Transactions of JWRI, Special Issue on WSE2011 (2011)

Effects of Welding Parameters on Metal Transfer Process in Rotating Arc Narrow Gap Horizontal GMAW

–Metal transfer of rotating arc narrow gap horizontal GMAW–

Ning GUO*, Jing ZHANG*, Yanfei HAN*, Linlin ZHANG* and Xin YUAN*

***Shandong Provincial Laboratory of Special Welding Technology, Institute of Oceanographic Instrumentation, Shandong Academy of Science, No.28 Zhejiang Road, Qingdao 266001, China**

KEY WORDS: (Metal transfer) (Droplet transfer) (Rotating arc welding) (Horizontal welding) (Narrow gap welding) (Welding process)

1. Introduction

The horizontal gas metal arc welding (GMAW) technology is used increasingly, especially in the manufacture field of the large and heavy structure parts because of its considerable flexibility and productivity[1]. The rotating arc process was used to improve the sidewall penetration in the flat position[2, 3], seam tracking[4-6] and prevent the molten pool sagging during the horizontal welding[7].Recent research results showed that the rotating arc welding process could effectively improve the weld formation of narrow gap horizontal welding[7].

However, a better understanding of the metal transfer mechanisms involved in the GMAW process is still imperative and would be most useful for precise control of the geometry and the quality of the weld bead[8-11], as well as for control of heat input in the substrate. The metal transfer in GMAW was almost studied only by the computed simulation method. The experimental results of rotating arc narrow gap welding were rarely reported, especially in horizontal position.

With the development of welding technology, a number of sensing techniques have been used, e.g. sensing of airborne sound, sensing of welding arc voltage, sensing of arc light and high-speed photography. Compared with other methods, photography can directly provide information on the droplet-transfer rates and the droplet shapes [12]. In this paper, the metal transfer of rotating arc narrow gap horizontal welding was studied by the high-speed photography system. The emphasis was placed on the analysis of the effects of welding parameters on metal transfer process.

2. Experimental Apparatus and Procedure

In this work, a FASTCAM SUPER10K high frame rate digital camera (3000frames/s) is used to obtain the images of the molten pool formation process in real time. A continuous xenon lamp is used as the back-lighting source. The welding power source is KEMPPI PROMIG5000. The power source is operating in constant wire-feed and constant voltage mode. The square groove with the width of 9mm and depth of 20mm is applied during the welding process. The diameter of the wire is 1.6mm.

3. Results and Discussion

3.1The Effect of Arc Voltage on Metal Transfer

Under the same process parameters, the metal transfer processes in different arc voltages are studied, the effects of the arc voltages on metal transfer in the rotating arc horizontal welding are presented.

Metal transfer with arc voltage of 26V is shown in Fig.1. The arc length is short with the lower arc voltage. During the wire downward motion, the tip of the wire presents penpoint shape which is the characteristic of spray transfer. But the short circuiting appears due to the short arc length. During the wire upward motion, the low wire melting efficiency, the slow metal transfer frequency and large droplet size present the globular transfer mode. When the wire moves to the location near the sidewall of the groove, the metal transfer transforms to short circuiting transfer. When the wire moves to the central of the groove, the metal transfer transforms to globular transfer mode again. So with arc voltage of 26V, the short circuiting transfer mode exists in the welding process, the globular transfer mode appears only at the location of groove center.

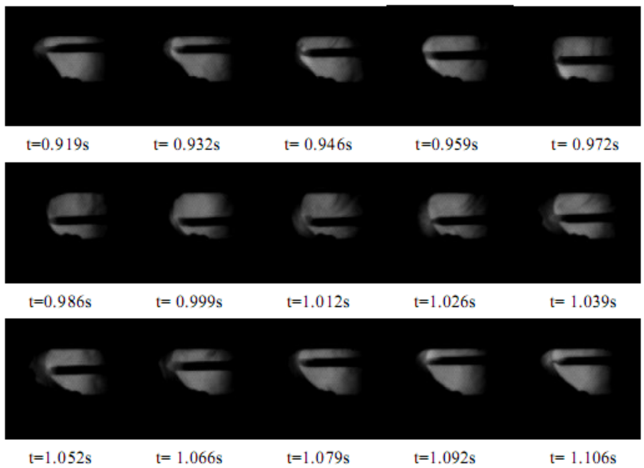

Fig.1 Droplet transfer with arc voltage of 26V

Metal transfer with arc voltage of 29V is shown in Fig.2. It indicates that the mode of metal transfer is spray transfer during the whole process. The transfer frequency is smooth in all areas except the central area, where the transfer frequency is slower during the process of wire upward motion. The short circuiting seldom appears.

Metal transfer with arc voltage of 30V is shown in Fig.3. It can be seen that the metal transfer mode is similar with that of 29V. While the metal transfer frequency larger and the droplet size smaller than that of 29V.

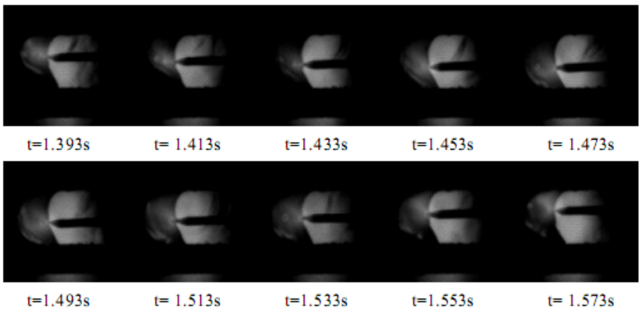

Fig.2 Droplet transfer with arc voltage of 29V

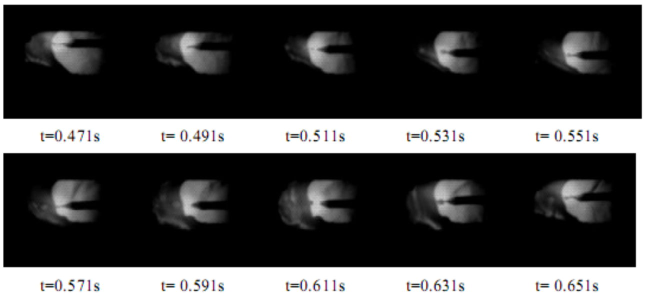

Fig.3 Droplet transfer with arc voltage of 30V

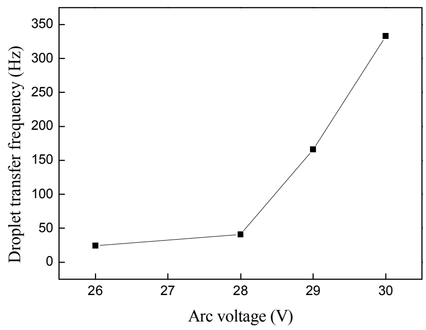

Fig.4 Arc length and droplet transfer frequency with different arc voltage

In a rotating period, the rotating arc length and the metal transfer frequency are different at different locations. Therefore, the metal transfer frequencies at the location of the groove centre when the wire moves upwards are compared. Metal transfer frequency at this position with different arc voltages is shown in Fig.4. Under the same parameters, the metal transfer frequency increases with the arc voltage. The welding current increases a little due to the rise of arc voltage. The arc length is short with the lower arc voltage. So it presents short circuiting transfer mode even though the tip of the wire presents the characteristics of spray transfer. When the voltage increases to 28V, the obvious spray transfer appears near the sidewall of the groove due to the increase of welding current. Globular transfer and short circuiting appear only at the centre of the groove. When the voltage increases to 29V or 30V, the spray transfer appears during the whole period while it includes a small number of globular transfers in the centre. The short circuiting transfer does not occur. Therefore, with the rise of arc voltage, welding current and arc length increase. It can be seen that the metal transfer changes from globular transfer and short circuiting transfer to spray transfer, the transfer frequency increases accordingly.

3.2 The Effect of Wire Feed Rate on Metal Transfer

The metal transfer with wire feed rate of 4m/min is shown in the Fig.5. The metal transfer is spray transfer mode near the lower sidewall. It transforms to globular transfer when the wire moves upwards to the centre of the groove and transforms to spray transfer when the wire moves to the upper sidewall again. The transfer mode does not change during the downward movement. Just the transfer frequency lowers and the droplet size increases at the central area.

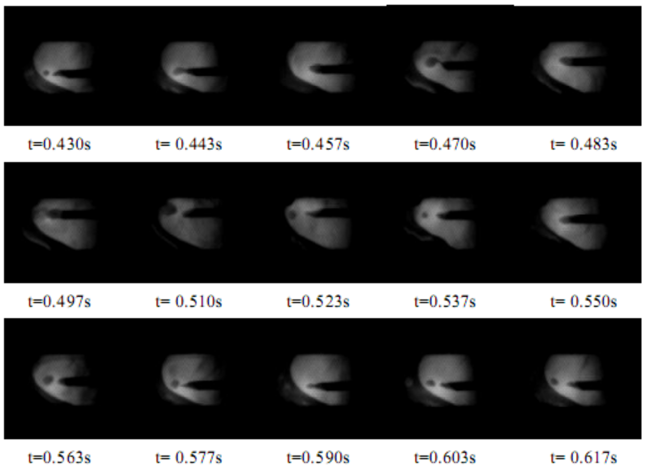

Fig.5 Droplet transfer with wire feed rate of 4m/min

The metal transfer at wire feed rate of 6m/min is shown in the Fig.6. It can be seen that the wire extension stretches very long with the high speed wire feed making the arc voltage low and arc length relatively short. But because the welding current increases, the metal transfer presents spray transfer mode during the whole process. Just because the tip of the wire is near the molten pool surface, the short circuiting occurs frequently.

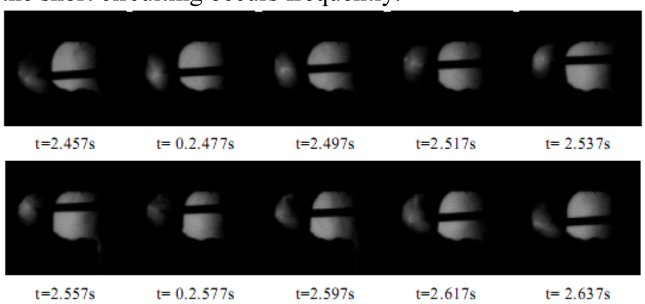

Fig.6 Droplet transfer at wire feed rate of 6m/min

In this paper, the method that constant voltage with constant wire feed is adopted. So the wire feed rate changes the welding current directly. But with the other parameter unchanged, different wire feed speeds presents different equilibrium position of wire feed rate and of wire melting rate. With different wire feed speeds, the wire extension stretches variously. This will directly causes the different arc length. With a slower wire feed speed, welding current is small. The metal transfer mode is based on spray transfer and globular transfer at this time. The short circuiting rarely happens because of the long arc length. With the high wire feed speed, the metal transfer is spray transfer mode due to the improvement of welding current, but because of the long wire extension making a shorter arc length, the short circuiting transfer occurs frequently.

Conclusions

1. The metal transfer process with different welding parameters in rotating arc narrow gap horizontal welding is observed by the high-speed photography system.

2. The transfer mode in different areas of groove presents different mode with different arc voltage and wire feeding rate.

Acknowledgements

The research was supported by National Natural Science Foundation of China (Grant No. 51005141)

References

[1] K. Christensen, T. Sorensen, J. Kristensen, Sci. Technol. Weld. Join. 10 (2005)32-43.
[2] F. Matsuda, Narrow Gap Welding, Japan Welding Society/Kuroki Press, Osaka, 1984.
[3] J. Wang, Y. Ren, F. Yang, H. Guo, Sci. Technol. Weld. Join. 12(2007)505-507.
[4] Y. Shi, W. Yoo and S. Na, Sci. Technol. Weld. Join. 11(2006)723-730.
[5] E. Halmoy, Sci. Technol. Weld. Join. 4(1999)347-351.
[6] C. Kim, S. Na. Proc. IME. BJ. Eng. Manufact. 215 (2001)1281-1288.
[7] C. Yang, N. Guo, S. Lin, C. Fan, Y. Zhang, Sci. Technol. Weld. Join. 14(2009)172-177.
[8] R. Kovacevic, In Proceedings of the MoldMaking Conference, Rosemont, Illinois, 3-5 April 2001, 263-276.
[9] S. Kim, A. Basu, E. Siores, Int. J. Adv. Mfg Technol. 12(1996) 393-401.
[10] L. A. Jones., T. W. Eagar, J. H. Lang, J. Physics D: Appl. Physics, 31(1998)107-123.
[11] H. E. Beardsley and R. Kovacevic: In Proceedings of the 31stCIRP International Seminar on Manufacturing Systems, Berkeley, California, 26-28 May 1998, PE99-126-1-PE99-126-6.
[12] Y. Wu, R. Kovacevic, Proc. Inst. Mech. Eng. B, J. Eng. Manuf. 216(2002)555-564.