ANALYZE AND RESEARCH OF CORROSION RESISTANCE OF LASER CLADDING LAYER ON THE ANTI-ACID STAINLESS STEEL SURFACE

Geyan Fu[1] , Jianjun Shi[2], Tuo Shi[3]

[1]*Soochow University, China; Email:Fugeyan@suda.edu.cn.* [2]*Soochow University, China.* [3] *Dongnan University, China.*

Abstract: The effect of coating, which is formed with laser cladding and plasma spray welding on the base metal of anti-acid stainless steel, on anti-corrosion has been analyzed and studied. A 5KW laser with CO2 flow transverse is used for cladding Co-base alloy or Ni-base alloy powder replaced on the base metal. Comparing with the plasma spray welding layers, the laser cladding layers have lower defect rate and higher product rate. The result of test shows that the laser cladding layers have higher corrosion resistance properties.

Key words: laser cladding, plasma spray welding, corrosion resistance.

1. FOREWORD

In petrochemical industry, reactor and nuclear power plants, varieties of anti-acid stainless steel valves are widely used. The working mediums in these sectors are corrosive and even radioactive. The results of the corrosion not only destroy the sealing face and shorten the life of the valves, but also can cause the laying off or production halts because of the leakage of the mediums and may pollute the environment and even cause the vicious accidents. The quality of the sealing face is the important index checking the valves' fundamental characteristics. For the stainless steel valves, the requirements are even higher. The way of strengthening the sealing face of the high parameter stainless steel valves is by bead overlaying welding on the valves directly, but not inserting[1,2].In this article, the laser cladding layer on the surface of 20HJ63-20P stainless valve and methylamine-pump

Please use the following format when citing this chapter:

Fu, Geyan, Shi, Jianjun, Shi, Tuo, 2006, in International Federation for Information Processing (IFIP), Volume 207, Knowledge Enterprise: Intelligent Strategies In Product Design, Manufacturing, and Management, eds. K. Wang, Kovacs G., Wozny M., Fang M., (Boston: Springer), pp. 723-728.

valve in urea production line, and comparied in property of anti-corrosion with traditional plasma spray welding coating.

2. EXPERIMENT CONDITIONS

The valve used in this experiment is 20HJ63-20P cut-off valve used in nuclear power station and 3W-2BJ1 in-outlet valve of methylamine-pump used in urea production line. The materials are both austenite stainless steel, and the chemical constitutions (Wt%) are: 0.08%C, 1%Si, 2%Mn, 12%Ni, 18%Cr, 0.7%Ti, 3%Mo. There are two kinds of specimens: square and annulus. Cladding layer is made of a HGL-90 5kW laser with CO_2 flow transverse. The alloy powder of Co-base or Ni-base is used on the coat of sealing face, which is glued by 2123 PF resins. The thickness of the presetting layer is from 1 to 3.5mm according to different requirements. The laser cladding is done on the 2-dimension numeric linked platform. The square specimens are done using multiple tracks scanning and the lap of splice is half of the laser spot's diameter. The annulus specimens are done on the numeric gyrated platform using single track scanning. The process parameters are: laser power $P = 2000 \sim 3000$ kW, scanning speed $v = 8 \sim 12$ mm/s, spot dimension $\phi = 5$ mm. To compare with the traditional process, other specimens which are machined by plasma spray welding. Alloy powder and thickness of the coating are the same as the laser machining. The pattern of the welding machine is DP-500, and the blowpipe is LFH, using flour handing.

After the experiment observe and analysis, the microscopic structure of the laser cladding layer, grade the grains, measure the thickness of the layer and the width of the micro hardness and heat-affected zone and analysis the defects of the layer. We used MEF3 optical metallographic microscope to observe in microscopic structure of the layer. We also observe and analysis the pattern of the melting zone and basal body using the JSM35C made in Japan and S650 and SEM, and assay the component of the site and appraisal the rate of dilution of the laser cladding layer using EDX-9100 energy spectrometer.

3. DETECT AND ANALYSIS COMPARISON

Fig.1 and fig.2 show the metallurgical structure of the cladding layer and indentation photo of microhardness test of the laser cladding and the plasma spray welding. It can be divided into 3 areas: melting zone, bonding zone and basal body along the vertical direction to the machined surface. The texture of the laser melting zone is minute and homogeneous, the measuring grain degree is grade 11~12, and the width of the bonding zone is 5~20um; while the texture of the plasma spray welding is rougher, the grain degree is grade 9~10, and the width of the bonding zone about 80~120 μ m. The quality of the cladding layer is measured among the 100 dissected specimens. The yield of non-defect of the laser cladding is above 95%. While there are many defects such as crack, voids, foreign materials in plasma spray welding coating. Seen in fig.3 and fig.4, the yield is about 65%. While we test the micro-hardness along the crucible zone of the top middle and down layer in lengthwise direction and from the edge to center in cross direction, the area of indentation can be seen in fig.1 and fig.2. The result shows that the mean micro-hardness of laser cladding is $HV_{200g} = 581$ kg/mm^2, and it is 20%~40% higher than the spurt welding of the same flour, and the uniformity is also higher than the spurt welding in both lengthwise and cross direction.

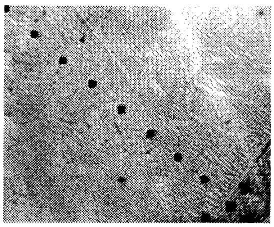

Figure 1. laser clad layer and its combination region

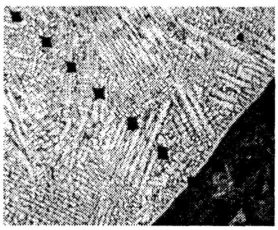

Figure 2. plasma-spray welding layer and its combination region

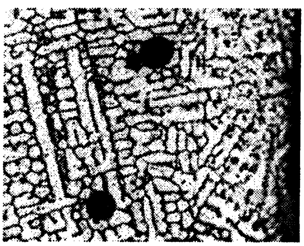

Figure 3. gas holes in the lower part of plasma-spray welding layer

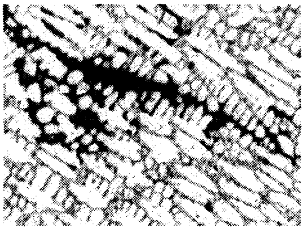

Figure 4. impurity in arborescent crystal of plasma welding layer

Observed by the energy spectrometer, the mean content of the Ti, Fe and Ni in the laser cladding layer are diluted to 0.075%wt, 8.58%wt and 1.385%wt by the basal body. While in the plasma spray welding layer the mean content of the 3 elements are 0.83%wt, 16.19%wt and 2.06%wt. It can be seen that the rate of dilution to the 3 elements of the plasma spray welding are 10 times, 2 times and 1.5 times higher than the laser cladding. As for the loss factor of the Co, Cr and W diffuse to the heat-affected zone and basal body, plasma spray welding coating is more serious than laser cladding layer.

According to the test results, the analysis can be gotten below:

(1) The basic difference between the two kinds of technology is the different heat source. Comparing the high-energy laser beam with the plasma arc, the former have the characteristics of quick heating-up, high temperature, short actuation duration and concentrated heat source. The laser cladding can get a high speed of 10^5~10^6C/s of the heating-up and cooling velocity of the crucible zone. The laser beam can melt the flour layer instantly, and at the same time melt the surface of the basal body and make it combine with the crucible zone to form firm metallurgy layer. The high-speed heating-up and cooling shorten the actuation duration, decrease the melting percentage of the basal body, reduce the diffusion of the elements between the crucible zone and the basal body and minish the dilution rate. Because of the smaller energy density of the plasma spray welding, the heat-affected duration is longer so that the diffusion between the crucible and the basal body is aggravated and the width of heat-affected zone become lager so that increase the pollution of the crucible zone. Because of the high-speed heating-up and cooling of the laser cladding, the metallurgy elements in the melting bath can form many kinds of chemical compounds quickly so that the number of the non-self crystal nucleuses increase and it greatly improves the nucleation rate so that many small and homogeneity microscopic structure form. The minute structure can improve the bonding force at the grain boundary and strengthen the work piece's strength and ductility. The minute structure not only reduces the impurity content at every unit of grain boundary, but also

monishes the components' aliquation degree during the quick cooling so that monishes the affection of corrosion generated by the galvanic cell effect.

(2) In laser machining, the laser beam can generate convection mass transfer effect in the melting bath[3,4]. It can agitate the melting bath fully and the bubbles in the melting bath rise up with the foreign materials to form the dense layer. This improves the quality of the crucible zone. While the plasma spray welding uses plasma to melt the flour and then accelerate to a certain speed and eject to the surface of the basal body through the air. During this process, many bubbles and contaminant may distribute among the large arborescent crystal at the cladding layer and interface, see fig3 and fig4. Electrochemical inhomogeneity generated by the non-metal foreign material, the inhomogeneity of chemical constitution because of the dilution of the crucible zone and the inhomogeneity of the metal texture reduce the corrosion resistance.

4. THE CORROSION RESISTANCE OF THE CRUCIBLE ZONE

We use the method of linear cutting to get two kinds of layer as test piece, and one is the laser cladding layer with the same materials as the basal body, the other is the plasma spray welding layer, and 4 pieces are needed for each. The corrosion experiment is done by throw them into different solutions. The solutions are placed in the water channel of 60℃ to keep its temperature, and the test pieces of two different technologies will be corrupted in the four different solutions for 8 hours, 24 hours, 48 hours and 72 hours. Before weighing the loss weight with rigorous analysis balance, clean the test pieces. The test results and analysis data are shown in table 1. P in column 2 table 1 stands for the test piece of plasma spray welding, while L stands for laser cladding. The unit of corrosion speed in the table is $g/m^2 \cdot h$, i.e. the loss weight of the test piece by corrosion in every 1 hour and every 1 square. From the data, it is concluded that the corrosion speed of the laser cladding test pieces in the four solutions (H_2SO_4, HNO_3, NaOH and urea) are all lower than the speed of plasma spray welding test pieces, so it has a better corrosion resistance, especially in the solutions of H_2SO_4 and HNO_3.

Table 1. the test results of corrosion

the corrosion medium	test piece	the corrosion speed($g/m^2 \cdot h$)			
		8h	24h	48h	72h
10%H_2SO_4	P	139.98	133.96	79.28	
	L	5.28	3.53	2.55	
speed ratio	P/L	26.5	37.95	31.1	

		the corrosion speed($g/m^2 \cdot h$)			
10%HNO_3	P	629.85	233.19	127.22	
	L	1.83	0.67	0.46	
speed ratio	P/L	344.2	348	276.6	
20%NaOH	P	0.043	0.070	0.047	0.043
	L	0.039	0.066	0.036	0.028
speed ratio	P/L	1.10	1.06	1.30	1.53
30%urea	P	0.664	0.415	0.37	0.345
	L	0.55	0.349	0.0246	0.186
speed ratio	P/L	1.21	1.19	1.50	1.85

5. CONCLUSIONS

(1)By comparing the two kinds of surface strength technologies on anti-acid stainless steel surface, it is found that the laser cladding is better than plasma spray welding. Because of the high speed melting and cooling generated by the energetic laser beam scanning, the melting bath is formed on the basal body surface and at the effect of convection mass transfer, the minute and dense layer with no voids and foreign materials is formed. It can realize the metallurgical bonding between the coating layer and the basal body. It reduces the dilution rate and diffusion rate of the components of the crucible zone, and improves the hardness and strength and corrosion resistance. The carbon content in the flour can reduces properly, so that the corrosion resistance will be improved.

(2) The corrosion speed of the laser cladding test pieces in the many kinds of solutions is lower than the speed of plasma spray welding test pieces, so it has better corrosion resistance, especially in the solutions of H_2SO_4 and HNO_3.

6. REFERENCES

1. Gao Qing-bao., (1994), The bead weld technology of valve, *Mechanical Industry Press*, pp. 305–416.
2. Yang Yuan-yuan., (1995), Hand book of valves design, *Mechanical Industry Press*, pp. 398–440.
3. Wang Jia-jin., (1992), The laser machining technology, *China Measurement Press*, pp. 274–279.
4. Zhengzhong Gguang., (1998), handbook of laser processing technique, *Measurement Press of China*, pp. 255–264.