MAIN TOPICS, ABSTRACTS & KEY WORDS

Influence of presetting nickel base alloy sheet on microstructures and mechanical properties of dissimilar steels joints by UNGW

Zheng Shaoxian[1], Xu Longqiang[1], Zhao Xilong[1], Shi Wei[2]

(1. Lanzhou Jiaotong University, Lanzhou 730070, China; 2. Lanzhou LS Test Technology Co., Ltd., Lanzhou 730314, China). p1 – 7

Abstract Influence of presetting nickel base alloy sheet on microstructures and mechanical properties of 15CrMo/1Cr18Ni9Ti dissimilar steels joint by ultra-narrow gap welding (UNGW) was studied. The results showed that when the thickness of nickel base alloy sheet was less than 0.6 mm, part of weld zone near the fusion line solidified with A mode and formed austenitic cellular crystals, while the other zone still solidified with FA mode and was made of austenite equiaxed grains and dendrite ferrite. No solidified cracks appeared in the center of weld. When the thickness of nickel base alloy sheet was 0.9 – 1.2 mm, the center of weld zone solidified with A mode due to Ni macrosegregation, where coarse austenitic columnar crystal and solidification crack formed. When the thickness of presetting nickel base alloy sheet was 0.6 – 0.9 mm, Ni mass fraction of weld zone near the fusion line was 2% higher than that of filler metal (ER347L), which brought better effect of inhibiting carbon diffusion than that of the joint without presetting nickel base alloy sheet. However, when the thickness of presetting nickel base alloy sheet changed in the range of 0.3 – 1.2 mm, the effect of joint on inhibiting carbon diffusion had no significant change. Dissimilar steel welded joints had martensite layer in the uneven mixed zone, while a certain width of carbon-rich hardening zone and carbon-poor softening zone formed near the fusion lin after heat aging treatment.

Key words: **dissimilar steels welding**, **carbon diffusion**, **nickel base alloy**, **solidification crack**, **microstructure**

Fatigue property of non-load-carrying fillet welds in cruciform joint

Nie Chunge, Zhang Xu, Guan Mingzhu, Li Xiaofeng

(Dalian Jiaotong University, Dalian 116028, Liaoning, China). p8 – 12

Abstract Based on structural stress method, fatigue property of non-load-carrying fillet welds in cruciform joint was investigated by numerical analysis and fatigue test in this paper. First, it was observed that the fatigue property of joint decreased with fillet weld size increasing according to the structural stress at weld toe section, which was also verified by fatigue test. Meanwhile, the comparison of test data and *S-N* curve of F class in BS 7608 standard indicated that stress modification was necessary for fatigue evaluation. Then, the structural stresses of joint were calculated by finite element models including root gap and penetration respectively, and the results indicated that the two details only affected the fatigue property of joint slightly. By comparing with load carrying fillet weld joint, it was verified that the impact on fatigue property of details was dominated by force status. When defining quality levels for imperfection of weld, an appropriate criteria should be set by considering the force status of joint to reduce the manufacturing costs of structures.

Key words: **non-load-carrying fillet weld**, **fatigue property**, **structural stress**, **quality levels for imperfections**, **cruciform joint**

Extract periodic parameters of GMAW electric signal with short-circuit transition craft based on LabVIEW

Huang Ning, Feng Zhanrong, Xiong Guangjin, Fang Ping

(Nanchang Hangkong University, Nanchang 330063, China). p13 – 17

Abstract Traditional parameter extraction method is to use Analysator Hannover or it's development, the previous extraction methods is hard to operate and easily go error by noise in LabVIEW. In this paper, based on the LabVIEW pulse measurement function and centered on the ends of a short circuit voltage signal, the corresponding current waveform with a certain range was checked whether it's maximum value was less than the threshold value as the standard, and was determined whether it was an instantaneous short circuit. The measurement function was made into a sub vi. In order to improve the program structure and human-machine interaction, JKI state machine was used to design a concise human-machine interface with U-PDD and I-PDD as assistants. By selecting the appropriate reference level and threshold current, variation diagram and frequency diagram of short circuit time, short circuit cycle time, frequency diagram and it's variation coefficient were measured. Experiments showed that this method could accurately measure the required results.

Key words: **short circuit transition**, **electrical signal**, **short circuit time**, **short circuit period**, **parameter extraction**

Brazing performance comparison between CuSnTi alloy solder paste and solder foil

Qi Yuefeng[1], Huang Xiaomeng[2], Wang Li[3], Wang Feng[2], Li Xiaoying[1]

(1. Beijing Non-ferrous Metal and Rare Earth Research Institute, Beijing 100012, China; 2. Beijing Engineering Research Center of New Brazing Materials for Electronic Information, Beijing 100012, China; 3. Beijing Institute of Near Space Vehicle's Systems Engineering, Beijing 100076, China). p18 – 23

Abstract To verify the melting condition of $CuSnTi_{8-5}$ solder paste, the same welding process of the solder foil could be used, and properties of soldered joints with solder paste were not lower than that of soldered joint with solder foil. Differential thermal analysis (DSC), wettability test and mechanical properties of the joint were tested. The microstructure of the joint was analyzed by scanning electron microscope (SEM) and energy dispersive spectrometer (EDS). The related properties of solder paste and solder foil were compared. The results showed that $CuSnTi_{8-5}$ solder paste had a close solid-liquid temperature to the solder foil, which fully met the welding process of the solder foil. The wettability and spreadability of the solder paste was better than that of the solder foil, and the strength of the soldered joint with the solder paste was higher than that of the soldered joint with the solder foil. The reason was that under the same soldering temperature, the solder paste had a longer interaction time with the substrate, which obtained more wetting kinetic energy, so it presented a higher spreading coefficient. In addition, the solder foil could not form obvious wetting fillet around the weld as the solder paste did, which affected mechanical properties of the soldered joint. Through analysis of microstructure, the difference in wettability and mechanical properties of the soldered joints was due to the different state of Cu-Ti solid solution formed between soldering seams with the solder paste and the solder foil and the base metal.

Key words: **CuSnTi solder**, **joint strength**, **microstructure of joint**, **wettability and spreadability**

Microstructure and mechanical properties of Sn-0.7Cu-*x*Nb composite solder

Liu Zheng[1], Zhang Yaocheng[2], Xu Yuhang[1], Liu Po[1]

(1. Guilin University of Aerospace Technology, Guilin 541004, Guangxi, China; 2. Changshu Institute of Technology, Changshu 215500, Jiangsu, China). p24 – 27,60

Abstract The effect of Nb nano-particles on the microstructures and mechanical properties of Sn-0.7Cu composite solder was studied in this

paper. The results showed that the microstructure of Sn-0.7Cu composite solder was refined by adding Nb nano-particles and the tensile strength of joint with Sn-0.7Cu composite solder was improved. When Nb content was 0.12% (mass fraction), the maximum tensile strength reached 25.36 MPa, but the elongation of the solder was reduced. The fracture mode of Sn-0.7Cu-*x*Nb composite solder was all plastic fracture. The size of dimples on the fracture surface of Sn-0.7Cu composite solder decreased gradually with the increase of Nb content, which indicated that the growth of Cu_6Sn_5 intermetallic was inhibited by adding a small amount of Nb nano-particles.

Key words: **Nb particles, Sn-0.7Cu solder, microstructure, mechanical properties, fracture morphology**

Effect of Ni on steel/aluminum resistance spot welding

Cai Ning, Zhang Yongqiang, Wang Pengbo, Wang Haiquan, Ju Jianbin, Fu Can

(Shougang Group Co., Ltd., Research Institute of Technology, Beijing 100043, China). p28 – 34

Abstract Taking DC01 steel plate and 5082 aluminum alloy plate as the base material, effects of welding current (9 – 12 kA) and Ni coated layer on shear strength, normal tensile strength and interfacial phase composition of resistance spot welded joint were studied under conditions of electrode pressure 3 kN, welding time 300 ms and holding time 100 ms. The results showed that nugget size and the strength of the joint increased with the increase of welding current. The shear force of Ni coated steel / aluminum joint was one order of magnitude higher than that of normal tension. Under 10 kA welding current, the shear force and normal tension of Ni coated steel/aluminum joint were significantly higher than those of steel/aluminum direct welding, which was due to the formation of Al_3Ni phase at the steel/aluminum interface, which inhibited the formation of brittle Fe_2Al_5 intermetallic compound.

Key words: **steel/aluminum welding, resistance spot welding, shear strength, cross tension, intermetallic compounds**

Research status of inertial friction welding of dissimilar alloys

Liu Yingying[1], Li Jiejie[1], Tian Wantao[1], Wu Fanglin[2], Tan Qianhui[3]

(1. Xi'an University of Architecture and Technology, Xi'an 710055, China; 2. China Railway Academy and Engineering Consulting Limited of Sciences, Beijing 100081, China; 3. Shanxi Fenglei Drilling Tool Limited Company, Houma 043013, Shanxi, China). p35 – 41

Abstract In this paper, the research status of inertial friction welding of steel and other alloys, aluminum alloy and other alloys, titanium alloy and other alloys, high temperature alloy and other alloys was described. The selection of process parameters, design of end plane, preheating before welding and post-welding heat treatment of inertial friction welding were summarized. The problems existing in inertial friction welding of dissimilar alloys were analyzed and summarized. The results showed that the joint with the same strength as the base metal and good welding quality could be obtained by adopting reasonable process parameters, designing difform end plane, adding intermediate transition layer, preheating treatment before welding and post-welding heat treatment. Suggestions in the follow-up study were that process parameters of the inertia friction welding of dissimilar alloy and design of end plane were optimized by combining with numerical simulation, element distribution and amount and type of newly formed phase of the joint were adjusted and controlled, and flow behavior of metal at welding interface was studied in depth to obtain a better comprehensive performance dissimilar alloy inertia friction welded joint.

Key words: **dissimilar alloys, inertia friction welding, welded joint, microstructure, mechanical properties**

Welding tests of high performance Q420qENH weathering bridge steel

Che Ping[1], Li Junping[1], Huang Huiqiang[1], Wang Qingfeng[2], Sun Tuo[2], Li Weiwei[2]

(1. China Railway Baoji Bridge Group Co., Ltd., Baoji 721006, Shaanxi , China; 2. Yanshan University, Qinghuangdao 066004, Hebei, China). p42 – 50

Abstract For high performance Q420QENH weathering bridge steel plate in this paper, the re-inspection of the base material, the deposited metal test of the welding material, the weldability test of the steel plate, series of temperature impact test of the butt joint and the welding procedures qualification test of the typical joint were carried out to evaluate and analyze mechanical properties, weldability and weather resistance of the steel. The results could provide reference for the application of Q420qENH weathering steel in bridge fabrication.

Key words: high performance weathering bridge steel, welding performance, mechanical properties, test evaluation

Path planning of arc additive manufacturing for mine sprocket chain pocket

Dong Manshu[1,2], Zhu Han[3], Zhang Xiaochao[3], Bai Kai[1,2], Liu Long[1,2], Gao Hongming[3]

(1. Ningxia Tiandi Ben Niu Industrial Group Co., Ltd., Shizuishan 753001, Ningxia, China; 2. Ningshudi Heavy Equipment Technology Co., Ltd., Shizuishan 753001, Ningxia, China;3. Harbin Institute of Technology, State Key Laboratory of Advanced Welding and Joining, Harbin 150001, China). p51 – 55

Abstract A curved surface delamination algorithm was proposed for arc additive manufacturing of sprocket chain pocket with large curvature. For the area to be arc additive manufactured, layered design and welding path planning were carried out to obtain smooth and continuous path points, which could well adapt to the curved surface of the chain socket. The results showed that each axis of the robot moved gently and the welding gun run smoothly without speed mutation during welding. The surface of the cladding layer is uniform and smooth, and it is highly consistent with the curved surface of the chain socket. The edges were adapted to the surrounding contours without defects beyond the contour edges. It was confirmed that the obtained path planning algorithm was suitable for the additive manufacturing process of the sprocket chain pocket surface.

Key words: wire-arc additive manufacturing, curved surface delamination, path plan, attitude design

Effect of specimen surface state on microstructure and mechanical properties of linear friction welded joint

Ji Yajuan[1,2], Li Zan[1,2], Tao Jun[1,2], Jin Junlong[1,2]

(1. AVIC Manufacturing Technology Institute, Aeronautical Key Laboratory for Welding and Joining Technologies, Beijing 100024, China; 2. Beijing Friction Welding Technology and Equipment Engineering Center, Beijing 100024, China). p56 – 60

Abstract In this paper, for TC4 titanium alloy commonly used in aircraft components, effect of three states of wire-electrode cutting, rough milling surface and grinding surface before welding on formability, microstructure, oxygen element distribution and mechanical properties of linear friction welded joint were studied, respectively. Results showed that joints in three states were well formed. The macrostructure after welding included base metal (BM), thermal mechanical affected zone (TMAZ) and weld zone (WZ). Grains of TMAZ was elongated along the direction of the force and α phase dissolved. Dynamic recrystallization occurred in WZ, and fine lamellar microstructure was formed inside the grains. The content of oxygen element in the joint of wire cutting and rough milling states did not increase significantly, which was similar to that in the joint of grinding state. Joints in the three states before welding had equal tensile properties. Under conditions of $K_t = 1$, $R = 0.06$, 550 MPa, Joints in the three states had equal fatigue life

Key words: titanium alloy, linear friction welding, wire-electrode cutting, rough mill, grind