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Technical Information No. 11

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Abrasion resistant, white cast iron materials

Microstructure and properties

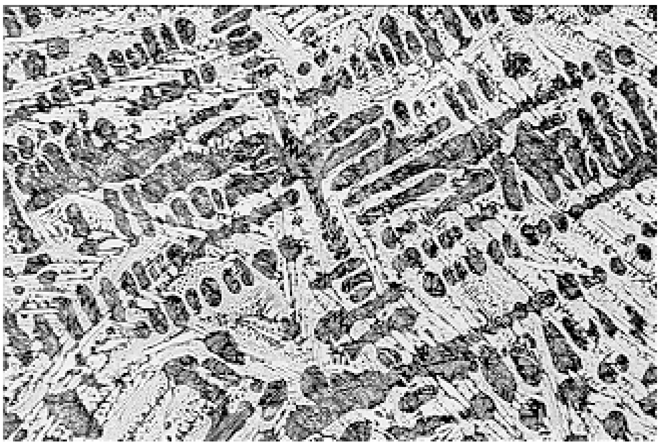
Abrasion resistant cast iron materials are white, carbide-solidified cast iron materials which contain a high level of hard particles in the form of iron or chromium carbides. The carbides are held by a hard matrix. Generally the matrix is martensitic but there are also cases of an austenitic matrix as well, which only becomes more solid during the wear process associated with strain hardening.
Since they are highly resistant to wearing, white cast iron materials are particularly suitable for applications involving wear caused by minerals, for example in grinding tools, in reducing, mixing and conveying equipment and systems and in pumps.

Abrasion resistant, white cast iron materials

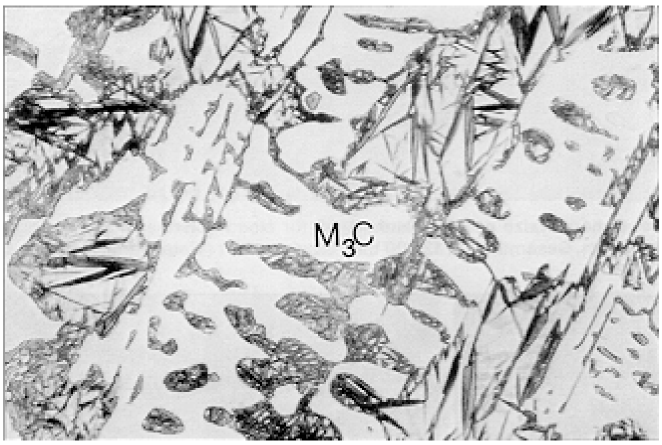
DIN EN 12513, which was issued in January 2001, restructured the nomenclature of the varieties of abrasion resistant, white cast iron. This replaced the previously applicable DIN 1695, in which the chemical composition was still included in the name, as in the designation of steels. The designations in the new DIN EN 12513 are based on those for cast iron, with lamellar graphite or spheroidal graphite, in accordance with the described nomenclature for the GJN. The letter N indicates white, graphite-free solidification ("no graphite"). This is followed by the hardness specification, the minimum value of which is generally the most important factor affecting the choice of material. In this connection it should be noted that the hardness of white grades of cast iron is specified according to the Vickers method.

DIN EN 12513 differentiates between 3 classes of white, abrasion resistant cast iron: Unalloyed or low-alloyed, higher-alloy nickel and chromium cast iron and high-alloy chromium cast iron. Since the materials with a high chromium content all have the same minimum hardness of 600 HV but may contain differing amounts of chromium, their designations are supplemented with "XcrY", where Y refers to the chromium content in weight in %.
Unlike other cast iron materials, the chemical composition is also included in the standard for white, abrasion resistant grades of cast iron because it determines the microstructure, response to heat treatment and, above all, the wear characteristics.

The wear characteristics of any particular type of iron material depend on a range of factors. The main factors are the basic structure, the carbon content and the type and distribution of carbides. Martensitic steels and cast iron materials, for example, are more wear resistant than austenitic grades. Pearlitic qualities, in comparison, are much less resistant to wear. In martensitic grades the starting-up conditions still have an influence on the wear characteristics, whereas the major factor for austenitic grades is the cold hardening of the austenite under the influence of the impacting wearing particles. In addition, the carbides should be evenly distributed and not too small, otherwise it is possible for a carbide to become easily dislodged from the matrix by an abrasive particle brushing along it, and then washed away.
The amount of carbide particles as hard material is dependent on the amount of carbon. The greater the carbon content, the greater the hardness if all other variables remain constant, and the lower the toughness. Hardenability can be increased with the elements nickel, copper, molybdenum and manganese. Only when these have been added is it possible to produce a hardening structure, even in larger cross-sections. However, the amount of nickel that can be added is limited because excessive amounts will lead to excessive proportions of residual austenite and even lead to the formation of graphite, thereby drastically reducing the degree of hardness.
As an alloy element, chromium offers graphite-free solidification and prevents the precipitation of graphite even during



100 µm



100 µm

Microstructure of wear-resistant, white cast iron (illustrated here by GJN-HV 550)

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heat treatment. Like nickel, copper, molybdenum and manganese, chromium also improves hardenability. Furthermore, it also forms chromium mixed-carbides which are notable for much greater hardness (1200 – 1600 HV) than iron carbide (800 – 1200 HV). Chromium mixed-carbides are also distributed more evenly in the microstructure, which is also an advantage compared to iron carbide in relation to wear. Chromium also provides improved resistance to corrosion, to such an extent that high chromium levels can achieve a performance to match that of the lower limits of stainless steels.

In some grades the desired microstructure can be achieved in the as-cast condition. Others require additional heat treatment to remove unwanted microstructure portions and achieve the desired properties.

In cast parts with a high chromium content the largely martensitic basic structure is generally produced by heat treatment. Otherwise there is a risk of the presence of different pearlite, martensite, bainite and austenite elements, in dependency on wall thickness, which would make it impossible to produce the hardness in the as-cast condition with absolute reliability. Optimum service properties for these materials are not generally achieved in the as-cast condition. Nevertheless, they are certainly used for occasional applications in this condition, partly for reasons of cost but also to avoid the risk of cracking during heat treatment.

Machining of white cast iron

The high wear-resistance and hardness of abrasion resistant, white grades of cast iron make them difficult to machine. Generally, therefore, every effort is made to avoid the need for machining. In many cases it is possible to pre-cast holes or threads with sufficient accuracy. Also, steel bolts can be screwed into pre-cast holes with rough threads, into which the thread required for assembly can then be tapped.

The development of modern cutting ceramics, in particular the "black varieties", led to a major advance in the machining of white cast iron, such that there is no longer any need for the complexity of soft annealing and subsequent re-hardening, as previously required for chromium cast iron. The types of cutting ceramics that can be used are mixed ceramic materials (Al_2O_3 + TiC), nitride ceramic on the basis of silicium nitride and especially polycrystalline, cubic boron nitride (PKB or CBN). Diamonds, on the other hand, are not suitable.

Classification of varieties of abrasion resistant, white cast iron according to DIN EN 12513

Materials according to DIN EN 12513			Chemical composition [Weight %]								
Abbreviation EN-	Number EN-	Hard-ness HV	C Min.	SI	Mn	P	S max.	Cr max.	Ni	Mo	Cu
Unalloyed or low-alloyed cast iron											
GJN-HV350	JN2019	350	2.4 to 3.9	0.4 to 1.5	0.2 to 1						
Chromium-nickel cast iron											
GJN-HV520	JN2029	520	2.5 to 3	max .0.8	max. 0.8	0.1	0.1	1.5 to 3	3 to 5.5	-	-
GJN-HV550	JN2029	550	3 to 3.6	max. 0.8	max. 0.8	0.1	0.1	1.5 to 3	3 to 5.5	-	-
GJN-HV600	JN2049	600	2.5 to 3.5	1.5 to 2.5	0.3 to 0.8	0.08	0.08	8 to 10	4.5 to 6.5	-	-
Cast iron with high chromium content											
GJN-HV600(XCr11)	JN3019	600	>1.8 – 2.4 >2.4 – 3.2 >3.2 – 3.6	1	0.5 – 1.5	0.08	0.08	11 - 14	Max. 2.0	Max. 3.0	Max. 1.2
GJN-HV600(XCr14)	JN3029	600	>1.8 – 2.4 >2.4 – 3.2 >3.2 – 3.6	1	0.5 – 1.5	0.08	0.08	14 - 18	Max. 2.0	Max. 3.0	Max. 1.2
GJN-HV600(XCr18)	JN3039	600	>1.8 – 2.4 >2.4 – 3.2 >3.2 – 3.6	1	0.5 – 1.5	0.08	0.08	18 - 23	Max. 2.0	Max. 3.0	Max. 1.2
GJN-HV600(XCr23)	JN3049	600	>1,8 – 2,4 >2,4 – 3,2 >3,2 – 3,6	1	0,5 – 1,5	0,08	0,08	23 - 28	Max. 2,0	Max. 3,0	Max. 1,2