

Chapter 1-2FERROUS GROUP OF METALS AND ALLOYS - IRON

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Introduction

- 1 The ferrous group of metals and alloys comprise those having iron as the base metal.
- 2 Iron exists in three forms, with the following characteristics:
 - 2.1 Alpha - polymorphic; stable below 906°C magnetic up to 768°C .
 - 2.2 Gamma - polymorphic; stable between 906°C and 1403°C - non-magnetic.
 - 2.3 Delta - polymorphic; stable between 1403°C and melting point (approx. 1532°C).

CAST IRON

3 Cast iron is produced from iron ore which is converted by smelting processes into various grades of pig-iron; these are not of use for constructional purposes until re-smelted, the chemical composition adjusted and the metal cast into the desired form.

CHILLED IRON

4 Chilled iron is produced in moulds made wholly or partly of metal. The surface of the casting is white and hard, whilst the interior is grey.

MALLEABLE CAST IRON

5 A variety of cast iron which is cast white, and annealed at about 850°C to remove carbon, or to convert the cementite to graphite rosettes. It is distinguished from grey and white cast iron by exhibiting some elongation and areareduction during tensile testing.

CAST IRON ALLOYS

6 The desirable qualities in cast iron can be improved by means of alloying with other elements; particulars of all such alloys are to be found in the relevant specifications, but for convenience those in frequent use are dealt with in a general manner in para. 7 to 14.

Aluminium cast iron

7 Aluminium cast iron with an aluminium content of 1.0 to 1.75 per cent is used for the production of an alloy that may be hardened by the nitride process, by means of which an extremely hard wearing surface is formed. With this alloy the persistent formation of oxide during the pouring of the molten metal is a disadvantage, because the skin of oxide becomes thicker as pouring proceeds, resulting in the production of unsound castings.

Chromium cast iron

8 Chromium cast iron has a reduced graphite-carbon content, effected by the addition of the chromium. Additions of 0.30 to 1 per cent chromium gives a uniform fine grain structure to the metal and when the amount of chromium is increased to 3 per cent the graphite content disappears, the alloy showing a very white fracture when broken. Chromium also gives an increase in the tensile strength at higher temperatures and reduces the tendency of castings to growth. If the basic cast iron is hard the resultant alloy may be too hard to machine although the amount of chromium may be as low as 0.25 per cent; the addition of nickel reduces this hardening effect.

Molybdenum cast iron

9 Molybdenum may be added to cast iron in quantities varying from 0.25 to 1.25 per cent and its action is to form carbide and increase the tensile strength and hardness. The influence on grey cast iron is greater than that of any other element for producing increase in the strength. The maximum increase in strength is obtained when the quantity of molybdenum added is about 2 per cent, but over this amount there is a decrease in the tensile strength of the alloy. Molybdenum retards the various changes that take place in the alloy throughout the full range of temperatures, during heating processes. This alloy also has good wearing qualities, and has a uniform structure even in heavy sections.

Nickel-chromium cast iron

10 Nickel and chromium may be used together to produce cast iron alloy with a range of qualities suitable for particular classes of work. The addition of these elements is usually from 0.50 to 1 per cent chromium and up to 3 per cent, nickel, giving a refined grain structure with increased hardness and strength without increasing machining difficulties. The use of chromium also obviates lowering the silicon content in the cupola mixture which would be necessary if nickel was used alone. The Brinell hardness number of this alloy is approximately double that of ordinary white cast iron. The alloy, produced by mixing grey cast iron, 1.50 per cent nickel and 0.50 per cent chromium, is harder and tougher than the base cast iron, and is machined more easily. Nickel-chromium castings may be hardened by cooling directly they are removed from the red hot moulds.

Nickel iron

11 The addition of 0.25 to 5 per cent nickel improves the texture of cast iron and gives better machining qualities and increased resistance to wear and corrosion, with a reduction in the coefficient of expansion. When the amount of nickel is increased from 10 to 18 per cent, the alloy changes in structure and becomes austenitic with high resistance to scaling at temperatures up to 815°C. the alloy is less liable to corrosion by the action of many acids, alkalis, etc.

Invar

12 A 35 per cent alloy is used for the production of invar which has a coefficient of expansion that is practically zero, and is non-magnetic; for these reasons invar is used in the manufacture of scientific instruments.

Titanium cast iron

13 The alloy formed by the addition of titanium to cast iron is similar in character to a silicon iron and has a reduced reaction to chill. The size of the graphite particles in the alloy is reduced and this results in an increase in the tensile strength. Titanium is mostly used in more complex alloys containing other elements such as chromium, vanadium or molybdenum.

Vanadium cast iron

14 Vanadium additions to cast iron are carbide forming in effect and the resultant alloy has a very fine grain and a more even distribution of fine graphite flakes than the base cast iron. The alloy is harder and tougher with increased effect of chill to a greater depth than is usual with the original cast iron, due to stabilisation of the cementite caused by the presence of vanadium. The amount of vanadium usually added to cast iron varies from 0.10 to 0.50 per cent.