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本期责编：李 刚

电 话：(022) 27631854（编辑）

地 址：天津市南开区红旗路 196 号

邮 编：300110

E-mail: hjjsh1972@126.com

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MAIN TOPICS, ABSTRACTS & KEY WORDS

Research for 3D printing molding quality of combined spider

ZHANG Liying, QIN Guopeng
(CNNC Jianzhong Nuclear Fuel Co., Ltd., Yibin 644000, Sichuan pro., China) P1-5

Abstract: The combined spider, whitch belongs to the most demanding nuclear core products, is one of the key core products of the HRP1000 control rod assembly. In order to break through the restrictions of international patent protection and technical barriers in the domestic nuclear fuel manufacturing and accelerate the industrialization process of nuclear fuel laser 3D printing manufacturing, it is necessary to summarize the quality influencing factors in the 3D printing manufacturing of parts and study the corresponding quality control measures. Laser 3D printing is a new metal additive manufacturing technology. Compared with the traditional machining method of "reducing material manufacturing", its quality control method is more complex in thermal stress and deformation of workpiece, and has many quality influencing factors, so the process is not easy to be controlled. In this paper, the primary research results of laser 3D printing quality control method for combined spider is introduced from four aspects: raw material input control, environment and printing boundary condition control, equipment maintenance control and printing process control. This study is of great significance to ensure the quality of self-developed nuclear fuel products and the safety of nuclear power operation.

Key words: combined spider, control rod assembly, 3D printing, molding quality, nuclear grade stainless steel

A novel method for producing GH4169 spherical powder for additive manufacturing

CHEN Huanjie[1], *YANG Zhuang*[3], *LIU Zhaoyun*[2], *WANG Yingchuan*[2], *WANG Yuting*[1], *XU Hui*[1]
(1. Shenzhen Aerospace Science Advanced Material Co., Ltd., Shenzhen 518000, Guangdong pro., China; 2. Shenzhen Aerospace Technology and Innovation Industrial Co., Ltd., Shenzhen 518000, Guangdong pro., China; 3. Z-YANG Shenzhen CNC Machine Tools Co., Ltd., Shenzhen 518000, Guangdong pro., China) P5-9

Abstract: As the development of additive manufacturing technology, complex parts made of GH4169 are widely used in aerospace, automotive and energy fields. Spherical powder raw material is a crucial factor affecting the performance of additive manufacturing parts. Gas atomization is the most popular method of powder production with a high yield of fine powder and the powder size distribution is relatively narrow. However, there were some disadvantages such as relatively poor sphericity, more satellite powder and hollow powder, and serious material segregation. A novel powder manufacturing method named Arc Plasma Micro-Blasting (APMB) had been proposed and developed in this paper. The new process synergistically integrated several powder manufacturing process techniques including atomization, rotating electrode, arc blasting to produce spherical metal powders. The GH4169 powder was manufactured by this process and the results showed that it had high sphericity and good flowability. The Hall flowrate was 17 s/50 g, the apparent density was 4.34 g/cm^3, and the tap density was 4.82 g/cm^3. The main phase of the powder was γ phase, and there was no obvious Laves phase in the interdendritic region, which contented the requirements of additive manufacturing for powder.

Key words: arc plasma micro-blasting (APMB), GH4169, spherical powder, additive manufacturing

Development of stainless steel clad brazed composite pipe and analysis of its microstructure and properties

SUI Jinling[1], *LI Yunzhi*[2], *MA Limei*[1], *CHEN Qi*[1], *DING Jie*[1]
(1. Institution of Engineers, Beijing Institute of Petrochemical Technology, Beijing 102617, China; 2. National Industrial Information Security Development Research Center, Beijing 100040, China) P20-23

Abstract: In order to reduce the transportation cost of corrosive liquid in petrochemical industry, a double-layer metal clad pipe composed of 20 steel base pipe and 0Cr18Ni9 clad pipe was developed. Copper foil was placed in the middle of the double-layer tube as solder, under the protection of inert gas, after applying the preload, induction heating technology was used for brazing. The microstructure, element line distribution, shear strength, fracture morphology and alloy phase of the interface were analyzed. The results showed that the interface of composite tube was compact, mechanical engagement was formed, no coarsening was found in metallographic structure. The elements of iron, copper, chromium and nickel had diffused and migrated at the interface between copper foil and stainless steel pipe or copper foil and carbon steel pipe. A new copper nickel vanadium alloy phase was formed at the interface between copper foil and stainless steel to form metallurgical bonding. No copper containing alloy phase was formed at the interface between copper foil and carbon steel pipe, so no metallurgical bonding was formed. The average shear strength of the composite

pipe was 157.8 MPa, the shear fracture occured in the copper solder layer, and the fracture was tear dimple, which belonged to ductile fracture.

Key words: bimetal composite pipe, brazing, joint surface, microstructure and properties

Effect of impact behavior of thermally sprayed WC particles on residual stress of ultra-high strength steel

LIU Zijian[1], *YU Yun*[2], *JIA Zhihao*[1], *PEI Xiangzhong*[1], *DING Kunying*[1]

(1. Tianjin Key Laboratory for Airworthiness and Maintenance of Civil Aircraft, Civil Aviation University of China, Tianjin 300300, China; 2. Beijing Aircraft Maintenance Engineering Co., Ltd., Beijing 100621, China) P27-31

Abstract: In high-velocity oxygen-fuel spraying, the impact state of WC particles on the residual stress of 4340M ultra-high strength steel matrix after impact affects the fatigue performance of the matrix. In order to study the effect of particle velocity and temperature on the residual stress of matrix after impact, the flight status of particles was measured using SprayWatch spray monitoring device, and the residual stress of matrix was calculated using finite element method. The test results showed that the spraying parameters, spraying distance and powder type affected the speed and temperature of particle flight during the spraying process. The impact speed of tungsten carbide particles was most affected by the size of the barrel, and the impact temperature of tungsten carbide particles was most affected by the type of powder. The results of finite element analysis showed that the type of particle determines the density of the particle, and the higher the density of the particle, the greater the residual stress obtained by the matrix. With the same particle type, the faster the impact speed, the greater the residual stress at a certain impact temperature. The results of the finite element calculation were consistent with those of the Almen test.

Key words: high-velocity oxygen-fuel spraying, WC, ultra-high strength steel, finite element analysis, residual stress

Effect of different fillet weld leg sizes on deformation and residual stress of T-joint

LI Yusheng[1], *FANG Yuanbin*[2]

(1. Military Representative of the Ministry of Naval Equipment in Huludao, Huludao 125004, Liaoning pro., China; 2. Shanghai Electric Appliance Research Institute (Group) Co., Ltd., Shanghai 200063, China) P32-35

Abstract: Different fillet weld leg sizes affect the welding deformation and residual stress distribution of structural parts, which is of great significance to practical engineering. In this paper, the welding process of T-joint was analyzed by means of welding numerical simulation, and the post welding deformation and residual stress of the joint were obtained. At the same time, the correctness and effectiveness of the finite element model were verified by blind hole test. The results showed that $Z_1 \times Z_2 = 9$ mm×9 mm scheme had the minimum total deformation and equivalent residual stress peak value after welding, and $Z_1 \times Z_2 = 8$ mm×10 mm scheme had the maximum total deformation after welding, $Z_1 \times Z_2 =$ 10 mm×8 mm scheme had the maximum peak value of longitudinal and transverse residual stress. The maximum errors between the longitudinal and transverse residual stress simulation results and the test results were 8.82% and 8.43% respectively, which met the requirements of engineering application. The research provided guidance for the control of fillet weld leg size and the optimization of residual stress.

Key words: fillet weld leg size, welding deformation, residual stress, numerical simulation

Image enhancement of weld toe surface crack in construction welding of power steel pipe tower

XUE Qin, *LU Feng*, *XU Jun*, *DONG Hanyu*, *BAI Juhong*

(Huzhou Electric Power Supply Company, State Grid Zhejiang Electric Power Co., Ltd., Huzhou 313000, Zhejiang pro., China) P69-74

Abstract: In the intelligent detection of cracks on the welding toe surface of power steel pipe tower construction, the fuzzy interference caused by weather, machinery and other factors on the image needs to be considered. The features showed multi-scale properties, and the detection accuracy was not high. Therefore, the features need to be enhanced. An image enhancement method based on fusion of multi-scale features for surface cracks at weld toe of power steel pipe tower was proposed. Firstly, wavelet transform was used as a multi-scale analysis tool to extract the multi-scale features of the surface crack image of the weld toe of the electric steel pipe tower. Secondly, Bayesian was used to smooth the image. Finally, the image was defogged through pseudo dark channel calculation to detect the significant area of the image, and the significant area was gray-scale mapped according to its vector difference. Finally, the image enhancement was completed. The experimental results showed that the SNR and MSE of the surface crack image of the construction toe of the power steel pipe tower under this enhancement algorithm were 7.4 and 1.2 respectively, and the contrast measurement value was at least 3.81 and 1.71 higher than that of other methods. The processed image quality was high.

Key words: electric steel pipe tower, image enhancement algorithm, multiscale features, Bayes, wavelet transform, noise interference

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