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Study of technological conditions for welding cast iron

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ABSTRACT: This article provides a study of technological conditions for welding cast iron

KEY WORDS: cementite, graphitizer, welding, cast iron, crack, welding thermal cycle

I. INTRODUCTION

Cast iron is widely used as a structural material in industry, which is due to the simplicity and low cost of manufacturing cast iron products, good casting properties, wear resistance, reliable operation under conditions of alternating loads and elevated temperatures, and so on.
Cast iron is a multicomponent iron-carbon alloy containing over 2% C, up to 5% Si and some manganese. Sulfur and phosphorus are generally impurities. In addition, chromium, nickel, molybdenum and other elements are introduced into alloyed cast iron, giving it special properties. The presence of eutectic in the structure of cast iron determines its use exclusively as a casting alloy.

II. LITERATURE SURVEY

Depending on the composition, crystallization conditions and cooling rate, carbon in cast iron can be in a chemically bound state in the form of cementite or in a structurally free state in the form of graphite. [1]. The presence of cementite in the alloy gives the fracture a light color. Therefore, cast iron in which carbon is in the form of cementite is called white. Graphite gives the fracture a gray color, and such cast irons are called gray. [2-3].
Graphitizers in cast iron are carbon, silicon, aluminum, copper, nickel, etc. These elements form solid solutions with iron, increasing the number of vacancies and displacements in its lattice, facilitating diffusion, reducing the activation energy and weakening the bonds between carbon and iron atoms and thereby promoting graphitization. The degree of their influence varies. [4].

The strongest graphitizers are carbon and silicon. Silicon, the content of which in gray cast iron is 1.2-3.5%, affects the structure of cast iron and, first of all, the degree of its graphitization. Silicon changes the degree of eutecticity of the alloy, which is understood as the ratio of the total carbon content in cast iron to its content in the eutectic. Using the graphitizing effect of silicon, it is possible to obtain eutectic cast iron by introducing a smaller amount of carbon into it. By adjusting the ratio of carbon and silicon in the alloy, it is possible to obtain the desired structure in the cast iron. [5-6].

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III. METODOLOGY

According to their structure, cast irons are divided into the following groups:
1) white cast iron, in which all carbon is in the form of cementite; 2) gray cast iron, in which carbon is contained mainly in the form of lamellar graphite; H) high-strength with spherical graphite; 4) malleable cast iron (flaky graphite).
White cast irons have a limited scope of application, since the cementite present in its structure in the form of secondary cementite and in the composition of ledeburite gives it high fragility, hardness, and they are practically not amenable to cutting. Bleached cast irons find some use in industry, in particular when casting parts for crushing and grinding plants and for other parts that require greater surface hardness and wear resistance. In bleached cast iron, due to different crystallization conditions, a cementite eutectic (HB 400-500) is formed in the surface layer, and a graphite eutectic is formed in the middle of the casting. Such cooling conditions are obtained when casting cast iron into a metal die or raw sand mold; for these purposes, cast iron with a low silicon content is used.
Gray cast irons, in terms of their chemical composition, are an Fe-C-Si alloy containing Mn, P and S impurities. Hypoeutectic cast irons containing 2.4-3.8% C are most widely used in industry. A further increase in carbon causes a deterioration in the mechanical properties of cast iron. The best casting properties are ensured with a carbon content of at least 2.4%. The mechanical properties of cast iron are determined primarily by the graphite component. In terms of its structure, cast iron can be considered as steel, permeated with graphite inclusions, which act as cuts that weaken the metal base of the alloy. Therefore, the mechanical properties of cast iron depend on the number, size and nature of the distribution of graphite inclusions.
The degree of graphitization of cast iron also determines the structure of the metal base of the alloy. As it increases, cast irons with a pearlitic, pearlitic-ferritic and ferritic base are obtained, respectively. The fewer graphite inclusions and the smaller they are, the higher the strength of cast iron. Small and swirling inclusions of graphite give cast iron higher mechanical properties. The most unfavorable form of graphite inclusions is in the form of large linear deposits. Graphite inclusions have little effect on the compressive strength and hardness, which are determined primarily by the structure of the metal base of cast iron. The breaking load in compression is 3-5 times higher than in tension. Therefore, cast iron is used for products that work mainly in compression. Graphite increases the wear resistance and anti-friction properties of cast iron, providing a lubricating effect.
In addition, it improves machinability by producing free-flowing chips. By breaking the continuity of the metal base, graphite thereby makes cast iron less sensitive to external stress concentrators (surface defects, etc.).
High-strength cast iron with nodular graphite is similar in composition to ordinary gray cast iron, but due to alloying it with small additions of alkali, alkaline earth and rare earth metals and usually 0.03-0.07 Mg, the graphite in it acquires a spherical shape. The metal base can be pearlitic, pearlitic-ferritic and ferritic. Spherical graphite weakens the metal base of cast iron significantly less. Unlike flake graphite, nodular graphite is not a stress raiser. These cast irons, having good casting properties, high machinability and wear resistance, at the same time have mechanical properties similar to the mechanical properties of carbon steels. Castings made of high-strength cast iron are used in heavy, chemical and petroleum engineering.
Malleable cast iron is produced by prolonged heating at high temperatures (annealing) of white cast iron castings. As a result, graphite acquires a flake-like shape, which reduces the strength and ductility of the metal base of cast iron less. In industry, ferritic malleable cast irons (metal base - ferrite) and, less commonly, pearlitic malleable cast irons (metal base - perlite) are used. Ferritic malleable cast irons are more ductile, which explains their use in mechanical engineering. Cast iron has a low carbon and silicon content (2.5-3% C; 0.7-1.5% Si). A lower carbon content causes increased ductility of the alloy, as it reduces the amount of graphite released during annealing. The reduced silicon content eliminates the precipitation of lamellar graphite in the structure of the castings during cooling. Ductile iron castings are used for parts operating under shock and vibration loads. Malleable cast iron is marked with the letters KCH and the corresponding numbers (the first two are tensile strength, the second two are relative elongation).

Welding is used mainly to eliminate defects in cast iron castings when repairing failed equipment and, to a lesser extent, when producing welded-cast structures. Welding cast iron is challenging. All of the above groups of cast irons are characterized by reduced weldability. The most widely used and well developed processes for welding parts made of gray cast iron.
The poor weldability of cast iron is determined by the increased tendency of the alloy to form cracks, which is due to its low strength and ductility, as well as the formation of a weld during welding both in the weld metal and in the heat-affected zone at increased cooling rates of brittle structures as a result of bleaching. The presence of these structures (ledeburite) impairs the machinability of cast iron. Cracks in the weld metal and in the base metal in the heat-affected

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zone can arise from uneven heating and cooling, which are characteristic of the thermal cycle of welding, casting shrinkage of the weld metal, and the rigidity of the products being welded. Cracks during welding of cast iron can also occur in other areas of the part, in which, due to additional deformation caused by welding or local preheating, stresses appear that exceed the tensile strength of cast iron. Cold cracks develop instantly. Cracks can occur at the beginning of welding, when local heating causes compressive stresses, during the welding process, and also during cooling, when tensile stresses arise.

To eliminate cracks, brittle and hard structures in the weld metal, i.e. To ensure the structure of gray cast iron in it, it is necessary to ensure such a chemical composition and cooling conditions under which the graphitization process is most fully carried out. When choosing the composition of the weld metal, it is necessary to take into account that the graphitizing effect of elements under welding conditions is much weaker than under the conditions of producing castings. Compared to iron castings, a higher carbon and silicon content is required in the weld to eliminate the ledeburite structure. Under welding conditions, carbon is a stronger graphitizer. Manganese, which belongs to the carbide-forming elements, when present in the weld up to 1.0-1.2% and a relatively low carbon content, manifests itself as a graphitizer. A small amount of vanadium, chromium and titanium helps to grind the graphite and thereby improves the mechanical properties of the weld. The graphitizing effect of nickel and copper is weak. The mechanical properties of the weld metal are improved by modifiers. Therefore, modifiers are introduced into the composition of filler metals.

The formation of bleaching structures and cracks in the heat-affected zone is influenced by both the thermal cycle of welding and the chemical composition and structure of the cast iron being welded. Cast irons with a rough structure, large graphite inclusions and ferrite grains are poorly welded. Fine-grained pearlitic cast irons with small graphite inclusions are less prone to cracking. Nickel and titanium improve the weldability of cast iron, which is associated with the grinding of the metal base of the alloy and graphite inclusions under the influence of these elements. Cast irons that have been exposed to high temperatures and water vapor for a long time do not weld well. Their welding requires special, complex techniques.

When considering structural transformations in the heat-affected zone when welding gray cast iron, the ternary state diagram Fe—C—Si can be used. The most dangerous area in terms of the formation of solid structures and cracks is the area adjacent to the weld pool and being in a solid-liquid state. When welding cast iron without heating (at cooling rates of more than 5°C/s), a layer of ledeburite and martensite is formed. The formation of a ledeburite layer in this area is influenced by the composition of the weld pool, since as a result of the diffusion process, redistribution of elements from the deposited metal to the base metal and vice versa is possible. This layer can be completely eliminated when using electrodes containing an increased amount of graphitizers or nickel, and under appropriate welding conditions.

IV.CONCLUSION

The results of the research performed provided the necessary basis for studying the technological conditions of cast iron welding.

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