MAIN TOPICS, ABSTRACTS & KEY WORDS

Vacuum brazing of Ti_3Al and 316L stainless steel

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Abstract Vacuum brazing of Ti_3Al and 316L stainless steel is realised with the Ag-Cu brazing filler. The interfacial microstructure of the joint is investigated by scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), and X-ray diffraction (XRD) and its forming mechanism is analysed. Meanwhile, effects of brazing temperature on interfacial microstructure and shear strength of the joint are studied. It is found that when holding time is fixed at 5 min, shear strength of the joint increases with the increase of brazing temperature. When the joint is brazed at 800 ℃, the highest joint strength of 343 MPa is achieved, and shear strength of the joint begins to drop with the further increase of brazing temperature. The typical microstructure of the joint is Ti_3Al/ $AlCu_2Ti + Cu_2Ti + Cu$ (s,s) + Ag (s,s) + $CuTi + Fe_2Ti$/ 316L stainless steel.

Key words: **Ti_3Al**, **316L stainless steel**, **parameters**

Microstructure and properties of sandwich panels T-joints in flux bands constricting arc welding

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Abstract 960 MPa high-strength steel sandwich plates were welded by a new method of flux bands constricting arc welding in order to solve the problem of poor fusion of core plate and panel T-joint in laser welding of sandwich plate. The forming of arc combustion and the change process of metal droplet transfer were studied with high speed camera technology. Microstructure and mechanical properties of the T-joints were studied through microstructure analysis, hardness test, micro-zone tensile test and T-joint axial tensile test. The results show that the welding flux can compress and stabilize the arc to improve the welding heat efficiency and promote the transition of the droplet in the process of welding, and that T-joint with good fusion of weld and core plate can be obtained. Microstructure of the coarse-grained zone in heat-affected zone of the welded joints is coarse lath martensite and blocky ferrite, and the fine-grained zone in heat-affected zone of the welded joints is fine lath martensite and granular bainite. The microstructure of the weld is mainly acicular and blocky ferrite distributed along the grain boundary of the prior austenite. Hardness distribution of the welded joint is uneven, the average hardness distribution is heat-affected zone > base metal zone > weld zone. In the micro-zone tensile test of the welded joint, weld zone is the weakest area of the joint for mechanical properties. In the T-joint tensile test, cracks first produced at fusion line and then extended to weld zone, finally, the joint fractured in weld zone, and the fracture shows ductile fracture characteristics.

Key words: **sandwich panels**, **T-joint**, **flux bands constricting arc welding**, **microstructure**, **mechanical properties**

Tribology properties of remanufacturing forming layer for joint sleeve of cardan axis by MAG surfacing after heat treatment

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Abstract The self-developed cored wire was adopted to practice remanufacturing experiment on joint sleeve with MAG surfacing deposition technology, aimed at the analysis on service environment characteristic and failure mode. Then, tribology properties were tested and compared between the quenched forming layer and substrate. The result shows that the worn mechanism of remanufacturing forming layer after quenching heat treatment and substrate is a mixture of adhesive wear and abrasive wear under the fretting wear condition of test temperature 100 ℃ and humidity 35% ~45%. The lamellar abscission area on the surface of the substrate worn sample is larger, and the abrasion loss of the substrate is greater than that of the quenched forming layer, which illustrates that fretting tribological properties of the quenched forming layer is preceded to the sub-

strate. And the self-developed cored wire is suitable for remanufacturing on the surface of joint sleeve of cardan axis to prolong its service life.

Key words: **joint sleeve**, **remanufacturing**, **MAG surfacing**, **quenching**, **tribology properties**

Microstructure and mechanical properties of Al/steel metal by ultrasonic-assisted laser welding-brazing

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Abstract Ultrasonic assisted laser welding-brazing technique was used for joining of 6061 aluminum alloy to steel dissimilar materials with Al-Si filler metal. Effects of ultrasonic vibration on joint interfacial microstructure, grain size and mechanical properties of the weld were investigated. Without ultrasonic vibration, three layers of intermetallic compounds (IMC) with the thickness range of 8.3 ~ 12.3 μm were observed in the heat source center of the interface between the weld and steel. The IMC thickness range away from the heat source was 1.5 ~ 2.6 μm. The joint strength was low and the joint failed at the interface of the weld and steel. When the ultrasonic power was 700 W, the spreading width of filler metal on the steel increased and the crystalline grain size decreased from 32 μm to 19 μm. The interfacial IMC was a continuous thin layer θ phase with a thickness of 0.5 ~ 1.0 μm. These changes led to the weld failure near aluminum fusion line and improved the joint strength by 1.6 times of that without ultrasonic assisted.

Key words: **ultrasonic vibration**, **laser welding-brazing**, **Al/steel dissimilar material**, **intermetallic compound**

Study on characteristics of the double-side feeding nozzle with water cooling for laser forming

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Abstract A double-side feeding nozzle with water cooling for laser cladding was designed. Effects of the working height between the powder outlet and the molten pool, together with the external protective gas flow on powder utilization and oxygen content in the molten pool were carefully investigated. Influence of the powder-carrying gas flow on oxygen content in the molten pool was explored. Effects of the external protective gas curtain on oxidation, slag inclusion and mechanical properties of hydrocarbon-coated 304 stainless steel specimens by laser cladding were studied. The results indicate that powder utilization gradually decreased and oxygen content in the molten pool increased with the increase of the working height between the powder outlet and the molten pool. Oxygen content in the molten pool was 3.92% ~ 5.48% when powder-carrying gas flow was only 1 ~ 12 L/min. Oxygen content in the molten pool decreased to 1.40% ~ 2.68% when powder-carrying gas flow was 1 ~ 12 L/min and external protective gas flow was 1 ~ 5 L/min. The slag inside the laser forming specimen was significantly reduced and the surface exhibited a metallic luster. The tensile strength and elongation of the specimens were enhanced by 7.8% and 23.1% in comparison to those specimens prepared using the single-side feeding nozzle.

Key words: **laser forming**, **lateral feeding nozzle**, **powder utilization**, **double airway protection**, **oxygen content**

Research progress on liquation cracking of precipitation hardened nickel-based superallloys in fusion welding

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Abstract Precipitation hardened nickel-based superalloys are widely used in aero and industrial gas turbine engines due to their excellent high temperature strength and hot corrosion resistance. However, the components' life and performance will be affected because of its high liquation cracking susceptibility during welding. The formation mechanism of liquation cracking of precipitation hardened nickel-based superallloys in fusion welding is introduced systematically. Several methods for controlling liquation cracking are introduced, including increasing heat input, pre-weld preheating, pre-weld heat treatment and adding filler alloys. At last, the main future research directions are pointed out.

Key words: **precipitation hardened nickel-based superallloys**, **liquation cracking**, **cracking mechanism**, **crack control**

Research progress on influence factor of transient liquid phase diffusion bonding of nickel-based single crystal superalloy

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Abstract Influence of interlayer alloy, welding parameter and crystal misorientation angle of base metal on the TLP joint of nikel-base single crystal superalloy is discussed in detail. Normally, the main alloying elements of interlayer alloy are similar to the base metal and B is selected as melting-point depressant. Owing to composition uniformity and fast diffusion rate in comparison to mealy interlayer alloy, morphous strip of interlayer alloy is beneficial to improve performance of the joint, which is the optimised state of interlayer alloy. Welding parameter, such as welding temperature, holding time, welding pressure and postweld heat treatment, should be selected rationally according to the perfomation requirement of base metal and joint, as well as processing procedure. To avoid the deleterious effect of stray grain on the mechanical properties of joint, crystal misorientation angle of welding samples should be minimized or eliminated.

Key words: nickel-base single crystal alloy, transient liquid phase diffusion bonding, interlayer alloy, welding parameter, crystal misorientation angle

Microstructure and mechanical properties of EH40 high-heat-input steel welded joint using double wires narrow gap MAG welding process

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Abstract Using 84 mm high-heat-input welding steel EH40 as an example, the butt welding test was given by double wires narrow gap metal active gas arc welding(NG-MAG). The microstructure and mechanical properties of this welding joint were tested and analyzed. The results showed that the method was suitable for high-heat-input welding steel with large thickness. There were better weld quality and no macro defects. The microstructure of HAZ consisted of lath bainite, granular bainite and acicular ferrite. The tensile strength of the joint was nearly 520 MPa, which was close to that of the base metal. The sample was bent at 180° and no obvious crack was observed on the tensile surface. The welded joints of high-heat-input welding steel EH40 with superior mechanical properties could be obtained by double wires narrow gap MAG welding process.

Key words: narrow gap welding, high-heat-input welding steel, microstructure, mechanical properties

Microstructure and mechanical properties of cold metal transfer arc additive manufactured 304 stainless steel

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Abstract Arc additive manufacturing of stainless steel based on cold metal transfer with different deposit rate was carried out. Tensile tests of different locations of the components were conducted and the fracture morphology was analyzed, and microstructure of the component was discussed. Results indicate that arc additive manufacturing based on cold metal transfer is a feasible metal additive manufacturing process. Yield strength and tensile strength of one component along horizontal direction are higher than that along the vertical direction due to the nonuniform microstructure of the components along the vertical direction. With higher deposit rate, the heat input increases, the secondary dendrite arm spacing in the fusion zone increases, and the tensile strength decreases.

Key words: arc additive manufacturing, cold metal transfer, microstructure, mechanical properties

Control system of automatic surfacing device for turbine guide blade repair based on PLC

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Abstract A kind of automatic surfacing device for guide vane repair based on Mitsubishi PLC control is designed. The combination of frequency converter and reducer motor is adopted to reduce the output speed to meet the requirement of blade shaft surfacing. Three stepper motors constitute the Qadir coordinate system, which controls welding gun to move flexibly in the welding space to finish welding the guide blade. In order to increase stability and reliability of the control system, sensor technology is used to assist PLC to achieve stable and effective control during surfacing.

Key words: **guide vane repair**, **automatic surfacing**, **sensor**, **control system**

Manufacturing and application of laser cladding coating for anti-accumulation of nodulation on roll ring of furnace bottom-roller

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Abstract In view of the phenomenon of nodulation accumulated on the surface of furnace bottom-roller, NiCr-Cr_3C_2 coating was prepared by laser cladding on the surface of roll ring of Ni-based furnace bottom-roller and microstructures and hardness of coated samples were analyzed to study its feasibility through experiments. And samples' service condition at medium temperature and high temperature was respectively checked after the actual machine use. The results show that the cladding coating has high hardness, good high temperature oxidation resistance and wear resistance, which has good application effect. The roll ring prepared by this method can solve the phenomenon of nodulation accumulated on the surface of furnace bottom-roller and prolong its service life.

Key words: **furnace bottom-roller**, **nodulation**, **NiCr-Cr_3C_2**, **laser cladding**, **coating**

Microstructure and properties of liquid phase diffusion welded joint of GH4413 nickel-based high temperature alloy

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Abstract Liquid phase diffusion welding of GH4413 alloy was carried out and BNi-2 was used as filler material. The microstructure, composition distribution and microhardness of the welded joint were researched under different welding parameters. Welding temperature was respectively 1 030 ℃ and 1 080 ℃, and heat preservation time was respectively 30 min and 60 min. The results of scanning electron microscopy (SEM) and energy spectrum analysis show that, when welding temperature was 1 080 ℃, and heat preservation time was 60 min, the solid solution with good performance formed in brazing seam. In addition, the width of brazing seam increased, the diffusion depth of brazing filler metal's elements to base metal increased gradually and intermetallic compounds formed near seam section of base metal with the increase of welding temperature and heat preservation time.

Key words: **nickel-based high temperature alloy**, **liquid phase diffusion welding**, **microstructure**

Application of GTAW and SMAW process for welding S31803 duplex stainless steel pipe

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Abstract In order to meet the welding task of duplex stainless steel pipe used for the production water treatment process in an overseas oilfield, reasonable welding materials, welding methods, optimized welding procedure and precautions during welding were proposed for welding difficulties and particularities of S31803 duplex stainless steel through analysis of material's weldability and repeated tests. Physical and chemical properties tests of welded joints were also carried out. The results showed that the welded joints were satisfied with both welding standards and design requirements.

Key words: **S31803 duplex stainless steel**, **welding procedure**, **physical and chemical properties**, **X-ray testing**, **ferrite content**

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