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METHOD OF CASE HARDENING STEEL

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This invention relates to improvements in steel manufacture and is directed more particularly to improvements in methods of providing steel with hardened surfaces and the products thereof.

The principal objects of the invention are directed to the provision of improvements in methods for treating steels to provide hardened surfaces, therefore and according to special features of the invention, steel may be treated in the novel way to bring about the hardening effect at low cost.

The ever increasing demands for better and less costly materials of all kinds in order to produce mechanisms to meet the requirements for stronger, faster, lighter and safer equipment have resulted in great efforts to meet the needs. These requirements for materials adapted to withstand extreme stresses, abrasive action at higher speeds and higher unit pressures have created problems in the metallurgical art which have been largely overcome by the method hereinafter described.

With prior art processes certain specific steels must be treated in certain ways wherefore the results are limited. In carburizing as well as in nitriding processes the time element is an important consideration because the cost is dependent more or less on the time consumed in treatment. According to the novel features of this invention it is possible to treat a wide range of materials, at least, it is not necessary to confine the treatment to a particular steel or to make it necessary to provide a special steel which will be particularly adapted for the novel treatment.

Not only by means of the invention is it possible to treat various steels in a relatively short time as compared with nitriding and carburizing operations but the treatment provides a non-brittle hardened surface of desirable depth which is tough while at the same time the core of the material is tough and of desirable tensile strength.

According to this invention, steels of various compositions may be treated. For instance ordinary cold rolled and cold drawn steels, class S. A. E. 1010, 1020, 1030, 1040, with or without high manganese, nickel steels of any particular composition up to and including 5% nickel, chromium-nickel steels of practically any composition, chrome-tungsten, chrome-molybdenum, chrome-vanadium and others may be treated by the novel process. Steels of the types above mentioned may be fabricated or formed into objects of various sizes and shapes, such as castings, forgings, tubes, rods, bars, sheets, etc., and the objects may either be finished ground or they may be hardened previous to the finish grind.

According to the method of this invention, the steel to be treated is immersed in a bath of nitrogen containing salts which is heated to a temperature ranging from 1400 to 1750 degrees F. or thereabouts. Steel may be treated with pure eutectic mixtures of various salts containing nitrogen.

In the treatment according to the present invention, nitrogen passes from the salts into the steel thus forming a solid solution of iron nitrogen. In some cases the bath may be as low in temperature as 850 degrees F. or it may be used up to the maximum temperature of 1750 degrees mentioned.

Sodium cyanide, potassium cyanide, ammonium carbonate and ammonium nitrate have been found to be satisfactory for the purpose of the invention, but no single salts such as cyanides, particularly sodium and potassium, are suitably adapted for the novel method. It is therefore preferable to use a combination of salts rather than a single salt.

Certain mixtures of salts containing nitrogen are heated within the range stated and during the process of treatment ammonia gas is passed through the bath. The decomposition of the ammonia in the bath is believed to impart to the steel nitrogen in the nascent form. The nitrogen penetrates into the steel thus readily forming a solid solution of iron-nitrogen. The hydrogen from the decomposition of the ammonia breakup passes upwardly to the top of the bath where it burns with a brilliant flame. The process should be carefully regulated on account of the possibility of the hydrogen and air forming an explosive compound, and requires complete knowledge of the subject.

Nitrogen has heretofore been considered as having a harmful effect upon steel in that it lowers in particular the elongation value and resistance to shock. In the method of this invention however experiments show that the impact value of the steel is not lowered to any appreciable extent, if at all.

No measurements of vapor pressure of these salts have been made but it has been definitely established that the operation can be carried out with no undesirable results without a hood over the bath but for general application a hood may be desirable.

The time for treatment in the specified bath indicates that the time of immersion of the steel to develop the proper case depends largely on the size of the work, the temperature of operation and the depth of the case required. It has been discovered when steel is immersed in the bath and heated within the temperature range mentioned, that it will have a case depth and an extremely hard surface fully as deep if not deeper, than that obtained by the so-called nitriding process where a special nitriding steel is used. At the same time, the hardened surface is decidedly less brittle than that obtained by the nitriding or any similar processes.

It has been demonstrated that the surface

hardness ranges from 600 to 1000 Brinnell hardness as determined by the well-known Monotrom apparatus, varying somewhat on the particular treatment.

In the method of this invention, carbon does not enter into the hardening of the surface layer as it does in the ordinary salt bath treatment and the action is quite unlike case carburizing which is the process of adding carbon to the surface and then hardening by heating the work above the critical point and quenching. In the carburizing operation, parts are usually packed in a granular compound which is mostly carbon and heated to a temperature between 1500 and 1800 degrees for hours. The carbon is taken up or absorbed by the surface of the steel so that when parts are later quenched the surface behaves like a high carbon steel that has been hardened.

It has been known for many years that heating steel in cyanide has been used extensively under the heading of cyanide dip, cyanide wash and cyanide reheat. In the first two operations work is preheated in the furnace and then treated in the cyanide bath from 15 seconds to four minutes before quenching. In the cyanide reheat, cold work is placed in the cyanide bath and treated from 10 to 40 minutes. These treatments provide a mixed nitrogen-carbon case which more or less increases the wear of the piece, but the case obtained is very light and can only be used where the piece has been thoroughly hardened before casing.

According to this invention a case has been produced having a depth averaging .020 while a .030 maximum has been obtained by the action of decomposition of the nitrogen compound. It is believed that the hardness is considerably greater than a nitrided case.

As an example an object containing from .15 to .25% carbon and from .1 to 1.5% manganese was immersed in a salt bath containing 15 to 40% calcium-cyanide, 20% to 40% sodium nitrate, 10 to 15% barium-carbonate and 5 to 10% sodium-chloride and subjected to a temperature some higher than the melting point of the combination. In approximately an hours time a case of extreme hardness having a depth of at least .020 was produced. In a similar demonstration where ammonia gas was used the time was reduced and it was only necessary to heat the bath to a point above the melting point.

The economies involved in connection with the invention have a direct bearing on the plant scale operation and the cost is considerably lower than by the use of the so-called nitriding or carburizing operations.

Experiments have demonstrated that steels treated by this process have extreme hardness, wear and abrasion resistance as well as chemical stability, in combination with a tough core having very high impact value.

The case produced, as previously explained, is approximately .020 deep and at least more than one-half of this case is of extreme hardness and is clearly visible in a fractured specimen wherein the hardness decreases gradually until the case merges with the core. The case, obtained by my novel method, is harder than anything previously known in case hardened steels and will readily cut glass. The resistance to wear is very great, amounting to considerably more than carburized and quenched steels. At the same time, the core has toughness, strength and impact resistance, all of which is desirable.

The hardness of the surface may be measured in different ways. It may be tried qualitatively with a file or by means of the Monotron or Vickers testing machines. Examination of Rockwell impressions show the surface of the specimens to be satisfactorily ductile, but the Rockwell point may puncture the case and should not be used to measure this particular result. Using the two machines previously described is preferred.

The process of the invention gives surface hardness with very little if any material distortion and the physical properties of the core of the material is not injuriously aected or materially changed.

The hardness and wear resistance is extremely great and the hardness is not injured by tempering, within reasonable limits while the material is rust-resistant to a desirable extent. The process may be adapted for various requirements and may be readily accomplished by selecting the proper steel of the proper composition for the purpose for which it is to be used. According to the invention it is possible to quench from the bath in either oil, brine, water or air and include in this various salt combinations as may be required for quenching media.

By means of the novel method described it is possible, therefore, to produce a steel which not only has a central portion or core of good tensile strength and toughness, depending upon the original grade of steel used, but which in addition has a hardened surface of considerable depth and toughness and which also is not brittle as compared with carburized steels and the like.

It is desired to point out that it is possible to treat steel and provide a case which is equal in hardness, toughness, depth and ductility equal to that produced by prior art methods in a much less time and the process is not limited to any particular steel wherefore economy in manufacture results.

Various changes and modifications may be made in the practice of the invention without departing from the spirit and scope thereof.

What I desire to secure and claim by Letters Patent of the United States is;

1. The process of treating steel to form iron-nitrogen and provide a hardened case which consists in, immersing the steel in a fused salt bath, said bath including from 15 to 40% of calcium cyanide, from 20 to 40% of sodium nitrate, from 10 to 15% of barium carbonate and from 5 to 10% of sodium chloride, heating said bath to within a temperature range of from 1400 to 1750° F., and leading ammonia gas into the bottom of said bath whereby said gas dissociates to supply nitrogen to the bottom of said bath and hydrogen to the top thereof.

2. The process of treating steel to form iron-nitrogen and provide a hardened case which consists in, immersing the steel in a fused salt bath, said bath including from 15 to 40% of calcium cyanide, from 20 to 40% of sodium nitrate, from 10 to 15% of barium carbonate and from 5 to 10% of sodium chloride, heating said bath to within a temperature range of from 1400 to 1750° F., and leading ammonia gas into said bath whereby said gas dissociates to supply substantially free nitrogen and hydrogen to said bath.

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