MAIN TOPICS, ABSTRACTS & KEY WORDS

Effect of time-selective piezoelectric vibration on resistance spot welding strength of aluminum alloy

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Abstract The piezoelectric actuator was connected in series to the spot welding electrode. Based on the trigger control system, pulse vibration was applied to the welding spot at different stages during the spot welding process. Resistance spot welding test was conducted on the 6061 aluminum alloy through mechanical tensile and metallographic observation, by which the influence of time-selective piezoelectric vibration on mechanical properties and nugget size of spot welded joints was analyzed and researched. The results showed that in the full-stage pressure hybrid control and solidification-phase pressure hybrid control, the shear strength of the joint was reduced, and a large number of crack defects appeared in the joint. When applying pressure hybrid control in the current welding stage, shear strength of the joint increased, the size of the nugget increased significantly, and there were much fewer internal defects. During the 120 ms pressure hybrid control in the welding stage, shear resistance of the joint reached a maximum of 2.11 kN. The pressure hybrid control at 60 ms after welding stage was compared with that at 60 ms before welding stage, nugget size increased and internal defects decreased.

Key words: **piezoelectric actuator**, **aluminum alloy**, **resistance spot welding**, **time-selective piezoelectric vibration**, **spot strength**

Formation of weld by high-power fiber laser-MAG hybrid welding

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Abstract Effects of laser power, defocusing amount, heat source sequence, heat source distance, heat source arrangement, welding speed and welding current on formation of weld by high-power laser-MAG hybrid welding were studied systematically with the method of plate surfacing. The results showed that the effect of defocusing amount on formation of weld was more significant with the higher laser power under the condition of lower current. The defocusing amount had little influence on formation of weld when the laser power was at 10 kW, while formation of weld surface was better with negative defocusing amount when the laser power increased to 20 kW. The influence of heat source sequence and heat source distance on formation of weld was also significant. Under the condition of negative defocusing amount, better formation of weld was obtained with arc-leading and larger heat source spacing. When using laser-leading and smaller heat source space, more spatter generated and the weld uniformity was poor. But better weld was obtained by significantly increasing the welding current. Using negative defocusing amount and arc-leading was more helpful to increase weld penetration.

Key words: **high-power fiber laser**, **MAG arc**, **hybrid welding**, **formation of weld**

Horizontal welding deformation of API X65 pipe in deep water J-laying

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Abstract The welding stress and deformation of GMAW automatic welding that was the key in deep-water offshore pipeline laying were re-

searched, which had process features of without backing, narrow groove and transverse welding. On the basis of theoretical analysis of welding stress and deformation, the average thermal cycle curve of weld cross-section was extracted as the loading heat source of multi-pass welding with SYSWELD software as a tool, Numerical simulation of multi-pass welding deformation and stress distribution of API X65 plate with the same pipe thickness and groove parameters was carried out, and a transverse automatic welding test system was set up for multi-pass welding verification. The results showed that the numerical simulation results of the final welding deformation were in good agreement with the experimental results, and the errors between them were mainly due to heat flow distribution, calculation accuracy of the two-dimensional cross-section model, constraints and the characteristics of the thermal cycle curve. In the process of multi-pass welding, the first few layers of welds had great influence on the final welding deformation, while the latter few layers of welds have little influence, which was due to the large basic deformation in the first few layers of welding, and the deformation compensation caused by the release of residual stress in the latter few layers of welding obviously offset a part of the welding deformation.

Key words: horizontal welding, thermal cycle curve, welding stress and deformation, API X65 pipeline steel plate, J-laying

Microstructure and mechanical properties of S32750 super duplex stainless steel welded joint by TIG

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Abstract S32750 super duplex stainless steel plates were welded by TIG under five different heat input. Microstructures of welded joints were carefully observed by means of optical microscope, laser confocal microscopy and scanning electron microscopy. N content of the weld and mechanical properties of welded joints were tested and analyzed in detail. The results showed that with the increase of heat input, the grain size of austenite in grain and on grain boundary increased gradually in the weld metal, while the ferrite content decreases linearly. The microhardness of welded joints under different heat input were higher than that of base metal. Nevertheless, the tensile strength under higher heat input was lower than that of base metal.

Key words: super duplex stainless steel, tungsten inert gas welding, heat input

Influence of reflow soldering parameters on soldering strength of flip chip LED

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Abstract The shear strength of the soldering position was taken as the characterization parameter, and the thrust measured by push-pull meter was converted into the shear strength of the chip solder joint. Parameters of reflow soldering in the flip chip LED package were optimized. The experimental results showed that when the design of reflux furnace temperature was unreasonable, the proportion of shear strength below 30 MPa was 17%, the proportion of 30 ~ 35 MPa was 11%, the proportion of 35 ~ 40 MPa was 11%, the proportion of 40 ~ 45 MPa was 15%, and the proportion of more than 45 MPa was only 46%. While using the optimized temperature, there was no shear strength below 35 MPa, the proportion of 35 ~ 40 MPa was 5%, the proportion of 40 ~ 45 MPa was 6%, and the proportion of more than 45 MPa was 89%. It was observed that settings of different soldering temperatures had a great impact on soldering shear strength of flip chip packaging. Through optimization of reflow soldering parameters, the size and number of cavities in the soldering surface could be effectively reduced.

Key words: LED, FCOB, reflow soldering, reflow curve

Effect of welding parameters on ferrite number of weld metal by E309L flux-cored wire

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Abstract The effect of welding parameters on ferrite number (FN) of weld metal by E309L flux-cored wires were investigated through three methods of ferrite tester, Schaeffler diagram and WRC – 1992 diagram. The results showed that change of FN in weld metal was the largest with the change of welding electric parameters, the gas flow was in the middle, and wire extension was the smallest. The FN in weld metal could be decreased by increasing wire extension and gas flow appropriately. The N element in weld metal was more sensitive to the change of gas flow and wire extension. WRC – 1992 diagram was more accurate due to the consideration of N element, while the ferrite tester was suitable for FN under normal process parameters. With the increase of welding electric parameters, wire extension and gas flow, FN in weld metal measured with Schaeffler diagram decreased gradually.

Key words: welding parameters, ferrite number, ferrite tester, Schaeffler diagram, WRC – 1992 diagram

Microstructure and properties of resistance spot welded joint of 55% SiC_p/A356Al composites

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Abstract 55% SiC_p/A356Al composites were welded by resistance spot welding process, and welding schemes for samples were designed to be directly welded without interlayer and welded with aluminum foil interlayer. The microstructure, shear strength, microhardness, nugget diameter and interface reaction of resistance spot welded joints under different schemes were analyzed and compared. Interface connection model of high volume fraction 55% SiC_p/A356Al composites was established, and the relationship between joint strength and interface model was discussed. The results showed that under the optimized welding parameters, the joint was well formed without obvious defects, and the SiC particles evenly distributed in the nugget zone without interfacial reactions. After being welded with aluminum foil sandwiched between the samples, strong and sub-weak connection reactions only occurred at the interface. The joint strength increased, and the average tensile shear force was 2 165.6 N. The average nugget diameter was 9.5 mm, microhardness of the joint was consistent with its microstructure distribution, and there was no significant difference from microhardness of the base metal.

Key words: 55% SiC_p/A356Al composites, resistance spot welding, microstructure, interfacial reaction, microhardness

Research progress of double wire welding technology and double wire Tri-Arc welding stability

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Abstract According to characteristics of the arc and wire feeding form, welding methods with double wire were classified into four categories in this paper, such as double wire with single arc welding, double wire with double arc welding, double wire with double arc welding plus cold wire filling and double wire with coupling arc welding. After briefly introduction of these technical principles and equipment, the research on welding stability of double wire with double arc welding and double wire with coupling arc welding was discussed and summarized. The development direction of double wire welding technology in system control, automation application and further improvement of welding efficiency was prospected, which provided reference for the innovative research and application of double wire arc welding and in-depth study of double wire three arc welding technology.

Key words: double wire welding, Tri-Arc DE, coupled arc, arc stability, control of stability

Diffusion bonding process of TiAl alloy and hydrogenated 0.5% TC4 titanium alloy

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Abstract The direct diffusion bonding of TiAl alloy and the diffusion bonding of TiAl alloy with hydrogenated 0.5% (mass fraction) TC4 titanium alloy were carried out. SEM, EDS, XRD and shear strength test were employed to investigate on microstructure and properties of bonded joints. Effects of bonding temperature, bonding time and bonding pressure on the interface and mechanical properties of bonded joints were studied. The results showed that holes at the direct diffusion bonding interface of TiAl alloy completely disappeared at bonding parameters of 1 473 K, 60 min, 30 MPa, and shear strength of bonded joints was up to 285 MPa. When hydrogenated 0.5% TC4 titanium alloy was used as the intermediate layer in diffusion bonding of TiAl alloy at bonding parameters of 1 123 K, 30 min, 15 MPa, holes at the diffusion bonding interface disappeared, together with a certain thickness of the reaction layer generated, and shear strength of bonded joints was up to 290 MPa. The phase composition of fracture interface was mainly composed of brittle phases, such as TiAl, Ti_3Al, $TiAl_2$ and Ti_3Al_5. Compared with the direct diffusion bonding, the diffusion bonding parameters of TiAl alloy could be greatly reduced by using hydrogenated 0.5% TC4 alloy as intermediate layer in diffusion bonding of TiAl alloy.

Key words: **TC4 titanium alloy**, **TiAl alloy**, **hydrogenated**, **shear strength**

Robot welding technology of two common welded joints

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Abstract Welding experiments of 8 mm thick plate horizontal butt joint and 6 mm thick plate flat angle T-joint were carried out by OTC arc welding robot. Influences of groove root gap, welding gun angle, arc voltage, welding current and welding speed on formation of butt weld in the root pass, width and reinforcement of back weld, as well as influences of welding speed, arc voltage and welding current on formation of weld, foot size and convexity of T-joint were emphatically analyzed. The welding parameters were optimized through experiments, and butt joints with well formation of both sides, good fusion, uniformly weld width and weld reinforcement were obtained. According to the test, the width of backside weld was 4.04 mm and the reinforcement of backside weld height was 0.17 mm. The width of front weld was 14.20 mm, and the reinforcement of front weld was 1.22 mm. T-joints were welded with the optimized welding parameters. The fillet welds were well fused in the area of both toes. The welds were even and slightly concave on the surface. The foot size measured by the test was 6.8 mm.

Key words: **welding robot**, **welded joint**, **welding parameters**

Arc spot welding process of stainless steel

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Abstract To reduce welding distortion, arc spot welding was used to join 3 mm and 5 mm thick 0Cr18Ni9 stainless steel sheets. Effects of three section welding current on weld penetration, nugget diameter and shear resistance of joints were mainly investigated. The research results showed that weld penetration, nugget diameter and shear resistance of joints increased with the increase of the first current and the second current. The first current mainly affected on weld penetration, while the second current mainly affected on both weld penetration and nugget diameter, especially nugget diameter. However, the third current did not affect weld penetration or nugget diameter, which mainly affected on formation of weld. Optimizing the first welding current and second welding current and their relevant parameter could improve the shear strength of arc spot welded joints.

Key words: **stainless steel**, **arc spot welding**, **penetration**, **nugget diameter**, **shear resistance**