李鹤喜[1, 2]，　王国荣[1]，　石永华[1]，　张为民[1]

（1.　　　　　　　　　　　，　　　　　510640; 2.　　　　　　　　，　　　　　　　　529020）

李鹤喜

: TG409　　　　　　　　: A　　　　　　　: 0253－360X(2008)02－0035－05

0 序 言

[4 5]

（　90°　　　　　）

[6]

[7]

, Hu

[1]

Hu

（SVD）

[2 3]，

1 图像矩阵的奇异值分解原理

$m \times n$　　　　　　　$A \in R^{m \times n}(R$　　　　　），　　　　　　　$U = [u_1, u_2, \cdots, u_m] \in R^{m \times m}$　　$V = [v_1, v_2, \cdots, v_n] \in R^{n \times n}$，　　$U^T U = I$, $VV^T = I(I$　　　　　　），

$$S = U^T A V = \begin{bmatrix} \Sigma & 0 \\ 0 & 0 \end{bmatrix} \quad (1)$$

$\quad : \quad \Sigma = \mathrm{diag}(\sigma_1, \sigma_2, \cdots, \sigma_p)$

$\sigma_i (i = 1, 2, \cdots, p) \quad A \quad (p \leqslant \min\{m, n\})$, $\quad \sigma_i^2 \quad AA^T \quad , S \quad A$

（SVD, singular value decomposition）。

$\quad 0 \quad , \quad \Sigma$

$: (1) \quad ,$

$A \quad ; \quad$

$, \quad 。(2)$

$, \quad 90°, 180°, 270°,$

$。(3) \quad ,$

SVD

SVD

$(\quad 90° \quad)$

2 焊接目标的主轴计算

$^{[8]} (\text{moments})。 \quad m \times n$

$(x, y) \quad A(x, y), \quad p+q$

$$M_{pq} = \sum_{x=1}^{m} \sum_{y=1}^{n} x^p y^q A(x, y) \quad (2)$$

$A(x, y) \quad ,$

$, \quad ,$

$, \quad 。$

(x_c, y_c)

$$x_c = \frac{M_{10}}{M_{00}}, \quad x_c = \frac{M_{01}}{M_{00}} \quad (3)$$

$: \quad M_{00} \quad ; M_{10}, M_{01}$

$x \quad y \quad 。 \quad (x_c, y_c)$

$p+q$

$$\mu_{pq} = \sum_{x=1}^{m} \sum_{y=1}^{n} (x - x_c)^p (y - y_c)^q A(x, y) \quad (4)$$

$, \quad ,$

$1 \quad , \theta \quad x \quad , a, b$

$,$

$$\theta = \frac{1}{2} \arctan\left(\frac{2\mu_{11}}{\eta_{20} - \eta_{02}}\right) \quad (5)$$

$:$

$$\mu_{11} = \sum_{x=1}^{m} \sum_{y=1}^{n} (x - x_c)(y - y_c) A(x, y);$$

$$\mu_{20} = \sum_{x=1}^{m} \sum_{y=1}^{n} (x - x_c)^2 A(x, y);$$

$$\mu_{02} = \sum_{x=1}^{m} \sum_{y=1}^{n} (y - y_c)^2 A(x, y)。$$

$(x_c, y_c) \quad 。$

图 1
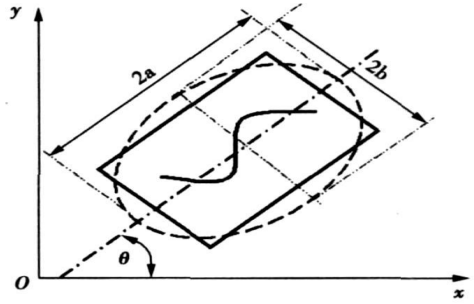
Fig. 1　Major axis of welding target

$, \quad$

$, \quad$

$。 \quad ,$

$, \quad$

$。$

a, b

$$\left.\begin{aligned} a &= \left\{\frac{2[\mu_{20} + \mu_{02} + \sqrt{(\mu_{20} - \mu_{02})^2 + 4\mu_{11}^2}]}{M_{00}}\right\}^{\frac{1}{2}} \\ b &= \left\{\frac{2[\mu_{20} - \mu_{02} + \sqrt{(\mu_{20} - \mu_{02})^2 + 4\mu_{11}^2}]}{M_{00}}\right\}^{\frac{1}{2}} \end{aligned}\right\} \quad (6)$$

3 焊接目标图像的归一化奇异值分解

$, \quad$

$, \quad , \quad 。$

$A_0(x, y),$

$\theta_0 = 0, \quad (6)$

$a_0 \quad b_0。 \quad A(x, y), \quad : ①$

$A(x, y) \quad , \quad (2)$

$(x_c, y_c); ② \quad \mu_{11},$

$\mu_{20}, \mu_{02}; ③ \quad (4) \quad (6) \quad x$

$\theta \quad a \quad b; ④$

$, \quad \theta; ⑤$

$R_l = a / a_0,$ $R_s = b / b_0;$ ⑥   SVD)   NSVD(Normalized
       ,   ; ⑦   SVD)   ,   ,
（1）   ,

$\sigma_i (i = 1, 2, \cdots, p)$。   。

                        ,   SVD   ,   360 mm × 120 mm,
       、   ,   。   ,   320 × 240   CCD   ,
                        ,   ,   ,
                                                                                                          ,

              ,   。

          , SVD   ,   。

                                       。   **5.1**   NSVD
                                                                     DSVD

4 奇异值相似判别准则

          " $\theta / R =$ /   "
                                          (   )   , θ

          ,   , x , $R = R_1 = R_s ($)
                        。 $\theta / R =$
                              。 $0^{\circ}/1.0,$ $\theta / R = 30^{\circ}/0.8,$ $\theta / R = 45^{\circ}/0.9,$ $\theta / R =$

          ,   60°/1.2 $\theta / R = 90^{\circ}/1.3$
          。   ,   DSVD
              ,   NSVD   , 1

                        ,   2   SVD   (SV)   10   。

                                                            J

$S_0 = \{ \sigma_{01}, \sigma_{02}, \cdots, \sigma_{0n} \},$
          $S = \{ \sigma_1, \sigma_2, \cdots, \sigma_n \},$

J

$$J = \frac{\sum_{i=1}^{n} [1 - \frac{\sigma_i - \sigma_{0i}}{\max(\sigma_i, \sigma_{0i})}] w(i)}{\sum_{i=1}^{n} w(i)} \qquad (7)$$

表 1 不同 θ / R 下的直接奇异值分解结果

Table 1 DSVD results at different θ / R values

奇异值	模板 0°/1.0	30°/0.8	45°/0.9	60°/1.2	90°/1.3
σ_1	98.722 3	82.795 2	80.062 0	82.761 9	98.723 0
σ_2	10.883 4	41.949 1	45.572 9	41.862 1	10.883 4
σ_3	6.082 9	19.130 2	18.816 9	19.323 6	6.082 5
σ_4	5.270 5	16.449 1	13.987 7	16.132 9	5.271 2
σ_5	4.246 8	10.804 4	13.572 8	11.197 6	4.246 7
σ_6	3.742 0	10.369 0	11.120 5	10.574 5	3.742 1
σ_7	3.593 9	7.863 4	9.449 9	7.648 4	3.594 1
σ_8	1.893 4	6.521 5	9.176 0	6.509 2	1.892 9
σ_9	1.782 7	6.080 6	7.354 0	6.112 5	1.782 7
σ_{10}	1.683 6	5.821 4	6.490 1	5.812 5	1.683 3

: n ,
       ,   , N ; $| \sigma_i -$
$\sigma_{0i} | / \max(\sigma_i, \sigma_{0i})$; $1 - | \sigma_i -$ 1   2   ,
$\sigma_{0i} | / \max(\sigma_i, \sigma_{0i})$; $w(i)$,
       $w(i) = 1 - (i / n)$ 。   ,   。

                              $J = 1,$ J 1   2   ,
                                                                                   $E = | \sigma_i - \sigma_{i0} |,$ i。

          , J 2   ,
$J_T,$ $J > J_T$,   。   1.4,   7   ,

5 试验结果与讨论

          ,
                        ,
                    ,   DSVD(Direct

表 2　不同 θ/R 值下的归一化奇异值分解结果

Table 2　NSVD results at different θ/R values

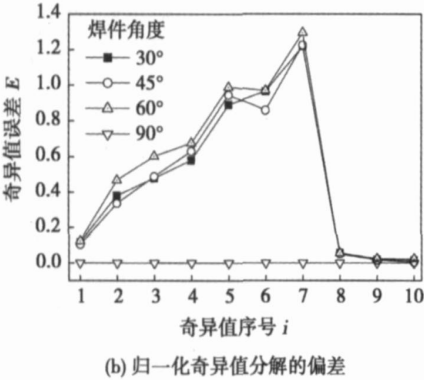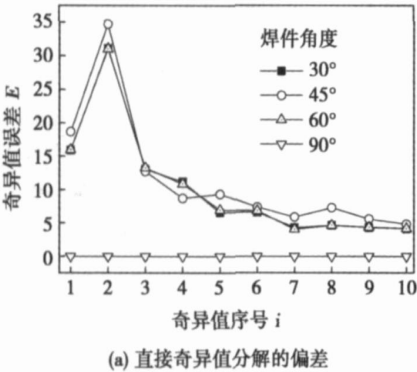| 奇异值	模板 0°/1.0	30°/0.8	45°/0.9	60°/1.2	90°/1.3
σ_1	98.722 3	98.838 6	98.825 0	98.844 8	98.723 0
σ_2	10.883 4	10.503 0	10.547 4	10.416 1	10.883 4
σ_3	6.082 9	5.603 5	5.594 5	5.479 9	6.082 5
σ_4	5.270 5	4.690 3	4.639 1	4.594 0	5.271 2
σ_5	4.246 8	3.356 9	3.301 7	3.258 2	4.246 7
σ_6	3.742 0	2.777 9	2.883 0	2.772 6	3.742 1
σ_7	3.593 9	2.375 4	2.368 9	2.298 8	3.594 1
σ_8	1.893 4	1.838 0	1.841 9	1.838 3	1.892 9
σ_9	1.782 7	1.801 6	1.799 8	1.758 9	1.782 7
σ_{10}	1.683 6	1.699 0	1.678 4	1.661 1	1.683 3

(a) 直接奇异值分解的偏差

(b) 归一化奇异值分解的偏差

图 2　直接与归一化 SVD 的奇异值偏差

Fig.2　Singular value errors for DSVD and NSVD

90°，　　　　　，　　　　　　　，
SVD　　　　　　　　　　。

5. 2　　　　　　　　　　　　　，
　　　，　　　　　　　　　　　5
　　　　，　　　　　　182，192，201，212
240，　　　　　10　　　　3　（
1　，　　　）。　3
　　　　　　　　　　　E　　　　　　。

表 3　不同灰度均值下的归一化奇异值分解结果

Table 3　NSVD results at different gray levels

奇异值	灰度均值 (182)	灰度均值 (192)	灰度均值 (201)	灰度均值 (212)	灰度均值 (240)
σ_1	99.177 1	99.190 1	100.504 3	103.574 7	124.708 6
σ_2	10.898 1	10.932 7	11.084 3	11.650 2	13.757 5
σ_3	5.974 2	6.107 1	6.163 8	7.530 0	7.550 6
σ_4	4.933 2	5.289 5	5.263 1	6.353 1	6.313 5
σ_5	3.997 4	4.259 8	4.253 5	5.552 1	5.086 8
σ_6	3.731 0	3.755 1	3.764 3	4.656 4	4.640 0
σ_7	3.518 3	3.611 0	3.674 9	3.872 4	4.422 4
σ_8	1.873 1	1.899 1	1.927 1	2.808 7	2.381 6
σ_9	1.623 4	1.782 6	1.769 3	2.725 4	2.056 8
σ_{10}	1.397 4	1.686 9	1.692 8	2.567 2	1.989 6
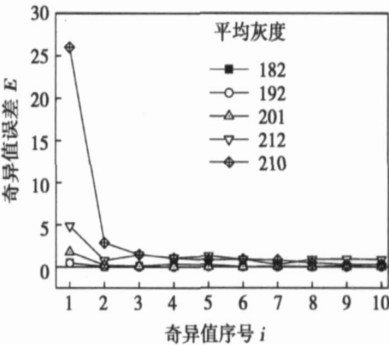
图 3　不同灰度下归一化 SVD 的奇异值偏差

Fig.3　Singular value errors under different gray levels

　　　35，　　　　　　30%，　　　　　　2
　　　　　　，　　，　　　　　　　，
　　　　　　　　，
　，　　　　　　　　，
　　　，　　　　　　　　　，
30°，45°，60°
　，　　　　　　　，
SVD　　　　　　，　　　　　　　。

　　　3　　　　　，　　　　　　　（
182，192，201，212），　　　　　　5
（5%），　　　　　　（　　　240），
　26，　　　25%。
　　　　　　　　　　　　　，
　　。
　　　SVD　　　　　。　　　，
　　　　　。

5.3

$J_T = 0.85,$

1,　2　　3　　　　　　　　,

(7)　　　　　　　　　　　　　　　　4

5, Y　　　　　　　　, N　　　　　　　　　　。

4

Table 4　Recognition results using NSVD

θ / R	J	(Y/N)
$30^\circ / 0.8$	0.902 6	Y
$45^\circ / 0.9$	0.907 6	Y
$60^\circ / 1.2$	0.886 8	Y
$90^\circ / 1.3$	0.999 7	Y
182( )	0.976 9	Y
192	0.996 1	Y
201	0.987 9	Y
212	0.855 8	Y
240	0.808 8	N

5

Table 5　Recognition results using DSVD

θ / R	J	(Y/N)
$30^\circ / 0.8$	0.365 2	N
$45^\circ / 0.9$	0.344 8	N
$60^\circ / 1.2$	0.376 1	N
$90^\circ / 1.3$	0.999 8	Y

　　　　4　　　　　　　　　,
,　　　　　　　　、
　　　　　　　,　　　　　　　　,
　　　　,　　　　　　。
　　　　,　　　　　　　　　　　　。　　5
　　　　　　　90°　　　(　　　　),　　　　　　30°,
45°　60°　　　　　　　　　,
　　　　　　　　　　。

6　结　　论

　　　(1)　　　　　　　　　　　　,

,
　　　　。

(2)　　　　　　　　　　　　　　　　,
　　　　　　　　　　　　　　　　,
　　　　　　　　　　　　　　　、
　　　　。

(3)　　　　　　　　　　　　　　,
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(4)　　　　　　　　　　　　　,

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(5)　　　　　　　　　　　,
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Email: lhx _wq@sina.com

Abstract: 2519 high strength aluminum alloy was welded with metal inert-gas welding process, and the effect of heat input on the microstructure, mechanical properties and fracture characters of the welds were studied. Results indicate that with the increase of the heat input, the second dendrite arm spacing increase and the content of solute in dendrite core decrease. After aging, the number of θ' phase decrease, but its size increase. And the morphology of the eutectic phase changes from low rod type to long band network type with the increase of heat input, which causes the fracture type from trasngrannular to intergrannular. The tensile strength reduces greatly with the increase of heat input, and the improvement of tensile strength is greater under low heat input condition after aging treatment.

Key words: high strength aluminum alloy; heat input; microstructure; fracture

Influence of diode-laser soldering procedure on mechanical properties and microstructure of Sn-Ag-Cu soldered joint

ZHANG Xin, XUE Songbai, HAN Zongjie, HAN Xianpeng (College of Materials Science and Technology, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China). p22—26

Abstract: Using different diode-laser soldering parameters, soldering experiments of Sn-Ag-Cu lead-free solder was carried out on Cu substrate using diode-laser soldering system, and the forming rules of the intermetallic compound were also analyzed in Sn-Ag-Cu soldered joints. The results show that, when the laser soldering time is 1s and the laser output power is 38.3 W, the mechanical properties of soldered joints are the best. With the change of laser soldering parameters, microstructures of soldered joints are relevantly changed. With the optimum laser soldering parameters, microstructures of soldered joint are fine and no excessive grow of Cu_6Sn_5 intermetallic compound, and the appropriate thickness of Cu_6Sn_5 layer is also got. Competitive experiments results show the intermetallic compound layer with laser soldering system is smoother than that with the IR soldering method, and the excellent mechanical properties can be abtained for the soldered joints.

Key words: diode laser soldering; lead-free soldered joint; intermetallic compound; microstructure

3D heat transfer model in laser deep penetration welding based on real keyhole

ZHANG Yi, CHEN Genyu, LI Lijun (State Key Laboratory of Advanced Design and Manufacturing for Vehicle Body, Hunan University, Changsha, 410082, China). p27—30

Abstract: The heat transfer in laser deep penetration welding includes heat conduction and convection in the welding pool. A 3D heat transfer model in laser deep penetration welding was developed. The main characteristics of the model has some characteristics as follows: (1) A prototype of the keyhole in the model was obtained from the experiments. (2) The convection and the temperature distribution in the depth were considered. (3) The same law in the solid and the liquid region, i.e. the viscosity of the material in the solid region was infinite; however the viscosity of the material in the liquid region was set to actual value. The model was solved by a finite element method, and the results show that: The isotherms in laser welding are shaped as ellipses. The temperature gradient and the velocity gradient on the front keyhole wall are greater than those on the rear keyhole wall. The convection flow in the welding pool is driven by the surface tension.

Key words: laser welding; heat transfer; mathematical model

Effect of heat treatment on microstructure and mechanical properties of high strength aluminum alloy welds

XU Lianghong, TIAN Zhiling, PENG Yun, ZHANG Xiaomu (State Key Laboratory of Advanced Steel Processes and Products, Centre Iron & Steel Research Institute, Beijing 100081, China). p31—34

Abstract: 2519 high strength aluminum alloy was welded, and the effect of aging treatment and solution treatment on the microstructure and mechanical properties were investigated. Results indicate that the aging treatment is helpful to improve the tensile strength of the joints, when the aging temperature is 150 ℃, and the tensile strength of the joints reach its max value. The tensile strength of the joints can be improved greatly by solution treatment, and with the increase of the solution temperature, the tensile strength of the joints increases. However, when the temperature reaches 540 ℃, liquid crack easily occurs, and the tensile strength will be decreased. The solution temperature can be improved to 540 ℃ by strength solution treatment, and the strength can reach 93% of that of the base metal.

Key words: high strength aluminum alloy; heat treatment; microstructure; aging

Automatic recognition of welding targets based on normalized singular value decomposition of image matrix

LI Hexi[1, 2], WANG Guorong[1], SHI Yonghua[1], ZHANG Weimin[1] (1. College of Mechanical Engineering, South China University of Technology, Guangzhou 510640, China; 2. College of Information Engineering, Wuyi University, Jiangmen 529020, Guangdong, China). p35—39

Abstract: A normalized singular value decomposition (SVD) of image matrix was presented for the automatic recognition of welding targets. In order to eliminate the dependence of SVD on the orientation and scale of a target image, the direction and length of the major axis of the target image were first determined using the 2ed-order moments, and the x-coordinate of the target image was rotated to the direction of major axis and the length of major axis was normalized, and then the SVD of the target image was completed, and the singular value obtained by the normalized SVD method can be used as the feature matching of welding target recognintion because of its stability. The contrastive recognition experiments were made using the conventional direct SVD and proposed normalized SVD for a planar weldment image with different orientations and scales. In addi-

tion, the effect of the target image brightness on SVD was also investigated. The experimental results shown that the normalized SVD method has high stability to the translation, rotation, scale and brightness of target images, and can be applied to the automatic recognition of welding targets.

Key words: singular value decomposition; moment; major axis; welding target; recognition

Experimental modeling on steady-state vibration of bonding tool in ultrasonic bonding CHENG Bao, HAN Lei (College of Mechanical and Electrical Engineering, Central South University, Changsha 410083, China). p40— 44

Abstract; The sinusoidally excited vibration of bonding tool at measurement for a ultrasonic load was measured by continuously scanning laser Doppler vibrometer PSV-400-M2(1. 5 MHz). The experimental phenomena and scanning testing results showed the steady-state vibration show uncertainty when the tightness changes; under the same tightness there is single-node in vibration, but under different tightness the node positions have changed; the velocity amplitude is not as the largest as expection. In addition, the mathematics modeling was carried out based on the vibration theory of flexible beam.

Key words: ultrasonic bonding; tightness; laser doppler vibrometer; scanning

Effect of gallium on microstructure and mechanical properties of Ag-Cu-Zn filler metals HAN Xianpeng[1, 2], XUE Songbai[1, 2], Gu Liyong[3], GU Wenhua[3], ZHANG Xin[1] (1. College of Materials Science and Technology, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China; 2. Province Key Laboratory of Advanced Welding Technology, Jiangsu University of Science and Technology, Zhenjiang 212003, Jiansu, China; 3. Changshu Huayin Filler Metals Co., Ltd., Changshu 215513, Jiangsu, China). p45— 48

Abstract; Spreadability, microstructures and mechanical properties of brazed joints of silver filler metals with different content of gallium were studied. The results show that silver filler metals with excellent spreadability and sound mechanical properties of brazed joint can be developed by optimizing the compositions of silver filler metals with gallium. By using brass plates as base metal and brazing with flame method, the mechanical properties of the joints brazed with lap-joint and butt joint were examined and analyzed. The results indicate that the fractures of two kinds of brazed joints had happened on the base metal, which shows better mechanical properties of the joints brazed with the silver filler metals with gallium and an substituted the silver filler metals with cadmium completely.

Key words: silver filler metal; spreadability; mechanical property; microstructure

Wettability and interfacial reaction product of electron beam

brazing of Ni-base superalloys K465 WANG Gang[1], ZHANG Binggang[1], FENG Jicai[1], HE Jingshan[1], MA Yibin[2](State Key Laboratory of Advanced Welding Production Technology, Harbin Institute of Technology, Harbin, 150001, China; 2. Institute of Space Medicoengineering, Beijing 100094, China). p49— 52, 56

Abstract; The vacuum electron beam brazing (VEBB) of Ni-base superalloys with BПр27 and BNi-2 filler metals was studied. In process of VEBB, effects of primary brazing parameters on wettability and selection of filler metals were investigated, then it points out that electron beam current is the most significant factors. Moreover, microstructure of brazed joint with Bтр27 filler metal was studied by means of scanning electron microscope, energy disperse spectrum and X ray diffraction. The investigation shows that the structure of brazing seam consists of a large amount of γ solid solution, a large amount of Ni_3B and CrB rich in W, and a small quantity of NbC.

Key words: electron beam; brazing; wettability; interfacial reaction product

Effect of magnetic field frequency on properties of Fe5 surfacing metal LIU Zhengjun[1], SU Yunhai[1], LU Hailong[2](1. School of Materials Science and Engineering, Shenyang University of Technology, Shenyang, 110023; 2. School of Jilin industry profession technique, Jilin, 132013). p53— 56

Abstract; The Fe5 alloy was overlaid on low carbon steel by plasma arc with longitudinal magnetic field. The scanning electron microscope, wear loss test, micro-hardness test were used to analyze the effect of magnetic field frequency on properties of surfacing metal. The results indicate that electromagnetic stirring can improve the shape and distribution of hard phase and refine the primary crystallization structure. The hardness and wear resistantance vary with magnetic field frequency. The properties of surfacing metal are improved when the magnetic field frequency in an optimal value.

Key words: plasma arc surfacing; longitudinal magnetic field; electromagnetic stirring; magnetic frequency

Influence of rare earths on Fe-based amorphous composite coatings by laser cladding ZHU Qingjun, ZOU Zengda, WANG Xinhong, QU Shiyao (School of Materials Science and Engineering, Shandong University, Jinan 250061, China). p57— 60

Abstract; The influence of rare earths (RE) on the laser cladded Fe-based amorphous composite coatings was investigated by micor alloying. X-ray diffraction and scanning electron microscopy was used to study the phase, microstructure and the influence of RE on the fabrication of the amorphous phase. The results show that the glass formation ability of the Fe38Ni30Si16B14V2 amorphous alloy can be enhanced by micor alloying of RE which is helpful for the synthesis of the amorphous phase under the condition of laser cladding. The crystallzation system of the amorphous alloy is changed by the addition of RE. It enhances crystallzation of the γ-Fe, Ni phase and depresses the crystalline of Fe_2B phase while the