Title	Microstructure and mechanical properties of overlaying specimens in GMAW hybrid an additional longitudinal electromagnetic field
Author(s)	Luo, Jian
Citation	Transactions of JWRI. 2010, 39(2), p. 97-99
Version Type	VoR
URL	https://doi.org/10.18910/5643
rights	
Note	

Microstructure and mechanical properties of overlaying specimens in GMAW hybrid an additional longitudinal electromagnetic field†

LUO Jian*

KEY WORDS: (Thermal mechanical property) (GMAW) (Magnetic field) (Overlaying welding) (Microstructure)

1. Introduction

Hot forge moulding has several remarkable advantages, including high working performances, high precision, high wear resistance (especially the red hardness) and good ductile plasticity, the bimetal material used in hot forge mould is subjected to the rigorous working environment on the hot forge process. The GMA Welding with a longitudinal electromagnetic field (LMF-GMAW) is one of the overlaying welding methods, which is of low cost and the high performance to manufacture the bimetal thermal forming mould. However, there is still a lack of practical detailed understanding of the thermal mechanical property about the LMF-GMAW work pieces.

In this paper, we focus on the need for understanding the thermal mechanical property of these work pieces with overlaying hard alloy components on the carbon steel base by using the LMF-GMAW method.

2. A New Experimental Method

The LMF-GMAW overlaying system consists of an induction coil with 350 turns and a multifunctional excitation power source, which can provide the coil with a variable polarity pulse current. The coil is filted on the torch and it can create a double polarity alternating electromagnetic field, because the direction of the additional magnetic field is coaxial with the axis of welding arc, so it is called the longitudinal magnetic field. The basic principle of LMF-GMAW overlaying system is schematically shown in **Fig. 1**. The based material Q235 carbon steel (0.14~0.22% C, 0.12~0.3% Si, 0.3~0.65% Mn, P and S controlling content, wt%) is used. The wire is the Cr-Ni-Mo series flux-cored CO2 arc welding wire, namely 414N (11.47% Cr, 3.02%Ni, 0.707% Mo, 0.055%C, 0.67%Mn, 0.2Si%, 0.013%W, 0.010Nb%, 0.011%V, 0.054%Cu, 0.006%Co, 0.023%Ti, 0.001%B, 0.089%N, 0.005%As, 0.006%S, 0.016%P, wt%).

The welding parameters are listed as follows: welding current is 200A, welding voltage is 28V, hybrid electromagnetic field is 0.02T, Preheating temperature is 200℃, Magnetic field frequency is 10Hz, CO_2 shield gas flowing is 18 L/min, welding speed is 520 mm/min.

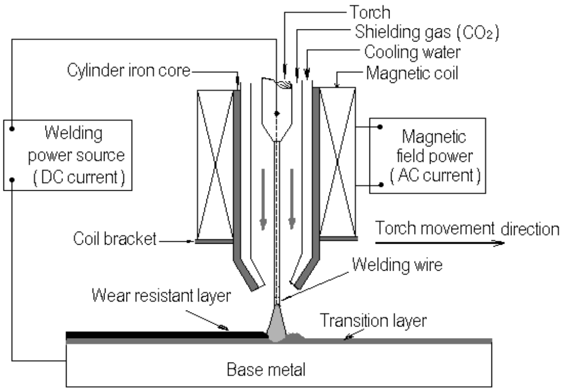

Fig. 1 Diagram of the LMF- GMAW overlaying system

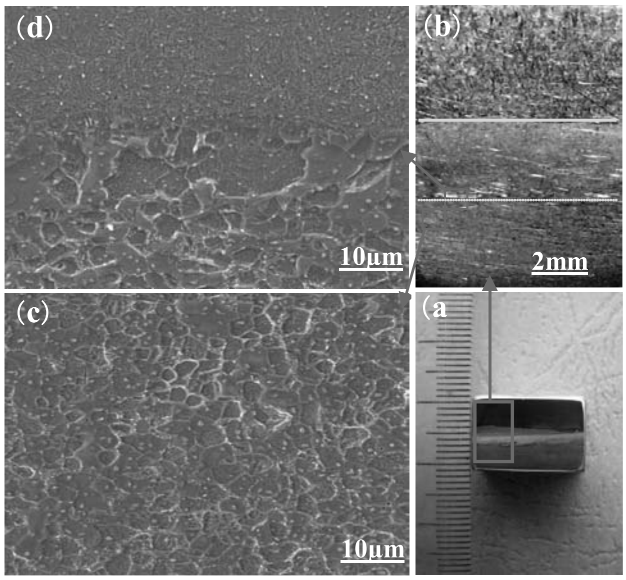

Fig. 2 Microstructure of the surface deposited layer on LMF-GMAW work pieces

† Received on 30 Sep. 2010
* The State Key Lab of Mechanical Transimission, Chonging University, China

Transactions of JWRI is published by Joining and Welding Research Institute, Osaka University, Ibaraki, Osaka 567-0047, Japan

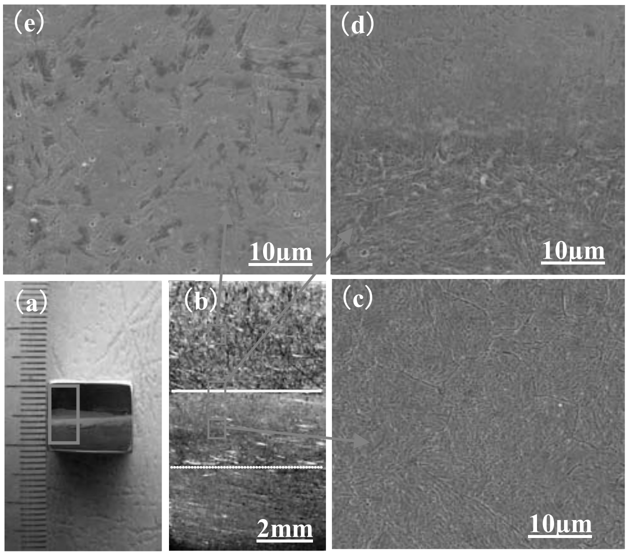

Fig. 3 Microstructure of the transition deposited layer on LMF-GMAW work piece

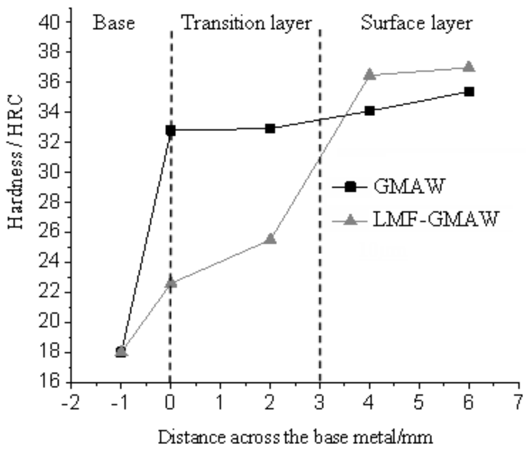

Fig. 4 Hardness of overlaying workpiece

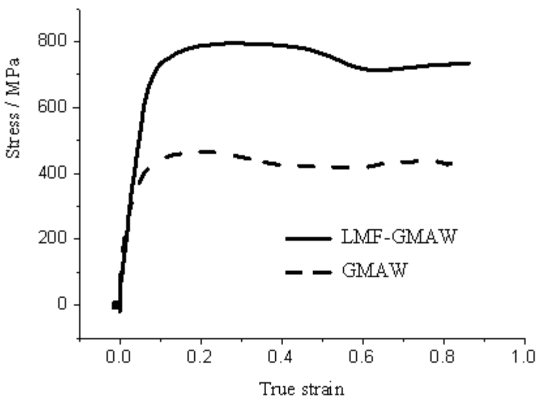

Fig. 5 True stress- strain curves of overlaying work pieces with a 70% deformation ratio and $5s^{-1}$deformation rate speed on the condition of 600℃ deformation temperature

3. Results and Discussion

Figure 2a and b show overlapping specimen and can be divided into three zones: base metal (seen in Fig. 2c), transition layer (seen in **Fig. 3**c) and surface layer (seen in Fig. 3e). Fig. 2d shows the grain is rough in the heat affected zone (HAZ), there is little obvious boundary from the base metal to the transition layer. But there is no obvious boundary line between the transition layer and the surfacing layer shown in Fig. 3d. The microstructure of the transition layer is made up of some reticular formations, which look like a spiked shape in the grain (shown in Fig. 3c). The microstructures of the surface layer are some regular lath martensite phases and dispersed hard particles resulting in a high wear resistance performance (shown in Fig. 3e).

Figure 4 shows the hardness value of the surface layer of the LMF-GMAW overlaying specimen is obviously higher than that of a conventional GMAW overlaying specimen. But the hardness of LMF-GMAW overlaying specimen increases continuously and smoothly depending on the distance from base metal, this typical hardness distribution is a very ideal distribution status, especially for the application of hot forming mould, which indicates that the gradient deposited layer has a good ductility and joining strength. So the hardness on the surface layer can be matched to the wear requirement, which is proved by the following wear experiment.

The hot compression experiment is used to evaluate the thermal mechanical property by a GLEEBLE-1500D machine in the hot forming mould's application environment. The thermal mechanical property shows the deformation resistance of the LMF-GMAW overlaying specimen is higher than that of general GMAW overlaying specimen for the same welding condition. The average difference value of true stress is near 400Mpa between the LMF-GMAW specimen and GMAW specimen. The deformation resistance of LMF-GMAW overlaying specimen is much greater than that of the general GMAW overlaying specimen, in other words, the thermal mechanical property of LMF-GMAW specimen is much better than that of general GMAW overlaying specimen, shown in **Fig. 5**. After some hot compression experiments, cracks are generated in the general GMAW specimen, but not in LMF-GMAW specimen, The different deformation shapes also show the hybrid additional longitudinal electromagnetic field can improve ductile plasticity of overlaying work pieces.

The wear testing result demonstrates that friction loss of the LMF-GMAW overlay specimen is lower than that of conventional GMAW overlaying specimen, the friction loss is decreased by an average 5% value, so the wear resistance property of the LMF-GMAW overlaying specimen is significantly improved. It also means that the additional longitudinal magnetic field can effectively improve the wear resistance performance of GMAW overlaying work pieces, besides the key material factors. The affecting mechanisms of LMF are given in our previous paper [1].

(a) LMF-GMAW work piece

(b) GMAW work piece

Fig. 6 The deformation shape of work pieces after hot compression experiment

4. Conclusions

Based on the comparison study of microstructure and mechanical properties between LMF-GMAW specimen and general GMAW, we conclude that LMF overlaying method can increase surface hardness, reduce surface friction loss, improve wear resistance, and enhance the thermal physical mechanical property of specimens.

References

[1] Luo J, Lin Y, Luo Q and Wu YX, Sci. Technol. Weld. Join., 9(2004),pp 465-469.