fig. 3 **a** SEM microstructure, **b** distribution of elements from substrate to coating by EDS, **c** micro-hardness profiles in the cross section of NiTi-TIG cladding

Fig. 4 XRD pattern of NiTi-TiG cladding and NiTi-Ni-TiG cladding

Fig. 5 Cross-sectional view of NiTi-Ni-TiG cladding

in the NiTi-Ni-TiG cladding due to the addition of Ni interlayer. The linear expand coefficient of Ni is between NiTi and stainless steel, which is beneficial to release the residual stress generated during the TiG surfacing process. Therefore, Ni interlayer can inhibit the crack generation [33, 34].

Figure 6a shows the SEM microstructure in the cross section of NiTi-Ni-TiG cladding. Figure 6b, c displays the distribution of chemical compositions and micro-hardness along the black line in Fig. 6a from the substrate to the coating. The NiTi-Ni-TiG cladding can be divided into three layers of NiTi coating, Ni interlayer and substrate according to the chemical composition shown in Fig. 6b, which is consistent with Fig. 5. The contents of Cr, Mn and Fe decrease while those of Ni and Ti increase from the substrate to coating. It is worthy of noting that the content of Fe in the coating layer is higher compared with the NiTi-TiG cladding (Fig. 3b), indicating that the Ni interlayer does not

act as a diffusion barrier. Meanwhile, the content of Ni in the coating layer is higher than that of Ti, which is quite different from the corresponding content relationship in NiTi-TiG cladding (Fig. 3b). The difference of Fe and Ni contents between NiTi-TiG cladding and NiTi-Ni-TiG cladding should account for the reduction of brittle phase Fe_2Ti after adding the Ni interlayer, which will be discussed later. Besides, the Vickers indentation in the Ni interlayer (Fig. 6a) shows no signs of cracking, indicating that the Ni interlayer is tough [42]. In Fig. 6c, the micro-hardnesses of the coating, Ni interlayer and the substrate is 610 HV_{500} , 141 HV_{500} and 190 HV_{500} , respectively. The micro-hardness of NiTi-Ni-TiG cladding coating is higher than those of Ni interlayer and substrate.

The micro-hardnesses of NiTi-TiG cladding and NiTi-Ni-TiG cladding are higher than those of SS and NiTi wire. It is mainly attributed to the formation of the brittle phases (Fe_2Ti). The brittle phases are formed in NiTi side because NiTi has a lower melting point than SS. In addition, the lattice distortions caused by residual stresses induced by the thermal gradient can also contribute to the hardness increase [43]. Nevertheless, the micro-hardness of NiTi-Ni-TiG cladding is lower than that of NiTi-TiG cladding. It should be attributed to the lower content of brittle phase Fe_2Ti , which can be confirmed by the lower intensity of the diffraction peak of Fe_2Ti in the XRD pattern presented in Fig. 4. Some investigations also reported that the adding Ni is favorable to eliminate the formation of brittle phase Fe_2Ti [33, 34]. The reduction of Fe_2Ti content should not be related to the effect of Ni interlayer on Fe content, because of that Fig. 6b shows higher Fe content in the coating. Instead, it is attributed to the reduction of the fusion ratio of base metals (NiTi and SS) by adding the Ni interlayer [33, 34].

Based on the analyses above, it can be concluded that the main microstructure difference between NiTi-TiG cladding and NiTi-Ni-TiG cladding is the number of cracks and brittle phases. The addition of Ni interlayer can eliminate the cracks and inhibit the formation of brittle phases. The former results from the stress release effects of Ni interlayer as mentioned above, while the latter is due to the dilution of Ni.

3.2 Indentation Properties

The cavitation erosion resistance of NiTi alloy has been deeply related to the elastic behavior that can be assessed by the depth recovery ratio η_h and the energy recovery ratio η_w in indentation tests [14, 37]. Figure 7 shows that the force-displacement curves during loading and unloading cycles acquired in nano-indentation tests. The nano-indentation characteristics of NiTi-TiG and NiTi-Ni-TiG claddings are similar to each other. The TiG-deposited NiTi claddings exhibit higher hardness and smaller maximum displacement compared with NiTi plate and SS substrate.

Fig. 6 **a** SEM microstructure, **b** distribution of elements from substrate to coating by EDS, **c** micro-hardness profiles in the cross section of NiTi–Ni–TiG cladding

Fig. 7 Force–displacement curves in nano-indentation tests

Based on Eqs. (1) and (2), the depth recovery ratio η_h and the energy recovery ratio η_w of the four tested materials are listed in Table 2. The depth recovery ratio η_h and the energy recovery ratio η_w of NiTi plate and TiG-deposited NiTi

Table 2 Properties of various types of samples

Sample	Maximum displacement (nm)	η_h	η_w
SS	536.75 ± 20.26	0.129 ± 0.014	0.138 ± 0.014
NiTi–TiG	385.26 ± 10.96	0.324 ± 0.014	0.389 ± 0.008
NiTi–Ni–TiG	390.30 ± 10.61	0.303 ± 0.013	0.368 ± 0.012
NiTi plate	600.29 ± 18.98	0.302 ± 0.019	0.346 ± 0.013

claddings are similar, demonstrating similar superelasticity. It indicates that the addition of Ni interlayer has no effects on the superelasticity. The superelasticity of NiTi alloy mainly depends on the B2 phase and the B2 phase is the main phase for both NiTi–TiG cladding and NiTi–Ni–TiG cladding. This is the exact reason why the superelasticity of these two cladding is similar to each other. In contrast, η_h and η_w of the TiG-deposited NiTi claddings and NiTi plate are much higher than that of the SS substrate. Cheng et al. also found similar results in NiTi cladding [28]. Accordingly, it can be concluded that the superelasticities of TiG-deposited NiTi claddings and NiTi plate are superior to that

of SS substrate. The higher hardness and more superelasticity should probably result in the better cavitation erosion resistance of NiTi–TiG cladding and NiTi–Ni–TiG cladding compared with SS.

3.3 Cavitation Erosion Behavior

Figure 8 shows the mass losses with cavitation time and MDE of SS, NiTi–TiG cladding, NiTi–Ni–TiG cladding and NiTi plate. It can be found from Fig. 8a that there are no obvious mass losses for all samples before the first 2 h, and this period is usually referred as the incubation period. After the incubation period, the mass loss of SS increases rapidly, especially after 5 h. In contrast, the NiTi plate is still in the incubation time with little mass loss. The rank of cavitation erosion resistance for tested materials is NiTi > NiTi–Ni–TiG cladding > NiTi–TiG cladding > SS. Based on Fig. 8, the cumulative mass loss of NiTi–TiG cladding after 11 h test is 2.6 times as much as that of NiTi–Ni–TiG cladding. Some authors believe that the difference in cumulative mass loss at this level is noticeable [9, 11, 18].

Figure 9 shows the damage morphologies of the SS, NiTi plate, NiTi–TiG cladding and NiTi–Ni–TiG cladding after cavitation erosion for 11 h. The SS exhibits a deeply eroded surface as shown in Fig. 9a. The inserted image in Fig. 9a shows a typical ductile fracture mode. For the NiTi plate, some small cavitation pits distribute evenly on the surface and the dimension of these pits varies in size but is no more than 10 μm , as shown in Fig. 9b. The cavitation behavior of NiTi–Ni–TiG cladding is similar to that of NiTi plate except that the number and size of cavitation pits are greater, as shown in Fig. 9d.

Figure 9c shows the damage morphologies of the NiTi–TiG cladding. The surface damage of NiTi–TiG cladding is not uniform, and there are mainly two kinds of damaged area (area A and B), except the undamaged area C. This is consistent with the results of Cheng et al. [31] who also found similar morphology that both the slightly damaged region and the severely damaged region existed on the surface of NiTi–TiG cladding after cavitation erosion. It is obvious that the mass loss of area A concentrates on the region at the vicinity of cracks, while a typical brittle fracture mode of erosion is clearly visible on area B in Fig. 9c.

The chemical compositions of area B and area C in Fig. 9c are listed in Table 3. The content of Fe at the undamaged area (area C) is much lower than that of severely damaged area (area B). The Mn could be ignored because of its little content. According to the Cr–Ti–Fe ternary phase diagram [44], the solubility of Cr is high in Fe_2Ti (> 60 at%). The phases of area B and area C can be predicted based on the isothermal section of the Fe–Ni–Ti ternary system at 1000 $^{\circ}\text{C}$ [45]. The reason for selecting 1000 $^{\circ}\text{C}$ isothermal section of the Fe–Ni–Ti ternary system is that the high cooling rate does not allow sufficient time for atomic diffusion during cooling. Therefore, the phases formed during the heating stage are likely to be retained at room temperature, regardless of the influence of cooling [34]. Miranda et al. [34, 46] also used the 1000 $^{\circ}\text{C}$ isothermal section of the Fe–Ni–Ti ternary system to determine the composition of the phase in the dissimilar welding of NiTi to SS. Accordingly, the phases of area B and area C may be predicted to be Fe_2Ti and B2, respectively. Hence, the brittle phase Fe_2Ti is damaged severely under cavitation attack while B2 with superelasticity is still intact. In addition, quite few severely damaged areas around the pores were found, which could be attributed to the small amount. It suggests that the pores are

Fig. 8 Comparison of cavitation erosion behavior of SS, NiTi–TiG cladding, NiTi–Ni–TiG cladding and NiTi plate: **a** erosion curves, **b** cumulative mean depth of erosion (MDE) after cavitation erosion for 11 h

Fig. 9 SEM images after cavitation erosion for 11 h. **a** SS; **b** NiTi plate; **c** NiTi-TiG cladding; **d** NiTi-Ni-TiG cladding

Table 3 Chemical compositions of the selected areas from NiTi-TiG cladding in Fig. 9c

Selected area	Compositions (at%)					Potential phases
	Ti	Cr	Mn	Fe	Ni	
B	28.19	8.14	4.00	34.53	25.14	B2
C	41.17	2.39	1.27	9.97	45.20	Fe ₂ Ti

not the main factor that deteriorates the cavitation erosion resistance.

Compared with TiG-deposited NiTi cladding, the SS exhibits poorer cavitation erosion resistance due to its low hardness and low recovery ratio of the surface. The NiTi plate shows the highest cavitation erosion resistance due to the superelasticity. During the cavitation erosion test, the fatigue crack tips can also be retarded and stabilized due to stress relief by the superelasticity [11]. Even though the superelasticity and micro-hardness of TiG-deposited NiTi cladding are equal to and higher than that of NiTi plate, respectively, the TiG-deposited NiTi cladding shows relatively lower cavitation erosion resistance. Some second phases or cracks existing in the TiG-deposited NiTi cladding should be the reasons. In the NiTi-Ni-TiG cladding, there are some second phases such as the Ni₃Ti, Ni, γ (Fe,

Ni), Fe₂Ti and Ni₄Ti₃ as shown in Fig. 4, which do not have superelasticity. In the NiTi-TiG cladding, except these second phases, there are also some cracks. These second phases and cracks can decrease the cavitation erosion resistance of NiTi-TiG cladding. Accordingly, it can be concluded that it is the second phases or cracks formed during the TiG process, rather than the increased micro-hardness, affect the cavitation erosion resistance of TiG-deposited NiTi cladding.

Compared with the NiTi-TiG cladding, the NiTi-Ni-TiG cladding has better cavitation erosion resistance. It should result from the Ni interlayer in the following two aspects. The first is that the Ni interlayer can inhibit the crack generation during cooling. This is confirmed by surface and cross-sectional observation. Figure 9c shows that the cracks in NiTi-TiG cladding can be the cavitation source during the

cavitation erosion. Bubble formation can be enhanced near the cracks. Thus, severe micro-jet and/or shock wave can impact the area near the cracks preferentially. Stress concentration at the boundaries of the cracks could also contribute to a more severe attack. The second is that the Ni interlayer can decrease the content of brittle phase Fe₂Ti. The brittle phase Fe₂Ti is easy to fracture and peel off during the cavitation erosion compared with the B2 phase. Figure 9c shows that the severely damaged area in NiTi–TIG cladding contains more brittle phases such as Fe₂Ti and the undamaged area contains more B2 with superelasticity. Accordingly, to reduce the brittle phases and cracks formed during the TIG process should be significant for the improvement of cavitation erosion resistance of TIG–NiTi cladding, which can be fulfilled by employing the Ni interlayer.

4 Conclusions

The NiTi claddings (NiTi–TIG and NiTi–Ni–TIG) on stainless steel (SS) by TIG surfacing process are successfully manufactured. The following conclusions are drawn.

1. The micro-hardness and superelasticity of NiTi claddings are higher than SS substrate, which results in superior cavitation erosion resistance of NiTi claddings. In comparison, the NiTi claddings exhibit inferior cavitation erosion resistance than NiTi plate due to the existence of cracks and brittle phases.
2. The addition of Ni interlayer in NiTi–TIG cladding can eliminate the cracks by releasing the residual stress generated in the TIG surfacing process and inhibit the formation of brittle phases by the dilution effect of adding Ni interlayer, while it has few effects on the superelasticity. Accordingly, the cavitation erosion resistance of NiTi–Ni–TIG cladding is enhanced compared with NiTi–TIG cladding.

Acknowledgements The authors would like to acknowledge Hang Liang and Zhaoxuan Zhang for preparing NiTi cladding by TIG surfacing process. This work was supported by the Opening Project of Material Corrosion and Protection Key Laboratory of Sichuan Province (No. 2017CL18) and The Strategic Priority Research Program of the Chinese Academy of Sciences (Grant Number XDA13040500).

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