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Study on the Laser Hybrid Cladding Technology on the Surface of Copper Substrate

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Abstract

To enhance the staying quality of the surface of the copperplate, the laser hybrid cladding technology can be used to clad Ni-Cr alloy on the surface of the copperplate. By the traditional laser cladding technology, it is hard to directly form good coat on the surface of the copperplate. In the article, the coat is made on the surface of the copperplate by the laser hybrid cladding technology, and the staying quality tests are made for samples by several methods, and the micro-hardness and the staying quality of the coat are far higher than the cooper substrate, and coat has good roughness of surface. And the test result indicates that the method adopting the laser hybrid cladding technology can prepare the alloy coat on the surface of the deep copperplate.

Keywords: Surface technology, Laser hybrid cladding, Induction cladding, Thermal spraying, Micro-arc Deposition

1. Introduction

At present, coppers and copper alloys have been widely applied in the industrial production. The continuous molten technology occupies the leading status in Chinese metallurgy industry, and its key component, crystallizer, is mainly made by coppers. Most traditional methods adopt the surface coating or the copper alloy to make the crystallizer to strengthen the staying quality, but the coat is thin and easy to be frayed after long time use. The laser cladding technology is a kind of new improved surface technology, and the steel surface cladding, especially the steel surface alloy powder cladding, has been widely used in commercial application (E.H Beyer, 2004, P.1-6). But it is more difficult to clad metals on the copper surface than to clad metals on the steel surface, because, first, the reflectivity of the copper to the CO_2 laser is very high, second, the coppers have good thermal conduction, third, the heat expansion coefficient of coppers is very high, and cracks will easily occur when forming the coat with most cladding materials, therefore, it is very theoretically and practically meaningful to study the laser hybrid cladding on the surface of copper substrate.

The laser cladding technology adds the cladding materials on the substrate, heats and melts the cladding materials and the surface coat of the substrate by the high-energy density laser radiation, and realizes quick agglomeration through the chilling action of the substrate, so the cladding coat combined with metallurgy will form on the surface of substrate (Guan, 1998, No.265). The laser cladding technology can improve the hardness, the staying quality, the anti-corrosion and the anti-oxidation of the surface performance of the materials, and it has been an effective method to strengthen the surface of the material. This technical method can not only enhance the surface performance of the material, but also save many expensive metals, and it can not only modify the surface, but also repair the surface (Shepeleva L, 2000, P.45-48), so its application foreground is very wide.

The traditional surface modified technique and the laser cladding technology have their own limitations, and the laser hybrid cladding technology can combine with the advantages of these two technologies, and compensate the deficiencies in these two technologies, which makes the laser cladding technology to be widely applied in relative industries.

2. Laser-deduction hybrid cladding technology

The deduction cladding technology is a new hybrid surface modified technology, and it utilizes the deduction skin turbulence heating principle to clad the fusible alloy on the surface of the work-piece and form the coat with the staying quality and anti-corrosion feature. In recent years, this technology has been widely applied in the oil fields, the metallurgy industry, and the industrial boilers (Zhang, 2001).

The deduction heating has high efficiency and little energy consumption, but in the production process, following phenomena still may exist such as the aberrance of the coat is too large, and the substrate is too heated, and the quality of the product can not be easily controlled.

The laser deduction cladding technology is to prepare the alloy powder layer on the substrate of the work-piece, and utilize the alternating electromagnetic field in the deduction loop to produce the turbulence in the work-piece, and melt the coat by virtue of the heats produced by the skin effect of the turbulence, and implement the laser cladding when making deduction heating, and combine the alloy powder layer with the substrate to strengthen the surface of the substrate. But because the turbulence control when implementing the deduction heating is very complex, so the reports about this research domain are very less, so the theoretical research about this aspect is very important.

3. Laser-thermal spraying hybrid cladding technology

The thermal spraying technology means a metal surface machining method which heats the spraying material to the melting or half-melting status, and pulverizes and quickens it by the high-speed airflow, and makes it to spray the surface of the work-piece with high-speed, and forms the spraying coat. According to the heating sources, there are four basic methods such as the flame spraying, the electric arc spraying, the plasma spraying and the special spraying. In China, the thermal spraying technology has been used to make the anti-oxidation coat on the copper alloys.

The thermal spraying possess following characters. First, the flame temperature is high, and the heat can be centralized, and the powder materials with high melting point and high hardness can be melted. Second, after spraying, the coat is flat and smooth, and the coat depth can be exactly controlled. Third, the area influencing the surface of the work-piece is very small. Fourth, the technical standard is stable and easy to be operated.

But there are many deficiencies of the thermal spraying on the copper surface. For example, the coat of the thermal spraying gives priority to the mechanical combination, and the surface prepared by the thermal spraying technology is very coarse, and the anti-variance is bad, so the hot impaction will be influenced under high temperature. In addition, the existence of the holes in the coat will induce the failure of the coat under low temperature, and produce cracks and impact the heat barrier feature and the anti-hot corrosion feature under high temperature.

The combination of the thermal spraying technology and the laser cladding technology can effectively solve part problems. The laser cladding can obviously enhance the surface coarseness of the work-piece after thermal spraying, and the air holes in the coat will be obviously reduced, and the structure of the crystal grain will become thin and equal, and the organization will be denser, and the straying quality will be obviously enhanced. However, because the thermal spraying coat and the substrate are combined mechanically, so under bad working conditions such as high temperature and impact, the performances of the coat need to be further studied (Y.J. Liu, 2008, P.373-374 & 392-395).

4. Laser-high energy micro-arc deposition hybrid cladding technology

The high-energy micro-arc deposition technology is a simple and flexible metal surface processing method, and it has been applied in the components in foreign aviation and spaceflight industry. It is a new technique without stress and distortion, and its shortened form is HEMAD. It directly utilizes the electric energy with high-energy density to intensively treat the surface of the work-piece, and by the function of spark discharge, the temperature of the contact part between the electrode and the work-piece in 10^{-6}-10^{-5}s will achieve 8000-25000℃, and as the electrodes, the conductive furious materials will be melted into the surface of the metal work-piece, and form the alloyed surface strengthened layer (Zhao, 2001, P.35-36).

Because the alloyed surface deposition layer with electrode materials can improve the material performance, the chemical materials and the mechanical materials of the work-piece surface, and its interior organizational and mechanical performance will not change. The high-energy maintenance deposition possesses not only some characters of the jointing technique and the spraying technique, but some special characters such as small heat input and the combination of the deposition layer and the substrate metallurgy.

At present, the high-energy micro-arc strengthening technique has been widely applied in many industries such as the motor, the electric equipment, the instrument, the light industry, the machine manufacturing, the farming machine, the chemical industry and the traffic transportation, and acquired good economic benefits. The high-energy micro-arc deposition can not only effectively enhance the staying quality, the anti-corrosion feature, the hot-hardness and the high-temperature anti-oxidation feature of the component surface, but also increase the surface coarseness and influence the fatigue performance of the material. In addition, this technology can be used to remedy the small abrasion of the work-pieces such as the molds, measures and components of the machine to maintain the normal operation of the equipments, so it has significantly economic values. Therefore, the manufacturing level and the technical level of the deposition equipment can be further discussed and enhanced, which is very meaningful to expand the application domain, enhance the stability, reliability and the production efficiency of the technology (Wang, 2000, P.3-5 & J.W Li, 2002, P.223-225).

The high-energy micro-arc deposition technology has many advantages, but its machining efficiency is very low, and the depth of the deposition layer is less than 1mm, so it is very difficult to prepare the deposition layer with certain depth on the copperplate, and the laser-high energy micro-arc deposition hybrid cladding technology can compensate the deficiencies of the micro-arc deposition technology, but in the production process, the laser cladding on the thin surface of the deposition can largely enhance the production efficiency. At the same time, for the laser cladding of the deposited work-piece, the crystal grain of the deposition layer is thin and equal, and the organizational structure of the cladding layer is denser, and the material shows that the staying quality and the hardness will be obviously enhanced.

Though the deposition layer and the copper substrate can form the metallurgy combination, but the combination area will have obvious cracks and air holes, which is decided by the micro-arc deposition principle, and these deficiencies can not been completely eliminated, so the performances under many bad working conditions such as high temperature and strike should be further studied.

5. Foreground and expectation

In the article, the combination of the traditional surface strengthening technology and the laser cladding technology is proposed, and by reasonable technical design, the cladding coat with even and dense organization and good staying quality can be prepared under the condition of high-power laser quick scanning. This research not only possesses good industrialized application foreground, and important scientific research values, but can improve the development of the advanced laser cladding technology.

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