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ARTICLE

Effects of Si Content and Aging Temperature on Wear Resistance of Surfacing Layers Welded with 4043 Aluminum Welding Wires

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Abstract: 4043 aluminum welding wires are extensively used for welding 6000 series aluminum alloys due to the good flow ability of the fusion state and the low cracking tendency during welding process. Some scratches and wear on the surfaces of aluminum structural components can be repaired by surface welding with 4043 aluminum welding wires. In the present study, the influences of Si content and aging temperature on the wear resistance property of the surfacing layers welded by tungsten inert gas (TIG) welding using 4043 aluminum welding wires have been analyzed by optical microscopy, scanning electron microscopy, hardness testing and abrasive wear testing. The results show that the increase in Si content can increase the fraction of eutectic Si particles, and the heat treatment can spheroidize eutectic Si particles, resulting in further improving the wear resistance property of the surfacing layers.

Key words: surfacing weld; wear resistance; microstructure; property; heat treatment

Al-Si series alloys have been widely used in aerospace and automotive industries, owing to their exceptional characteristics including high strength, excellent wear resistance, low coefficient of thermal expansion and good casting ability [1-7]. 4043 aluminum welding wires have been extensively used for welding 6000 series aluminum alloys due to the good flow ability of the fusion state and the low cracking tendency during welding process [8]. Some scratches and wear on the surfaces of aluminum structural components can be repaired by surface welding using 4043 aluminum welding wires. In addition, the eutectic Si particles in the surfacing layers can protect the α(Al) matrix against wearing and improve the wear resistance of the alloys. Previous studies[9-14] reported that heat treatment plays an important role in the improvement of the wear resistance of Al-Si alloys owing to spheroidizing the eutectic Si particles.

In the present investigation, we have analyzed the influence of Si content and aging temperature on the wear resistance property of the surfacing layers welded with 4043 aluminum welding wires based on the systematic analyses.

1 Experiment

6061 aluminum alloy sheets with 4 mm in thickness were surfacing welded with 4043 welding wires of 3.1 mm in diameter. The chemical compositions of 6061 aluminum alloy and 4043 welding wires are summarized in Table 1. Al-Si ingots were prepared by controlled melting of commercially pure aluminum and Al-26% Si master alloy in a graphite crucible using a medium frequency induction furnace and casting in a metallic mould. Al-Si welding wires with smooth surface were prepared by extrusion and drawing processes, subsequently cleaned by sulfuric acid, phosphoric acid and so on.

Surfacing welded samples with a size of 25 mm × 25 mm × 25 mm were prepared by TIG welding. Prior to the welding process, the oxide film on the surface of the base metal was eradicated by mechanical polishing, and then the surface was cleaned with organic solvent. The TIG welding conditions adopted during the welding process were 180 A welding

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current, 20 V welding voltage, 0.1 m/min welding speed and being shielded by pure argon (99.99%). The surfacing welded samples for investigation were subjected to a solution treatment at 540 °C for 4 h, followed by water quenching and artificial aging at 140, 170 and 210 °C for 12 h. The specimens of 4.8 mm gauge diameter and 12.7 mm length for wear testing were cut from the surfacing welded samples. The wear resistance of the surfacing layers was evaluated using a MMW-1 universal wear testing machine, and the wear loss was measured by electronic weight balance. The value for each condition is the average value of three specimens. The test conditions were 100 N applied load, 100 r/min rotational speed, 15 min sliding time and 25 °C ambient temperature. The schematic diagram of wear testing is shown in Fig.1. The specimens for microstructural observations were cut from the surfacing layers, followed by mechanical polishing. The microstructures were observed by optical microscope (OM, DMI5000M). The wear surfaces of the surfacing layers after wear testing were observed by scanning electron microscopy (SEM, SHIMADZU SSX-550). The hardness was measured by the 452-SVD Vickers hardness tester at the load of 5 N and a loading time of 15 s.

2 Results

2.1 Wear resistance property and hardness

Generally speaking, wear rate is calculated using wear loss per unit sliding time. Wear rate and friction coefficient are always used as an evaluation of wear. Fig.2 shows the wear rates and the friction coefficients of the surfacing layers welded with 4043 welding wires. It is observed that the wear rate and friction coefficient decrease with the increase in Si content of 4043 welding wires.

The wear rates of the surfacing layers welded by 4043 welding wires after different heat treatments are shown in Fig.3. As is seen, the wear rate varies evidently with the increase in aging temperature, and the lowest wear rate (0.0283 g/h) can be obtained by aging at 170 °C.

Fig.4 shows the friction coefficients of the surfacing layers welded with Al-5.9% Si welding wire before and after heat treatment. Compared with that before heat treatment, it is clear that the friction coefficient decreases obviously, and the wear on the surfacing layers after heat treatment is carried on more steadily in the whole wear process, while the surfacing layers before heat treatment are worn seriously in the late stage of abrasive wear.

Table 1 Chemical composition of 6061 aluminum alloy and 4043 welding wires used in the experiment (wt%)

Sample	Si	Mg	Cu	Cr	Al
Base metal	0.5	0.9	0.15	0.1	Bal.
Wire-a	5.0	—	—	—	Bal.
Wire-b	5.5	—	—	—	Bal.
Wire-c	5.9	—	—	—	Bal.

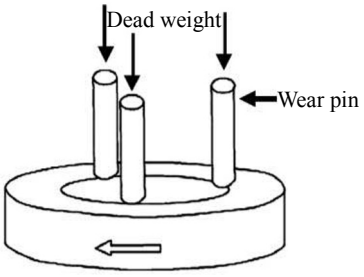

Fig.1 Schematic diagram of wear testing

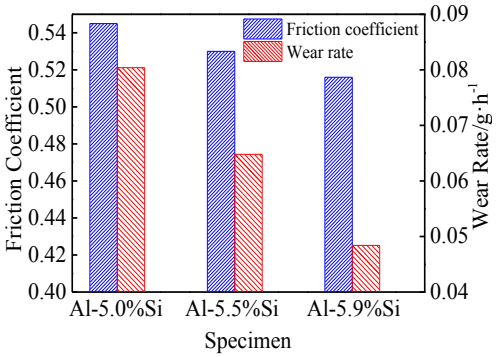

Fig.2 Wear rates and friction coefficients of the surfacing layers

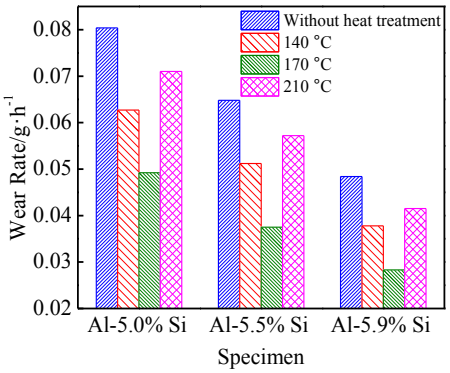

Fig.3 Wear rate of the surfacing layers welded by 4043 welding wires after different heat treatments

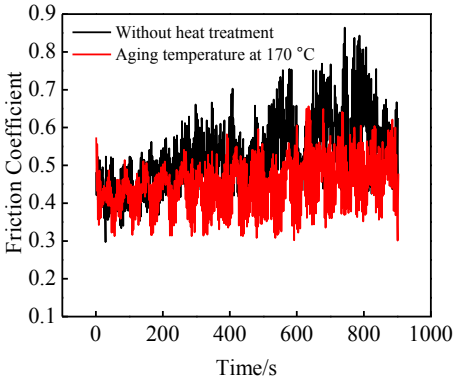

Fig.4 Friction coefficients of the surfacing layers welded with Al-5.9% Si welding wire before and after heat treatments