

## MAIN TOPICS, ABSTRACTS &amp; KEY WORDS

**Research status of dissimilar metal welding technology of ODS alloy and low alloy steel**

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**Abstract** The research progress of dissimilar metal welding technology between ODS alloy and low alloy steel was summarized and analyzed in the paper. The research status of friction welding, resistance welding and electron beam welding of ODS alloy and low alloy steels was mainly introduced in the paper, the microstructure, properties and oxide particles distribution of the welded joints under different welding methods were analyzed, the existing problems of various welding technology were summarized, and the causes and solutions of different problems were analyzed. The research direction of ODS alloy and low alloy steel welding in the future was summarized.

**Key words:** ODS alloys, low alloy steel, dissimilar metal welding, oxide dispersion strengthen

**Research progress on the effect of alloy elements on high entropy alloy coatings by laser cladding**

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**Abstract** The hardness, corrosion resistance, thermal stability and high temperature oxidation resistance of laser cladding high entropy alloy coating were introduced. The effects of alloy elements on the properties of high entropy alloy coatings were summarized. The research progress of high entropy alloy coating prepared by laser cladding technology in recent years was described, and the existing problems and future prospects of coating prepared by laser cladding technology were pointed out, in order to prepare high entropy alloy coating with excellent performance.

**Key words:** high-entropy alloys, coatings, laser cladding, alloy elements, properties

**Optimization of compound active agent for laser welding of TC4 titanium alloy based on response surface methodology**

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**Abstract** In this paper, the response surface method of Design-Expert V12 was used to design the compound active agent formula for TC4 laser welding, and the effect of active agent on the weld penetration and forming coefficient of TC4 laser welding was studied. The result showed that based on response surface method, the designed  $\text{Na}_2\text{SiF}_6$  and  $\text{Y}_2\text{O}_3$ ,  $\text{Na}_2\text{SiF}_6$  and  $\text{TiO}_2$ ,  $\text{Y}_2\text{O}_3$  and  $\text{TiO}_2$  had positive interaction on weld penetration, and  $\text{Na}_2\text{SiF}_6$  and  $\text{Y}_2\text{O}_3$ ,  $\text{Na}_2\text{SiF}_6$  and  $\text{TiO}_2$  had positive interaction on forming coefficient. TC4 titanium alloy was welded with optimized compound active agent, the weld penetration increased by 1.49 times than that of uncoated active agent, and the forming coefficient reached 0.494. Compound active agent I could not only significantly refine the coarse columnar crystal of the weld, but also refine the  $\alpha'$  phase of acicular martensite within the grain. The width of the heat affected zone was reduced, and the forming quality of the weld surface was

excellent. The tensile strength of welded joint was about 5.53% higher than that of the uncoated active agent, and the elongation after fracture was about 1.5% higher than that of the uncoated active agent.

**Key words:** response surface method, TC4 titanium alloy, laser welding, active agent

### **Effect of preheating on microstructure and hardness of AH36 laser weld**

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**Abstract** Butt welding experiment of AH36 plate by fiber laser was carried out to study the effect of preheating on the microstructure of weld. The result showed that the microstructure of AH36 joint was dominated by lath martensite(M) and a small amount of granular bainite without preheating. With the increase of preheating temperature, the cooling rate decreased, resulting in the decrease of martensite number and the increase of bainite number in the weld. When the preheating temperature was 250 °C, the microstructure was dominated by bainite and feather-like upper bainite. Microhardness of the joint was tested, and the result showed that the microhardness of the joint decreased with the increase of preheating temperature, which was consistent with the variation of martensite content in the weld.

**Key words:** AH36 marine steel, laser welding, preheating temperature, microstructure

### **Influence of preheating temperature on U75V laser cladding forming performance**

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**Abstract** The effect of preheating temperature on U75V laser cladding forming was studied, and the microstructure and hardness distribution of the cladding layer were analyzed. The results showed that when the preheating temperature was lower than 125 °C, the cladding layer appeared the defects of holes and uneven distribution of penetration depth, and the overall size fluctuated greatly. The multilayer cladding layer preheated at 125 °C had no obvious defects. After the base material was preheated, the microstructure of the cladding zone in the single-layer cladding layer changed from Widmanstätten to lower bainite, and the heat-affected zone was mainly coarse-grained martensite with little change in hardness. The microstructure of the cladding zone in the multilayer cladding layer was columnar crystals and equiaxed crystals, and the martensite in the heat-affected zone distributed in the area near the fusion line. The hardness of the cladding layer decreased after preheating, and the preheating had little effect on the martensite transformation.

**Key words:** U75V, laser cladding, preheating treatment, microhardness

### **Leakage cause of filter dryer after brazing**

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**Abstract** In view of the technical problem that the filter dryer used in air conditioning and refrigerator was easy to leak during service, ZEISS optical microscope, type microscope and Phenom XL desktop scanning electron microscope were used to analyze and compare the test results. The results showed that there were flux components and a large amount of aluminum, iron and other elements distributed in the crack of the filter dryer after welding. It was indicated that the leakage of filter after welding was partly caused by the corrosion of flux and slag inclusion de-

fect. There were obvious cracks and a large number of black slag inclusion in the unused filter dryer, which further indicated that another part of the reason for leakage of the post-welding dryer was due to a large number of defects and stress concentration, leading to the emergence of cracks. The joint action of defects and flux led to leakage in the service process of post-weld filter dryer. The existence of original defects was the source of cracks, and the existence of flux accelerated the expansion of cracks.

**Key words:** filter dryer, brazing, crack, defect, flux

### **Ultrasonic metal welding process of multilayer copper aluminum based on ABAQUS**

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**Abstract** Aiming at the process of ultrasonic welding of multi-layer same metal and single-layer dissimilar metal for the electrode lug of laminated soft package battery, ABAQUS software was used and combined with the actual welding head vibration data, as well as considering the variation law of friction coefficient of multi-layer interface, to establish a two-dimensional finite element analysis model of multi-layer copper aluminum ultrasonic welding, and the ultrasonic multi-layer copper aluminum metal welding behavior was analyzed. The results were compared with the welding temperature measured by infrared camera and the metallography of welding interface section. The results showed that friction heat and plastic deformation heat were the main heat sources in the ultrasonic welding process of multilayer copper and aluminum, and the welding plastic deformation would increase sharply when reaching a certain state. When multilayer copper and aluminum dissimilar metals were welded, the plastic deformation mainly occurred in the aluminum sheet in contact with the copper sheet. The simulation results were in good agreement with the experimental results, which had certain guiding significance for the electrode lug welding experiment of laminated soft pack battery.

**Key words:** ultrasonic metal welding, finite element analysis, dissimilar metal

### **Microstructure and properties of A508-3 steel welded joint based on tempered bead technology**

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**Abstract** Ni-based alloy electrode Ni690 was deposited on the surface of A508-3 steel with tempered bead technology for dissimilar materials, the microstructure and properties of the welded joint with temper bead was analyzed and compared with welded joint under conventional welding technology + 590 °C × 2 h post weld heat treatment (PWHT). The result showed that the hardness of coarse-grained zone of welded joint under conventional welding technology + PWHT decreased obviously, but the hardness of martensite zone did not decrease obviously. The hardness of coarse-grained zone and martensite zone of welded joints with tempered bead technology was obviously reduced. The tempered bead technology could soften coarse-grained zone and fusion zone. Although the hardness of the coarse-grained zone was about 73% ~ 89% that under heat treatment, the uniformity of joint hardness was better. From the test results, an ideal welding method for repair welding or manufacturing of large structures and avoiding PWHT was tempered bead technology.

**Key words:** A508-3 steel, tempered bead technology, post weld heat treatment, dissimilar metal welding, martensitic layer

### **Replacement and repair of nozzle stub of concentrated downcomer in steam drum**

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**Abstract** For the problems existing in the replacement and repair of nozzle stub of concentrated downcomer in steam drum, such as displacement of the downcomer, high cold crack sensitivity of welded joints and deviation of the maximum temperature from the weld during post weld heat treatment(PWHT), the corresponding technical schemes were formulated through theoretical calculation and analysis. The results showed that taking cylinder of steam drum as the load-bearing body and adopting the well-shaped suspension and fixing device could effectively prevent the excessive displacement of the downcomer in the process of cutting and repairing nozzle stub, and avoid staggering and folding of weld. Using asymmetric K-groove, reasonably arranging welding sequence of fillet joint and butt joint, increasing the preheating temperature and inter-layer temperature to 180 °C, and carrying out intermediate eliminating hydrogen heat treatment, the cold crack and other defects of BHW35 steel joint under the condition of large thick wall and high restraint were effectively avoided. The reasonable temperature field of PWHT was obtained with the main heating of the stub fillet weld and the auxiliary heating in the upper area of the steam drum corresponding to the downcomer pipe hole. After repairing, all inspections and tests were qualified, among which the hardness of the drum cylinder had no significant change from that before repair and the maximum residual stress measured in the repair area was 133 MPa.

**Key words:** nozzle stub, repair, BHW35 steel, cold crack, post weld heat treatment

### **Influence of welding defects on inside coolant quality of UHVDC converter valve water cooling equipment**

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**Abstract** In order to ensure the quality of inside coolant in the internal cooling system, the fluid pipeline and tank of the liquid receiving part of the equipment were prefabricated and welded with 304 or 316 austenitic stainless steel. Based on the unique working conditions of valve cooling equipment and the characteristics of base material, influence of welding defects on the quality of inside coolant was summarized through theoretical analysis and equivalent simulation test. The corresponding strategies for welding defects of stainless steel pipeline in valve cooling equipment was put forward, which provided a reference for improving the operation reliability of valve cooling system.

**Key words:** weld defect, inside coolant, stainless steel fluid pipe, ultra-high voltage direct current

### **Cutting and rewelding process of Canopy seal weld**

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**Abstract** In view of the problem of repairing Canopy sealing weld of drive structure of the pressure vessel in the third generation nuclear power reactor, the failed weld was cut and rewelded for repair in the paper. The repair process of Canopy weld after cutting and rewelding was studied, and the process from cutting to rewelding was discussed, as well as non-destructive testing and microstructure analysis of the rewelded weld. At the same time, the rewelded joint was compared with the welded joint that only underwent one welding with the same process, and the macrostructure and microstructure of the joint were compared and analyzed, so as to evaluate the quality of the rewelded joint. The test results showed that through controlling cutting quality of the weld and grinding the groove after cutting, the weld could be rewelded under the original process, and the rewelded weld passed the nondestructive testing. There were no harmful precipitates in the microstructure of the joint, and the weld quality was equivalent to that underwent only one welding. It was proved that the scheme of rewelding the failed welds after cutting could be used for the repair of Canopy welds.

**Key words:** Canopy sealing weld, drive mechanism, cutting replacement, rewelding