MAIN TOPICS, ABSTRACTS & KEY WORDS

Wire and arc additive manufacturing for mold material RMD545

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Abstract This research focused on wire and arc additive manufacturing for mold material RMD545 and the experiment of single layer and single bead deposition forming technology was carried out. The forming characteristics were analyzed and the interval of good forming technology was determined. The multi-ayer single-bead deposition forming technology test was carried out with proper parameters and the surface was well formed without obvious defects. The microstructure and properties of single-layer single-bead and multi-layer single-bead were analyzed. The result showed that with the increase of depositing current, the cooling rate slowed down, the martensite transformation decreased and the bainite transformation increased in single-layer single-bead microstructure, which led to a lower hardness. During the multi-layer single-bead depositing process, different layer had different thermal processes. It made a microstructure variation along the height direction. Microstructures from bottom to top were tempered martensite + acicular ferrite + tiny amounts of bainite, martensite + bainite + tiny amounts of acicular ferrite, and lath martensite. The hardness ranged from 350 HV to 500 HV. The tensile test showed that mechanical properties of the additive manufacturing wall structure could meet the performance requirements of the mold repairing.

Key words: wire and arc additive manufacturing, forming process, microstructure and mechanical property, mold material RMD545

12Cr2Mo1R heat-resistant steel/304 stainless steel welding of dissimilar steel

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Abstract The method of AA-TIG welding to weld bottom and the submerged arc welding to fill the cover surface was used to study the butt welding of two large and thick plates of 12Cr2Mo1R heat-resistant steel and 304 stainless steel. The microstructure and mechanical properties of welded joints were analyzed by methods of observing the microstructure and element distribution of welded joints and testing hardness, tensile properties, impact toughness and bending properties of welded joints. The results showed that the heat-affected zone of stainless steel was austenitic matrix with a small amount of band ferrite, the heat-affected zone of heat-resistant steel was bainite and martensite, while the weld was austenite and ferrite. It was founded by line scan analysis that the Fe and Ni element content in the fusion zone on the stainless steel side changed significantly, while the Fe, Ni, and Cr element content on the heat-resistant steel side change significantly. The microhardness test results showed that the hardness of the weld zone was about 220 HV, and there was obvious hardening in the heat-affected zone of heat-resistant steel. The tensile strength of welded joints was up to 678 MPa. The impact toughness of the weld and the heat-affected zone of stainless steel

and heat-resistant steel at －30 ℃ was 132 J, 124 J, 241 J.

Key words: **12Cr2Mo1R heat-resistant steel**, **304 stainless steel**, **submerged arc welding**, **AA-TIG welding**

Numerical simulation of influence of non-fusion on residual stress in multi-pass and multi-layer welding of thick steel plate

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Abstract The simulation of multi-layer and multi-layer welding process was realized based on the layer-by-layer activation modeling method, and the mixed heat source model was used to establish the finite element model of multi-pass and multi-layer welding for thick X70 steel plates with different thickness. The evolutions of welding temperature field and stress field were simulated and analyzed. The non-fusion defects and equivalent pipeline working conditions were introduced into the model. The influence of non-fusion defects on post-welding residual stress distribution and X70 pipeline safety was simulated and analyzed. The results indicated that, the maximum Mises stress at the repair welding seam containing non-fusion defects was 470 MPa, which was below the yield strength of base steel of X70 pipeline steel. The highest Mises stress under equivalent working conditions was located in the non-fusion defects and reached 592 MPa, which exceeded the yield strength of the parent metal but did not reach its tensile strength. The simulated results was in good agreement with the experimental results, which indicated that the founded model had high reliability and accuracy.

Key words: **multi-pass and multi-layer welding**, **non-fusion**, **numerical simulation**, **residual stress**

Welding deformation and manufacturing technology of 316LN irregular supports

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Abstract In order to control and study the welding deformation of the low temperature superconducting magnet supported by fusion reactor. In this paper, the thermal elastic plastic finite element analysis of 3 mm 316LN for TIG butt welding test and welding deformation measurement were carried out. The results indicated that the deviation of the welding temperature field from the measured values was less than 20 %. Based on this, the welding deformation and residual stress of the deformed support structure were studied. It was found that the residual stress rebalance after the release of the jigs was the main reason for the large deformation. Therefore, it was shown that thermal elastic plastic finite element analysis could be used to predict welding deformation of 316LN complex components.

Key words: **316LN**, **welding deformation**, **finite element analysis**, **heat treatment**

PSD based signal recognition system for thin plate welding groove

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Abstract Groove signal recognition is a difficult point in automatic welding process. Based on this, the light path diagram was designed with the photosensitivity of PSD sensor and the corresponding light path model was established. Aiming at the nonlinear distortion of the PSD sensor to a certain extent, a corresponding improved model was established. According to the characteristics of the output displacement and time curve of the PSD sensor, a relevant algorithm was proposed to extract the corner information of the groove, so as to realize the real-time extraction of the diagonal points and the shape fitting of the groove. The results showed that the signal recognition system could accurately detect the change of groove position and defects of groove in real time, so as to avoid errors in the later welding process and affect the welding quality.

Key words: sheet welding, signal identification, extraction of groove corner point, PSD distortion correction, groove defect detection

Development and prospect of lightweight material and connection technology of rail bus

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Abstract With the rapid development of rail passenger car industry, great progress has been made in vehicle materials and connection technology. The large-scale use of metal materials such as weatherproof steel, stainless steel and aluminum alloy has promoted the wide application of welding methods that arc welding, resistance welding and friction stir welding were represented and the automation rate of welding has been constantly improved to better ensure the quality of products. In this paper, the present situation, development prospect and service environment challenge of rail bus industry were briefly described, and the development course of vehicle application materials was summarized. The continuous application of new materials such as light alloy materials with higher strength and better performance, fiber reinforced composite materials for future use and their excellent comprehensive service performance in the field of promoting rail cars was analyzed. At the same time, some advanced connection technologies such as laser welding, laser-arc composite welding, self-punching friction riveting and green quality bonding, were prospected to solve the future prospect of new material connection technology. The development direction and research focus of lightweight materials and connection technology for rail passenger cars were put forward.

Key words: rail bus, lightweight, materials, connection technology

Development and application of electrode for – 50 ℃ ethylene spherical tank made of 07MnNiMoDR steel

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Abstract According to the characteristics of – 50 ℃ ethylene spherical tank made of 07MnNiMoDR steel, the suitable GER – 27M electrode was successfully developed by selecting slag system reasonably, determining Mn-Ni-Mo alloy system, and applying microalloying technology. A series of technological and mechanical properties tests were carried out on GER-27M electrode. The results showed that the welding process of

this electrode was good at all positions and the diffusive hydrogen content of deposited metal was very low. After a long postweld heat treatment at 40 kJ/cm vertical welding position, the data of −50 ℃ A_{KV} was still higher than the requirement of technical conditions. The weld metal had low re-heat crack sensitivity, wide heat treatment range and strong brittle fracture resistance.

Key words: −50 ℃ ethylene spherical tank, 07MnNiMoDR steel, GER-N27M electrode, mechanical properties of weld metal

Analysis of liquation crack of 6061 aluminum alloy welded joint

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Abstract Cracks were found in 6061 aluminum alloy corner joint. The crack was identified as liquation crack according to the distribution, microstructure and fracture morphology of the crack. The analysis showed that there were three important causes of the crack, coarse grain of the material, high welding heat input and weld shape deviates upward caused by magnetic blow. The problem of liquation crack of the joint was solved by selecting material with fine metal, reducing welding heat input and improving weld shape.

Key words: 6061 aluminum alloy, liquation crack, coarse grain, welding heat input, magnetic blow

Welding process, microstructure and mechanical properties of welded joints of scraper conveyors central groove in super heavy coal mining machinery

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Abstract The metal active-gas welding (MAG) experiment for welded joint of wear-resistant steel JFE-EH400 and cast steel ZG30MnSi of scraper conveyors central groove in this study was carried out in super heavy coal mining machinery. The microstructure, defect characteristics, inclusion composition and microhardness distribution of base metal and welded joints were investigated by OM, SEM, EDS element mapping and microhardness test. The results indicatd that the microstructure of cast steel ZG30MnSi was composed of tempered sorbite. And the microstructure morphology characteristics of wear-resistant steel JFE-EH400 presented alternate superposition distribution of ferrite + pearlite and precipitation strengthening layer. And the welded joint of JFE-EH400 and ZG30MnSi was composed of acicular ferrite (AF), polygonal ferrite (PF) and a small amount of pearlite, the microstructure morphology of welded joint presented interlocking features on acicular ferrite phase. The relationship between the microhardness value of the welded joint was heat affected zone (HAZ) > base metal > weld metal, and the high hardness points appeared in the HAZ near the overlap zone of the weld metal, the hardness values were as high as 329 HV 10 and 334 HV 10. For the welding production of the scraper conveyors central groove of the super heavy coal mining machinery, the bottom welding quality of the large-thickness medium plate JFE-EH400 and the ZG30MnSi dissimilar steel was the key. The welding process often produced cracks and pore defects due to the falling molten pool of impurities and rusts. Before welding, the removal of impurities, rust, etc. from the cast steel and groove surface and the strict implementation of welding process parameters and specifications were one of the main measures to avoid and solve welding defects.

Key words: scraper conveyors, central groove, bottom welding, welding defects