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MANGANESE ALLOY

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1 Claim. (Cl. 75—123)

This invention relates to a new alloy steel, and relates particularly to an alloy steel containing manganese and boron.

The object of this invention is to supply a manganese alloy steel which does not require thermal treatment to render it commercially useful; which has materially greater resistance to abrasion and impact than the heretofore known manganese steels; and, which may be readily repaired or rebuilt by welding with no adverse effects on the physical properties of the parent metal.

Cast manganese steel, containing from 10% to 14% manganese and more than 1% carbon, commonly termed Hadfield steel, has been extensively used for parts of equipment subjected to wear by abrasion and impact. This type of steel is extremely brittle in the "as cast" condition owing to the presence of a relatively high percentage of free carbides of iron and manganese. A thermal treatment is necessary to change the structure of the steel, and develop the required tensile strength and toughness. Briefly, this treatment comprises slowly heating the cast steel to a temperature of approximately 1850 degrees F., and maintaining it at such temperature for a protracted period of time to form a solid solution of the manganese and iron carbides in the iron matrix. When the steel is converted to a substantially austenitic condition it is quenched in water to prevent precipitation of manganese and iron carbides, which occurs when the steel cools at a normal rate.

Properly heat treated steel of this type is characterized by fairly high tensile strength, e. g., 90,000 to 120,000 lbs. p. s. i., a low elastic limit, but considerable ductility and toughness, and low hardness, i. e., 180 to 200 Brinell.

Repeated cold work on the surface of the heat treated steel effects a material change of structure, apparently causing segregation of the hard and brittle manganese and iron carbides, with the result that the hardness of such outer layer is increased to from 400 to 480 Brinell. At the point where the hardness approaches the above maximum, the outer layer becomes so brittle that it flakes or chips off, exposing metal of appreciably lower hardness.

The grade of ordinary manganese steel best adapted for use on wearing parts of equipment contains from 12% to 13.5% manganese and at least one-tenth as much carbon; this ratio of carbon being required to give to the steel the work hardening characteristic. Some forged manganese steels contain slightly less than 1% carbon, and while a relatively high tensile strength and toughness can be developed in such steels they will not resist abrasive wear to the same degree as the steels containing a higher ratio of carbon.

It has been determined that more than 2% manganese in steel acts to appreciably lower the carbon ratio of the eutectoid. Consequently, in all commercial manganese steel the carbon is above the eutectoid ratio. When such steel is heated to a temperature of some 700 degrees F., or higher, and permitted to cool at a normal rate in air, the austenitic structure is destroyed, and the steel is embrittled. When ordinary manganese steel is welded a portion of steel adjacent to the weld is heated to a temperature sufficiently high to result in reversion of the polyhedral structure to one approximating that of the original casting. For this reason the Hadfield type of steel is not suitable for use as a weld rod, except when the deposited metal and the embrittled parent metal can be properly heated and quenched in water. The disadvantages of this in industrial operations are obvious.

A steel containing from 2% to 10% nickel, in addition to the usual amounts of manganese and carbon, has been proposed in an attempt to overcome some of the difficulties of welding manganese steel. In this case nickel functions to form a more stable solid solution of iron and manganese carbides in the iron matrix, and thus inhibit the precipitation of free carbides when the steel is allowed to cool at a normal rate from elevated temperatures. It has been found, however, that the presence of an effective amount of nickel also acts to greatly retard surface hardening of the steel under cold work. Consequently, manganese steel containing nickel does not resist abrasion as well as ordinary manganese steel, and, for this reason industrial use of the nickel containing steel is restricted to weld rods.

I have discovered that an alloy containing manganese from approximately 6.25% to 16%, boron 0.25% to 1.75%, carbon from approximately 0.10% to not more than 0.85%, and the balance principally iron, has materially higher hardness than previously known manganese steels, and that many of the other physical properties and characteristics are also superior.

One distinct advantage of the alloy of the present invention is that it may be used for a wide variety of industrial purposes including wearing parts of equipment, in the "as cast" condition. The cast metal has a minimum hardness of about 525 Brinell, and this is increased from 150 to

200 hardness numbers by cold work. The tensile strength, ductility and toughness of the alloy are, in general, superior to similar properties of heat treated manganese steel of the previously known types.

The boron containing alloy is amenable to thermal treatment for the modification or improvement of various physical properties, such as, tensile strength and hardness. I have found, however, that thermal treatment is not necessary nor desirable when the cast alloy is to be used for the majority of industrial applications.

The outstanding advantages of the present alloy are due, chiefly, to the fact that hardness and other physical properties are developed by the combination of boron with one or more of the other essential components. Carbon is not essential in my alloy, but by reason of the fact that varying amounts of carbon are present in commercial grades of materials used in producing the alloy I find that it is desirable to allow for the inclusion of a small percentage of carbon.

In order to obtain the maximum value of physical properties and characteristics it is important that the carbon content in the present alloy does not exceed the theoretical ratio of the iron-carbon eutectoid. By thus restricting the maximum amount of carbon the precipitation of free carbides during slow cooling of the alloy from elevated temperatures is entirely avoided. I usually prefer to limit the carbon content to from 0.10% to 0.35%. I have found, however, that when the alloy contains as much as 0.85% carbon no free carbides are found in the "as cast" or welded material, regardless of the rate of cooling.

It will be apparent, therefore, that the structure of the manganese-boron steel is markedly different from the structures of heretofore known manganese steels.

The alloy of the present invention has a high degree of weldability, that is, castings or other forms of the alloy may be surfaced or rebuilt to original dimensions with weld rods having substantially the same composition, or materially different compositions. Bars, plates or other shapes of the alloy may be joined by welding to fabricate parts of equipment, etc. By reason of the fact that the rate of cooling does not adversely affect the physical properties of the alloy, any suitable method of welding may be employed.

Examples of alloys within the scope of the present invention which I have found to be particularly valuable for wearing parts of equipment are: manganese 9.50%, boron 0.65%, carbon 0.25%, and the balance substantially iron; manganese 12.50%, boron 0.95%, carbon 0.50%, and the balance substantially iron; manganese 15%, boron 1.10%, carbon 0.45%, and the balance substantially iron.

The alloy of the present invention comprises: manganese 6.25% to 16%, boron 0.20% to 1.75%, carbon not exceeding a maximum of 0.85%, and the balance substantially iron.

It will be understood that the alloy will contain fractional percentages of impurities incidental to manufacture, such for example, as sulphur and phosphorus. Commercial grades of ferro-alloys and steel invariably contain silicon, and consequently, varying amounts of silicon are introduced into the present alloy as impurities incidental to manufacture. The amount of silicon in the alloy should not exceed 1%.

I claim:

An alloy characterized by relatively high resistance to deformation and abrasion containing manganese 6.25% to 16%, boron 0.20% to 1.75%, carbon not exceeding a maximum of 0.85% and the balance iron.

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