

Development and further improvement of a heat-treatment system using an arc driven by alternating magnetic field

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Mechanical properties of a metal are modified by various heat treatments. A novel heat-treatment system is developed using a transferred arc which is driven by an alternating magnetic field imposed perpendicularly. The arc swings like a pendulum synchronizing with the change of the magnetic field. The amplitude of the arc motion and the distribution of the heat flow can be controlled by the flux density and the wave form of the imposed field. More than three times increase in Vickers hardness is obtained after the heat-treatment of carbon steel. Tiny melted spots are often scattered on the treated surface. Detailed observation reveals that the irregular movement of the anode spot results in such damage. Further study is required to understand why such irregularity occurs in the arc motion.

1. Development of the heat-treatment system

In an alternating magnetic field imposed to an arc perpendicularly, the anode root swings back and forth as shown in Fig.1.

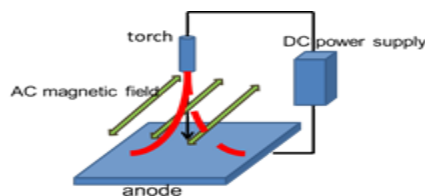


Fig.1 Schematic illustration of an arc driven by alternating magnetic field

The amplitude of the arc motion increases with the increase of the magnetic flux density. The heat flux distribution can also be controlled by changing the wave form of the alternating field. Considering these advantages, a novel heat treatment system has been developed.

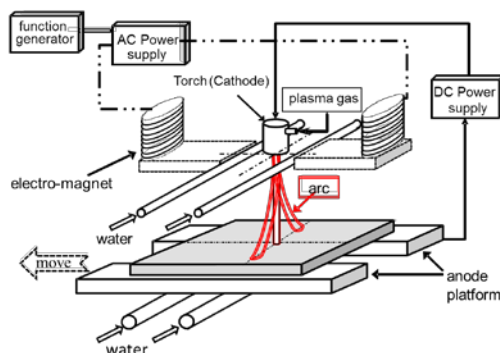


Fig.2 Arrangement of the developed heat treatment System [1]

The heat treatment device is composed of several systems. A transferred DC arc burns between a plasma torch and a work piece serving as an anode. The work piece travels in horizontal direction by a

platform driving mechanism. Various magnetic fields can be produced by an AC current supply. After heating, the work piece is quenched from the back side of the plate by cooling water.

2. Result of the heat treatment for carbon steel

The carbon steel plate was heat-treated by the arc driven by an AC magnetic field with rectangular wave form at the frequency of 50Hz. Drastic increase of hardness was obtained as shown in Fig.3.

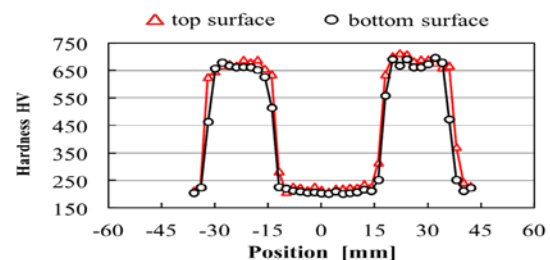


Fig.3 Hardness distributions after the heat treatment

3. Research for further improvement

Surface damage with many tiny spots was often found on the heat-treated work piece. The detailed observation of the arc motion revealed that irregular movement as shown in Fig.4 resulted in the surface damage. For further improvement, it is required to study how to prevent such irregular arc motion.

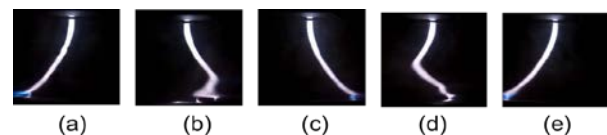


Fig.4 Irregular arc motion during one cycle of the imposed AC magnetic field

Reference

[1] R.Akiho, M.Sugimoto, K.Takeda, Y.Noguchi, T. Miura, Transaction JSME-C 79 (2013) 3979.