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MAIN TOPICS, ABSTRACTS & KEY WORDS

Weld Area Extracting and weld Defect Fidelity Getting for Image of Aluminum Weld Seam WU Lin (National Key Laboratory of Advanced Welding Production Technology, HIT, Harbin 150001, China), DAI Ming, LI Yan, p1 ~ 4

Abstract: In this paper, the weld area extracting in automatic recognition for weld defects had been investigated according to the feature of weld seam image. Based on the above, defects rectangle and end rectangle were defined for shape and size of defects correcting. Defects rectangle forming, cycle of segmentation and growth, defects degree extracting were designed. A satisfactory results were obtained on weld area extracting and a high fidelity of defects was gotten.

Key words: weld seam image; image processing; weld area extraction; triangle simulation; defects rectangle fidelity getting

Shape Parameter Definition and Image Processing of the Weld Pool during Pulsed GTAW with Wire Filler ZHAO Dong-bin (Department of mechanical Engineering Tsinghua University, Beijing 100084, China), CHEN Shan-ben, WU Lin CHEN Qiang, p5 ~ 8

Abstract: In pulsed GTAW with wire filler, the variation of the weld pool shape could be observed from the weld pool image, such as the pool width, length, rear angles, surface height, etc. A skilled welder can adjust the welding parameters according to the variation of the weld pool shape for ensuring the stability of the bead shape. With the captured images of the weld pool, the shape parameters of the weld pool can be calculated using image processing algorithm, for fulfill the requirement of real time control. Aiming at the characteristic of the weld pool shape during pulsed GTAW with wire filler, this paper proposed a nonlinear regressive formula for describing the weld pool shape with a few shape parameters. A fast algorithm of image processing was designed for extracting the shape parameters of the weld pool in real time. The testing results indicated the accuracy of the nonlinear regressive formula, and verified the feasibility of the image processing algorithm. This laid the foundation of the further modeling and control for the welding process.

Key words: pulsed GTAW with wire filler; shape of the weld pool; image processing

Mathematical Model of Pulsed Laser Welding CHEN Tao (Beijing

Polytechnic University, College of Laser Engineering, Beijing 100022, China), WANG Zhi-yong, XIAO Rong-shi, ZUO Tie-cuan, p9 ~ 14

Abstract: Based on the metal melt and vaporized interface 2D propagation mechanism, this paper founds the pulsed laser welding model. This model divides the interactive zone and pulse duration in to many units, which is used for weld profile calculation. We put forward the intensity redistribution mechanism in keyhole cavity to expisit the weld seam cross section profile preciously. This intensity redistribution mechanism in keyhole cavity mainly take up the Fresnel preciously at cavity wall, and the intensity superimposition is attributed to noncoherent superimposition, which is independent on the incident angle. The local unit after every reflection is decided by ray trace method. This model gives out the weld profile along with the laser pulse power P , focus diameter a , absorptance α , and the profile curve variation vs the interactive time t . The theory results show that the weld seam cross section profile is influenced significantly by laser pulse power, focus diameter and pulse duration. This is correspondent to actual weld situations. Meanwhile, the theory results can explain the weld cross section curve zigzagged characteristics.

Key words: pulsed laser welding; keyhole; intensity redistribution in cavity; mathematical model

Solid phase Welding between Chromium Bronze and Wolfram Alloy based on Superplasticity of Chromium Bronze YANG Yun-lin (Dep. of Materials Engineering, Luoyang Institute of Technology, Luoyang 471039, China), MA Feng, WANG Chang-sheng, ZHANG Ke-ke, p15 ~ 18

Abstract: The feasibility of solid-phase welding between chromium bronze and wolfram alloy was explored under the condition of superplastic deformation of chromium bronze. The results show when the sample surfaces of chromium bronze and wolfram alloy to be welded were carefully cleaned, pre-pressed under 10 ~ 30 MPa, at the welding temperature of 740 ~ 800 °C and at initial strain rate of $(1.67 \sim 13.3) \times 10^{-4} s^{-1}$, the shear strength of butt joint is up to or close to that of chromium bronze base metal in 3 ~ 10 minutes pressure welding, so that the solid-phase welding can be finished. The chromiumbronze takes place superplastic deformation in welding process, but the deformation of wolfram alloy is little. The atoms of two sides at initial interface appears obvious

diffusion.

Key words: chromium bronze; wolfram alloy; superplastic deformation; solid-phase welding

Thermal-fatigue of Roller Surfacing Metal FENG Ling-zhi(Tianjin University, Tianjin 300072, China), LI Wu-shen, SONG Bing-zhang, SONG Qing-yi. p19 ~ 22

Abstract By means of self-designed test method, thermal-fatigue resistance and influence factor for surfacing metal of three self-produced flux-cored wires and one solid wire for roller hardfacing were studied deeply. The mechanisms of thermal-fatigue crack initiation and extension were investigated. The results show that the thermal-fatigue crack initiation and extension were related to cycle stress and high-temperature oxidation. The more oxidation resistance, the more crack initiation resistance. Besides, the thermal-fatigue resistance were effected by microstructure and inclusion in surfacing metal. The homogeneous microstructure is advantageous to increase thermal-fatigue resistance, but inclusions facilitate the initiation, extension and branch of crack.

Key words: surfacing metal; thermal-fatigue resistance; oxidation resistance

Furnace Brazing of Diamond Grinding Wheel with Ni-Cr Alloy under Vacuum Atmosphere XIAO Bing(Department of Mechanical Engineering Nanjing University of Aeronautics & Astronautics Nanjing 210016, China), XU Hong-jun, WU Zhi-bin, Xi-peng. p23 ~ 26

Abstract The brazing of a monolayer diamond grinding wheel with active filler metals can show distinct advantages over conventional electroplated diamond grinding wheel in terms of faster cutting and longer life. The present study has shown that a commercially available Ni-Cr alloy can be used as an active filler material for brazing diamond grit. Furnace brazings carried out in a current of vacuum. SEM-EDS microanalyses have shown that during brazing the chromium present in the alloy segregated preferentially to the surface of the diamond to form a chromium-rich reaction product. X-ray diffraction reveals that the wetting and bonding behaviour on diamond surface by Ni-Cr alloy melt is realized through Cr_7C_3 , which is produced by interaction between Cr atoms of Ni-Cr alloy and C atoms of diamond surface at elevated temperatures. The analyses also indicate that the bond between the alloy and the steel substrate is established through a cross-diffusion of iron and chromium. Finally, a grinding test shows that the wear modes of such a brazed grinding wheel are mainly grit fracture and attrition rather than grit dislodgement from the bond.

Key words: abrasive wheels; monolayer; brazing; diamond

External Field Treatment Refining Microstructures of Pipeline Steel SAW Weld GUO Xu-ming(Institute of Metal Research, The Chinese Academy of Science, Shenyang 110015, China), QIAN Bai-nian, ZHANG Yan, LI Jing-li, ZHU Ping. p27 ~ 30

Abstract The effects of electromagnetic stirring and TIG surface treat process on the microstructures of pipeline steel SAW deposited metals were investigated. The results showed that electromagnetic stirring changed the size and distribution of inclusions in deposited metals,

increased the density of inclusions with 0.20. $6\mu\text{m}$ diameter, promoted the formation and refining of acicular ferrite within austenite gains. The contents of AF within austenite gains were increased from 85.1% to 91.7% and the low temperature toughness of deposited metal was improved. TIG surface treat process eliminated column grain structures of surface layer of welds. The size of acicular ferrite was greatly refined and grain boundary ferrite and side plate ferrite disappeared.

Key words: electromagnetic stirring; TIG treat process; grain refinement

CCD Sensor Assisted Weld Seam Tracing Method for Spherical Tank Welding Robot WANG Jun-bo (Tsinghua University, Beijing 100084, China), SUN Zher-guo, CHEN Qiang, JI Meng, JIANG Li-pei, JIAO Xiang-dong, XUE Long. p31 ~ 34

Abstract This research is mainly addressed on solving the weld seam tracing problems existing in design of wheel-mobile robot based spherical tank welding robot. Generally, the moving route of wheel-mobile robot can not be controlled accurately in real-time, however, weld torch must precisely moves along the weld seam at given speed to guarantee the weld quality of spherical tank. To solve this conflict, the moving mechanical structure of wheel-mobile robot and weld torch, which is under certain constraint condition, has been designed. A weld seam route detecting system based on two CCD sensors has been established. After the dynamic analysis about the motion of wheel-mobile-robot on spherical tank, a control model for weld seam tracing of wheel-mobile robot and its control strategy have been developed. Then, according to the constraint relations between the motions of wheel-mobile-robot and weld torch, a control algorithm which could control the weld torch position accurately in real time has been put forward. The exploited spherical tank welding robot has high weld torch tracing accuracy(up to $\pm 0.5\text{ mm}$), and has been successfully applied in the automatic manufacturing of spherical tank.

Key words: spherical tank welding; CCD sensor; wheel-mobile-robot; weld seam tracing

Accelerated Test Study of Residual Life Mathematical Model for the Friction Welded Joints in Boiler Snake Pipe ZHAO Ji-jun(Harbin Institute of Technology, Harbin 150001, China), SONG Xin, ZOU Jing-xiang, HUANG Jia-xiang. p35 ~ 38

Abstract Based on reliability theory, the specification of accelerated life test for friction welded joints in boiler snake pipe was worked out. The correctness of the specification and the concordance of the failure mechanism on the different combined stress levels were verified by high-temperature internal pressure burst duration test for a large number new friction welded joints of 15CrMo steel. The mathematical model which was used to calculate residual life with reliability for the friction welded joints of 12Cr1MoV steel having worked 132 000 hours was set up. Through calculation of the test data, the following conclusions were drawn: the friction welded joints is very reliable in the design life; the quality of the friction welding procedure is stable. The test method and mathematical model related in the paper also have practical value to forecast the residual life for high-temperature pressure-containing and to de-

termine the refresh time for extended service pipe and welded joint.

Key words friction welded joint; residual life; mathematical model; accelerated test study

Effect of Re Elements on the Properties of Self-shielded Flux-cored Wire

HU Qiang (Beijing Polytechnic University, Beijing 100022, China), WEI Qi, JIANG Jian-min, XIONG Di-jing, p39 ~ 42

Abstract The influence of three kinds of RE elements and RE metal mixture on the oxygen, nitrogen content and pore sensitivity in the weld of self-shielded flux-cored wire was investigated in the present study. Significant findings of this study revealed that the oxygen content and pore sensitivity in the weld were reduced with the increase of RE element addition, among which the RE metal mixture most effectively depressed the formation of porosity. The effect of RE element addition on the nitrogen content in the weld was insignificant due to the oxidation from the early deoxidization stage. However, the RE elements could effectively fix the nitrogen so that the nitrogen content in the weld could be controlled to certain beneficial ranges. It was also found out that proper RE element addition could increase the toughness of the weld metal and improve its microstructure by grain refinement.

Key words RE; self-shielded flux-cored wire; pore sensitivity

Lapping Repair for Quenching Crack inside a Cold Die Steel

GAO Dian-kui (Yanshan University, Qinhuangdao 066004, China), FU Yuming, BAI Xiang-zhong, p43 ~ 45

Abstract Low alloy cold die steel belongs to high carbon steel, so the quenching crack is easy to appear when it is hardened. The cold die with a large dimension, complicated structure and high precision will soon have to be scrapped because of there exists the quenching crack in it. How to repair the cold die with quenching crack is badly needed in industrial productions. The method of lapping repair for quenching crack inside the cold die steel has been studied in this paper in order to prevent the crack. The experimental research has been done. Firstly, the crack prevention has been executed around the tip of quenching crack inside the cold die of 9SiCr steel through pulse current discharge, the curvature of the crack tip will be increased after the crack prevention, so the crack can be prevented from extending. Secondly, the spark discharge is applied to the crack in surface with YG8 electrode, a reinforced layer which covers the crack can be formed, and it could be considered as a bridge in the tip of crack. After the lapping repair, the stress concentration can be caused in the die since there exists the similar area inside the reinforced layer. So the tip of crack under reinforced layer is treated with on the second pulse current discharge and the lapping repair for quenching crack inside cold die steel can be obtained.

Key words quenching crack; pulse current discharge; lapping repair; cold die steel

Filling Strategy of Multi-pass Welding

LI Kai (Research Institute of Robotics and Automation, Hebei University of Technology, Tianjin 300130, China), DAI Shi-jie, SUN Li-xin, YUE Hong, p46 ~ 48

Abstract In this paper, a new filling strategy for multi-pass welding, which can be used in robotic welding, is put forward. By analyzing

the shapes of the across areas of various kinds of beads in one joint, this paper gives out a build-up and welding sequence for V groove that the number of beads in a certain layer is equal to the ordinal number of the layer. With the equal across area of each bead in one joint, we work out that there is the equal layer height in the later layers from the second layer. So the filling strategy which plans the number of layers and the number of the beads in each layer for a V-type joint is presented. Using this filling strategy, the across areas of each beads are equal and the welding parameters are invariable. It overcomes the shortcoming of the filling strategies used before, in which welding parameters alternate frequently and are difficult to program. The welding test shows that the filling strategy could ensure the better quality of the joints.

Key words filling strategy; multi-pass welding; robotic welding; weld technology

Probability Distribution of Fatigue Life of Notched Friction Welded Joints under Variable-amplitude Loading and its Simulation

YAN Jun-hui (Northwestern Polytechnical University, Xi'an 710072, China), WANG Hong, ZHAO Kang, ZHENG Xi-rui, p49 ~ 53

Abstract The experimental investigation is first carried out on the fatigue property of notched friction welded joints of 45-carbon steel under constant amplitude loading and the analysis shows that the fatigue life can be expressed as the function of the equivalent stress amplitude $\Delta\sigma_{epw}$, i. e. $N_i = C [\Delta\sigma_{epw}^{2(1+n)} (\Delta\sigma_{th})^{2(1+n)}]^{-2}$, where C and $(\Delta\sigma_{epw})_{th}$ are the fatigue resistant coefficient and threshold respectively. C and $(\Delta\sigma_{epw})_{th}$ are found to follow the log-normal distribution. According to the physical meaning and their probability distribution of fatigue resistant coefficient C and threshold $(\Delta\sigma_{epw})_{th}$ in the fatigue life expression, the different fatigue specimen are assumed to be distinguished by the different combination of C and $(\Delta\sigma_{epw})_{th}$, while the difference between the fatigue specimens leads to the scatter of the fatigue life, so a new method is proposed to simulate the fatigue test and the probability distribution of fatigue life of notched friction welded joints of 45-carbon steel under the variable amplitude loading and checked by test results. It is shown that both the simulated fatigue life and the test result of fatigue life of 45 steel notched friction welded joints under the variable amplitude loading follow the log-normal distribution, and the two distributions agree well with each other. Therefore the proposed simulating method may be applicable in the fatigue reliability assessment of mild carbon notched friction welded joints under variable amplitude loading.

Key words variable amplitude loading; fatigue life; friction welding; probability distribution; simulation

Microstructure and Performance in the Inter-critical Region of Heat-affected Zone of HQ130 Steel

LI Ya-jiang (Shandong University, Jinan 250061, China), ZOU Zeng-da, WU Hui-qiang, WANG Juan, p54 ~ 58

Abstract Microstructure and performance of inter-critical region (ICHAZ) in which peak temperature is between A_{c1} and A_{c3} in the heat-affected zone of HQ130 steel are researched by means of thermo-simulation test, micro-image analysis SEM and TEM etc. For the prob-

lem of toughness decrease in the ICHAZ ($T_p = 800\text{ }^\circ\text{C}$), the effects of $M-A$ constituent and carbide aggregation on the brittleness were studied emphatically. The research results indicate that the microstructure in the ICHAZ of HQ130 steel is the mixture of lath martensite (ML), granular bainite (Bg) and sorbite (S) whose grains are small but not homogeneous. Cause of brittleness in the ICHAZ is related to produce $M-A$ constituent in the local zone and the aggregation of lamellar carbide. The weld heat input has important effect on volume content (V_f) of $M-A$ constituent but only little effect on long and thin $M-A$ constituent content (SV_f). By controlling weld heat input (E), the aggregation of carbide and $M-A$ constituent can be avoid or decreased, and the effective diameter of $M-A$ constituent is limited in the rang of $d_{M-A} < 1.0\mu\text{m}$ so the toughness in the ICHAZ can be assured.

Key words high strength steel; heat-affected zone; $M-A$ constituent; microstructure

Design of Changeable Gain Arc length PID Controller for All-position Welding of Thick-wall Pipe LIU Li-jun(Harbin University of Science and Technology, Harbin 150076, China), HAN Yong-kui, LU Yun-long. p59 ~ 61

Abstract The arc length is one of the most sensitive parameters that influence welding quality at all-position TIG welding. Due to the influence of tungsten electrode burning out, former pass appearance of weld molten pool movement, weldment geometry shape and effect of gravitation on arc length adjustment at different position, if arc length adjustment were not adopted, the arc length could not be kept fixed length. It is more extrusive that the force of gravity influences arc length at all-position welding, the some especial controlling measures must be taken in order to overcome its influence. Therefore, a Changeable Gain PID controller is developed based on the single chip microcomputer controlling, in which the techniques of fast control, separated integral and appended non-sensitive scope are used for improving control properties.

Key words changeable gain PID controller; all-position narrow gap and thick-wall pipe welding; arc length adjustment; single chip microcomputer controlling

Development of Wire for Large Current Double Side Submerged Arc Welding of Pipe Steel PENG Yun(Dept. of Mechanical Engineering, Tsinghua University, Beijing 100084, China), CHEN Wu-zhu, XU Zurze. p62 ~ 66

Abstract In this paper, the characteristics of wire for submerged arc welding of oil and gas pipe line and the principles for the design of chemical compositions of high toughness welding wire are discussed. Steels of wire are smelted in high frequency induction furnace, medium frequency induction furnace and top oxygen blown converter respectively. Matching the agglomerated flux SJ101, these wires are used for double side submerged arc welding. The chemical compositions, impact toughness, microstructure of weld metal and hardness and tensile strength of welded joint are investigated. The fractured surfaces of impact specimens are analyzed by scanning electron microscope, the microstructures of weld metal are analyzed by transmission electron micro-

scope, and the distributions of B, Ti, N are examined by Auger spectrum analysis. It is indicated that B segregates in the boundary of original austenite grains, that is beneficial for the restriction proeutectoid ferrite. Uniformly distributed particles are helpful for the produce of acicular ferrite. These factors, combined with low content of S, P, gas elements and impurity, result in high toughness of weld metal. The hardness of weld metal is between HV185 and Hv214, which is in the same level with the average hardness HV190 of base metal. The transverse tensile strength of weld metal is higher than that of base metal.

Key words pipe line steel; submerged arc welding; welding wire; mechanical property

Characteristic Analysis of Dynamic Signals in CO₂ Arc Welding Process

MA Yue-zhou (College of Materials Engineering, Gansu Univ. of Tech., Lanzhou 730050, China), WANG Chun-bai, CHEN Jian-hong. p67 ~ 70

Abstract Wavelet analysis is utilized on eliminating noises and interpreting zero crossings of welding current, arc voltage and arc sound in CO₂ arc welding process, which are collected by experiment system. Extracted energy of arc sound in different frequency ranges is as characteristic vectors that can indicate changes in the welding processing. The correlation between characteristic class and welding sprays is studied by statistic test to evaluate and reduce dimensions of characteristic class. The base to fulfill on-line diagnose of welding process has been advanced in this paper.

Key words wavelet analysis; welding signal processing; arc sound; characteristics extraction; evaluation and reducing dimensions

The Microstructure and Toughness of HAZ in Low Carbon Ti-Nb Series Steels after Welding YIN Gui-quan(Anhui University of Technology, Anhui 243002, China), GAO Jia-sheng, HONG Yong-cang, CHEN Rui. p71 ~ 74

Abstract Effects of cooling rate ($t_{8/5}$) during simulated welding thermal cycle on the microstructures and toughness of HAZ in two series Ti-Nb steels were studied. The morphology, numbers and distribution of ferrite and granular bainite, especially $M-A$ constituent in HAZ at different cooling rate ($t_{8/5}$) were observed by optical and electron microscopes. The relation between microstructures and impact toughness in different cooling rates was analysed. The actions of added microalloying elements Ti, Nb and N on improving microstructures and toughness of HAZ in specimens was discussed.

Key words microalloying Ti steel; weld; cooling rate; microstructure; toughness

Numerical Simulation on Temperature Distribution of PBGA Package during Laser Reflow Process TIAN Yan-hong(National Key Laboratory of Advanced Welding Production Technology, Harbin Institute of Technology, Harbin 150001, China), WANG Chun-qing. p75 ~ 78

Abstract In this paper, temperature distribution of PBGA component during laser reflow process of solder ball was simulated with finite element method, and effects of different heating means of laser on tem-

perature distribution were discussed in detail. Results of simulation showed that reflowing solder balls with laser can not damage the silicon chip and package with the characters of short heating time and low temperature in package comparing with traditional heating method such as infrared reflow and hot air reflow method. At the same time experiments on PBGA solder ball laser reflow were carried out. Results of experiment showed that surface of solder bump achieved by laser reflow method with proper parameters is much smoother than that achieved by hot air reflow method.

Key words PBGA package; laser reflow; solder ball; solder bump

Computer Control System of 500 Kw Preheat Flashing Butt Welding Equipment WANG Zhi-ping(Beijing Summit Technology Co., Ltd, Beijing 100086, China), TANG Qing, WANG Ke-zheng, p79~82

Abstract In this article the computer control system of the large scale flashing butt welding was introduced in the aspects of the makeup and its realization. The computer control system was adopted in stead of the traditional PLC method. In this system, the large scale SCR was controlled via the computer and the power voltage compensation. The protection of the sob phase SCR connection and the welding process as well as the control of the outer characteristic of the machine were realized by the voltage and current close-loop feedback, the flashing curve was finished by using the ratio valve, which can also be used in the new work-piece technology debugging. The parameters of the control system were collected by photoelectrical seclusion to avoid the disturbing of the electromagnetism in welding. Therefore this system achieved the perfect effect in control and protection.

Key words high-power; preheating flashing butt welding; control system

CAD System of Arc Welding Power Source ZHANG Li-bin(Jiamusi University, Jiamusi 154007, China), YAO Yu-huan, LIAO Ping, p83~84

Abstract The CAD system of welding power source is studied by Visual C++ in this paper and the optimum designing system is developed. It is called "AWPSCAD". This system touches upon alternating arc welding source, SCR arc welding source and inverter arc welding source. Using Visual C++ as menu tools it has many advantages such as transplant, complete infuction and convenient in operation. It has vast application vistas in researching designing and manufacturing for arc welding power source.

Key words arc welding power source; CAD system; optimum design

The Heat Damage Mechanism of WC Cemented Carbide for Hardfacing

Q U Shi-yao(Department of Materials Engineering, Shandong University of Technology, Jinan 250061, China), WANG Xin-hong, ZOU Zeng-da, LIU Xue-mei, p85~88

Abstract Using SEM, X-ray and EPMA, the heat damage charac-

teristic and mechanism of WC cemented carbide in the course of hardfacing have been investigated. The results showed that the heat damage of cemented carbide was inevitable. The main characteristic of heat damage was the decompose and diffusion of carbide. The grain of fringe carbide grew up, re-separated out and a new phase was formed. The type of heat damage for WC cemented carbide was melting and dissolve of carbide, diffusion and reaction of element. The mechanism of heat damage for cemented carbide was the element diffusion and chemical reaction between cemented carbide and matrix metal. The diffused zoom and new phase were formed at the interface of cemented carbide and matrix. The kind, size content and method of hardfacing all directly affected the level of heat damage.

Key words cemented carbide; hardfacing; heat damage; mechanism; mechanical property

Experimental Phenomena of Carbon Migration in Dissimilar Metal Weldments

YANG Hou-jun(Central China Power Corporation Group Wuhan 430077, China), ZHANG Yin-ling, CAO Sheng, LU Wen-guang, p89~92

Abstract In order to research the influences of ageing factors on carbon migration in dissimilar metal weldments, the electron probe was used to inspect carbon distribution at the interface of ferritic basic metal side. The least squares fit for experimental datum of carbon migration and the possibilities of the state identification by least square method were discussed. Three series of tests were carried out and the experimental and fits results were analysed on the basis of phenomenology. on the basis of analysing of test results, we can discover, the more seyvicing temperature and time are the more carbon migration, width of carbonizing layer and decarbonizing layer are. It is impossible that they can be imitated in the least square method.

Key words DMWs; carbon migration; experiment; analysis.

Cyclic Stress-strain Behaviors for Butt Joint ZHANG Gang(Department of Material Engineering, Shenyang Institute of Technology, Shenyang 110015, China)LI Jian-jun, DING Chun-hui, p93~96

Abstract Low cycle fatigue tests had been carried out to investigate the cyclic behaviors of welded butt joint of structural steel. Cyclic stress-strain curves of weld metal base metal and welded joint were obtained respectively by means of incremental step method in various strain levels with single sample method. The different cyclic stress-strain behaviors of three kinds of specimen were compared and analyzed. For butt joint specimen, the weld metal heat affection zone and base metal are loaded cyclically. It is proposed that the heterogeneity of mechanical property resulted from the heterogeneous microstructure of welded joint causes the different cyclic stress-strain properties from the other two kinds of specimen. The heterogeneity affecting fatigue behaviors of welded joint should be conceded during the design of boiler and pressure vessel structures.

Key words welded joint; fatigue; cyclic; stress; strain