MICROSTRUCTURE OF CAST IRON AFTER PLASMA BLEACHING

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ABSTRACT

This work presents results of metallographic examination of the surface layers of grey cast iron, subjected to plasma bleaching. In the sintered layer are detected ledeburite structure, martensite, ferrite and graphite particles. It is shown that the pre-cast aluminum cladding surface increases the dispersion of carbide particles and the hardness of the melted layer.

Keywords: grey cast iron, microstructure, plasma fusion, bleaching, modifying aluminum, hardness.

INTRODUCTION

Grey cast iron is widely used for the manufacture of many parts in a variety of industries. From cast irons are made the most vital parts of a car - engine blocks, brake discs [1], cylinder liners diesel engines [2], piston rings, etc. [3]. The most frequently used unalloyed or low-alloyed grades of grey cast iron are with a lamellar graphite form.

The physical and mechanical properties of service parts made of cast iron are determined primarily by features of its microstructure. The main feature of the microstructure of the cast iron is the existence of a lamellar graphite mold. Flake graphite gives greater continuity of the metallic matrix. Therefore, grey cast iron has relatively low resistance values for time at relatively low rupture ductility. In addition, even modified, or doped grey cast badly resists abrasion and sliding wear when applying high contact loads. On the other hand, due to the plate-like shape of graphite in gray cast iron, it has low sensitivity to surface stress concentrators. In addition, grey cast iron has a high damping capacity (internal friction is 4 to 10 times higher than that of steel) and thus dampens vibrations well. So, in many cases it is expedient to produce grey cast iron core parts of automobiles, and the surface of the wear resistant materials to perform, for example, with a white cast iron alloy [4].

Widely reported in the literature is the possibility for hardening products for cast iron surface whitening during crystallization or in saturated surface diffusion with chromium, vanadium, or aluminum [5]. However, most of the known methods of whitening for the surface of cast irons require a number of additional technological measures, that are not in a position to guarantee the quality of the bleached layer without pores, graphite inclusions and cracks. There is also a significantly complicated and costly process of hardening. Studies of the possibility for bleaching grey iron with plasma remelting surface [6], show the high efficiency of this method, however, data on the possibility for additional alloying the surface layer of iron in the literature is not enough.

Whitening grey cast iron by surface melting induction, laser or other means, to ensure the formation of a surface layer of the structure, leads to a ledeburitic-martensitic composition with high hardness and wear resistance. The obtained continuous layer without large inclusions, cracks and roughness is satisfactory for difficult tasks.
The aim of this work is to study the possibility of fusion plasma for surface chill cast iron with lamellar graphite, and to characterize the microstructure and properties of cast iron after application of an aluminum underlayer and subsequent fusion plasma.

EXPERIMENTAL

Hardened layers were obtained without the additional cooling forced way, only relying on the heat sink into the metal. The starting temperature of the investigated irons was 20°C, after processing, it was raised to 80 - 120°C. Surface bleaching was made by remelting the cast iron surface by exposing it to the plasma jet. The influence of surface chill was assessed by measuring the hardness, microhardness and microstructure of the remelting zone, the transition zone and the heat affected zone.

RESULTS AND DISCUSSION

Grey cast iron has in the initial state a ferritic-pearlitic metal based plate and a graphite mold (Fig. 1).

After the plasma iron surface remelting, its hardness increased from 24 HRC to 52 HRC. The depth of the surface layer bleached was about 2 mm. The bleached layer has a dense structure, with no visible cracks and chips. The microstructure of the bleached area of the iron is shown in Fig. 2. It can be seen that it is a hypoeutectic white cast iron, in which there are no graphite particles. The metal substrate is an austenite-martensite composition in the axes of the dendrites. The microhardness of the austenite-martensite composition is 550 - 590 HV10. The dendrites do not have a clearly defined general direction of the growth axes of the first order. This means that the heat in this layer during crystallization, was very effective and was carried out both in the direction of the base metal and the atmosphere. The average dendritic parameter is 4 - 6 mm, which corresponds to approximately the crystallization rate in the direction of the axes of the dendrites of the first order of 1000°C s⁻¹. In the interdendritic space there is an eutectic cementite type, with microhardness 722 - 810 HV10.

In the lower layers of the molten layer there is a transition zone where are present both the structure characteristic for the base metal, the remelting zone and the intermediate products transformations, resulting from the rapid crystallization of liquid iron (Fig. 3).

Clearly visible are also the graphite plates that have not dissolved in the iron melt during the plasma treatment, due to the short exposure time. For the graphite plates, on both sides an adjacent cementite eutectic type, in which the carbide particles are arranged perpendicular to the surface of the graphite plates, is observed. We can assume that the transition zone has been formed during accelerated cooling of molten iron, heated to temperatures of a solid-liquid state. When it is not soluble, the graphite plate is the substrate on which the crystals of the carbide phase are grown. The metal based eutectic structure formed martensite and austenite. At some distance from graphite plates is located an area of high structure, having martensite and austenite. The integral microhardness of these areas is 440 - 480 HV10. In the deeper layers of the samples, described above, the...
composition is replaced by structures more typical for grey cast iron. The cooling rate at the surface remelting pig iron at these depths is relatively low, so martensite meets troost-martensitic structures.

It is known [7], that introducing iron into aluminum in an amount of 10 – 17 % leads to a significant increase in its hardness and wear resistance, due to the formation of carbides of the type (Fe, Al) 3C. The doped surface layers of aluminum on the workpiece whiten at plasma remelting only at its preliminary application to the surface of the reinforcement. Using the method of plating, a flexible tool [8] for this purpose leads to obvious advantages, allowing to automate the process of applying aluminum and provides a constant thickness of the aluminum layer on the surface of the product.

The plasma remelting of cast iron clad aluminum method leads to an even greater increase in hardness, than plasma remelting without cladding. Hardness increases from 52 HRC to 62 HRC, and remelting zone microhardness increases up to 1000 - 1050 HV. The general type of structure, formed in the zone remelting is unchanged (Fig. 4). The bleached layer has a typical eutectic structure. The number of the eutectic components decreases, and the volume fraction, occupied by the dendrite arm, increases. Based on the substantial solubility of aluminum in α-iron at a temperature ranging from the melting point to room temperature (from 30 % to 8 % by mass), suggests that, while most of the aluminum is contained in the base metal. The dendritic structure in the zone of remelting the plasma surface is coated with aluminum at 4 - 6 microns. Obviously, the metal substrate is the refining zone and a minor amount of martensite austenite. Increasing the amount of martensite due to the action of aluminum has led to a sharp increase in the hardness of hardened layer up to 62 HRC.

CONCLUSIONS

Thus, prior to application of grey cast aluminum surface by plating a flexible instrument and subsequent remelting of the surface of the plasma, can significantly improve the hardness of the hardened layer, compared with the plasma remelting without coating with the aluminum layer. The quality of the hardened layer is much higher than in the bleaching iron, obtained by induction heating. In the zone of remelting, there are no pores and soluble graphite inclusions, which gives reason to recommend this as a very effective treatment for grey iron parts, working in conditions of intense friction, temperature and contact stresses.

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