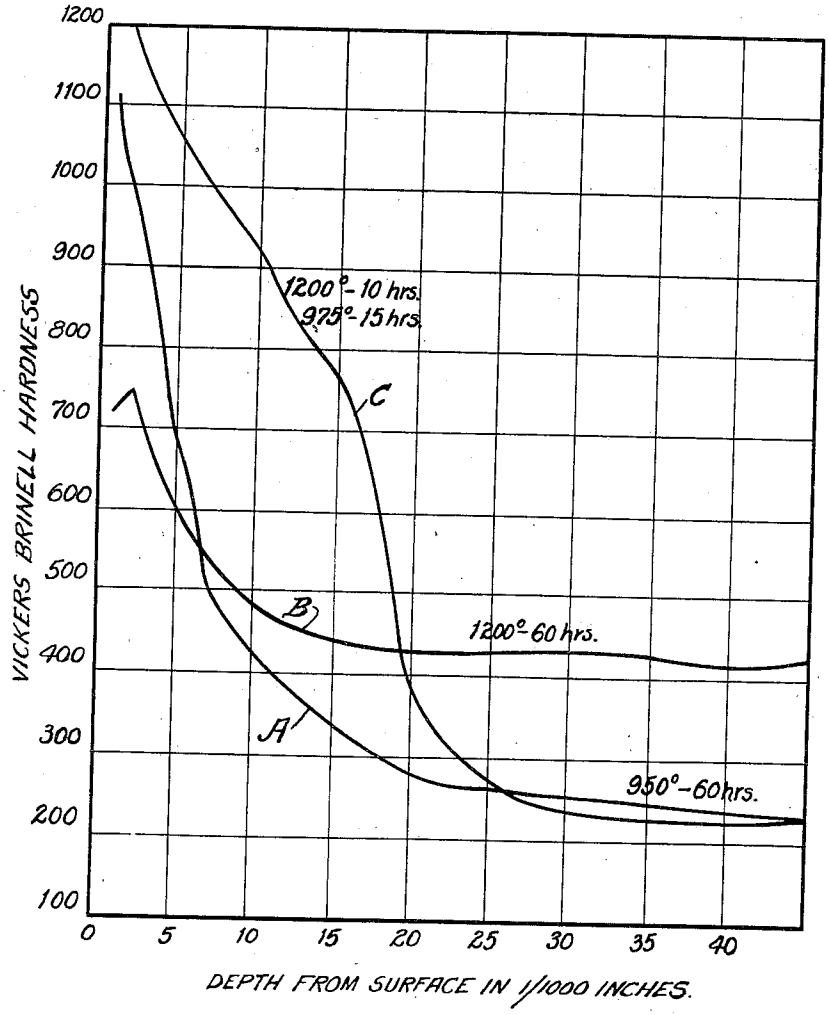
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PROCESS OF SURFACE HARDENING STEEL

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PROCESS OF SURFACE-HARDENING STEEL

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This invention relates to a process of surface-hardening steel, and particularly to the process usually called "nitriding" steel. One of the principal objects of the present invention is to materially shorten the time required to obtain a satisfactory hard surface of proper depth by nitrogen hardening. The present invention consists principally in nitriding steel in two stages, the first being effected at a temperature of about 1200° Fahrenheit and the second being effected at a temperature of about 975° Fahrenheit or lower. It also consists in maintaining circulation of the ammonia during the nitriding treatment.

The accompanying drawing which forms part of this specification, is a graph showing the hardness of steel of like composition nitrided under different temperature conditions.

In the process of nitriding heretofore used, the steel was submitted to the action of ammonia gas in a closed retort kept at a temperature of approximately 1075° Fahrenheit for a long period, frequently ninety to one hundred hours; and in carrying out that process it has been customary to take care to keep the temperature from rising above 1100° Fahrenheit in order to avoid a decrease of hardness.

I have discovered that the time required to produce satisfactory surface hardening can be greatly reduced by two factors, namely, first, dividing the operation into two stages, in the first of which the temperature is maintained above the temperature heretofore used and in the second of which the temperature is maintained below such customary temperature; and second, keeping the ammonia in active motion about the steel.

The graph in the accompanying drawing shows the Vickers-Brinell hardness at different depths below the surface of steel of the same composition submitted to nitriding action with ammonia, at different temperatures. The steel of this particular example was of a composition commonly used for nitriding and contained aluminum, chromium and molybdenum. The graphs for steels of other composition vary but are similar in type. The curve A shows the hardness of a steel treated for sixty hours at a temperature of 950° Fahrenheit; curve B shows the hardness of steel of the same composition treated at a temperature of 1200° Fahrenheit for sixty hours; and curve C shows the hardness of steel of the same composition treated at a temperature of 1200° Fahrenheit for ten hours followed by treatment thereof at 975° Fahrenheit for fifteen hours. As shown by this graph, the hardness of the steel treated in two temperature stages for a total period of twenty-five hours is greater than the hardness of the same steel treated at one temperature stage for a period of sixty-hours, for all depths up to .019 of an inch below the surface. By nitriding at a high temperature, say 1200° Fahrenheit, the required depth of penetration is obtained quickly, say, in ten to fifteen hours; and by continuing the operation at a reduced temperature, namely, a temperature of less than 1100° Fahrenheit, an extremely hard surface can be obtained in another ten or fifteen hours.

Nitriding steed submitted to the ordinary nitriding process is liable to be brittle; but such brittleness can be largely overcome by suitable heat treatment prior to nitriding. The purpose of such preliminary heat treatment is to change the texture of the steel to the condition commonly called sorbitic. By initially heat treating the steel to bring about this sorbitic condition, the Izod impact value for notch brittleness may be raised from one foot pound up to thirty-five to forty foot pounds.

If the ammonia is kept in active motion around the surface of the steel, the time required for nitriding is considerably reduced; and any suitable device may be used for positively propelling or circulating the ammonia. It is also desirable to use a suitable reagent that will take up the hydrogen as it is dissociated from the ammonia. Tantalum scrap is especially suitable and can be repeatedly reclaimed for further use.

In carrying out my process, the temperature of the first stage is reduced as rapidly as practicable to the temperature of the second stage, any suitable apparatus or artificial means being employed for this purpose to

shorten the period of treatment in the interest of economy; and, after the treatment at the second temperature has continued long enough the retort is withdrawn from the furnace and allowed to cool to a temperature of about 350° Fahrenheit before the steel is removed from the retort and exposed to the air.

While I have had very satisfactory results, using a first stage temperature of 1200° Fahrenheit and a second stage temperature of 975° Fahrenheit, these temperatures are subject to variation within reasonable limits, say 100° Fahrenheit above and below these specific figures. Thus the first stage temperature may range from about 1100° Fahrenheit to about 1300° Fahrenheit, while the second stage temperature may range from about 1000° Fahrenheit down to 800° Fahrenheit. The higher the temperature, the more rapid the operation. In practical operation it is desirable to regulate the furnace so that it will require half an hour or more for the temperature of the steel to rise from 950° Fahrenheit to 1050° Fahrenheit in the atmosphere of ammonia; because nitriding begins at approximately 900° Fahrenheit, and if the heating is slow, a considerable initial nitrided case is obtained before the higher temperature is reached, and the effect of this gradual increase of temperature is to prevent the building up of a very coarse network of nitrides, which might result from starting the nitriding operation at too high a temperature.

My process of nitriding is applicable to any ordinary steel and particularly to the so-called "nitriding steels." The addition of aluminum to a steel results in the formation of a nitrided case which has a deeper hardness and greater surface hardness than steel without aluminum, and for this reason the so-called nitriding steels carry a minimum aluminum content of .50%. The addition of a carbide forming element such as chromium or molybdenum also tends to increase the hardness and such additional element is generally used as an ingredient of nitriding steel. Ordinary steels submitted to the ordinary nitriding process obtain an extremely hard surface, but the depth of the hardness is seldom more than .001 of an inch, and hence it is not of great value for use where the pressures to be applied thereto are likely to be high enough to break through the very thin hard surface.

What I claim is:

1. The improvement in the process of nitriding steel which consists in heat treating same in two stages in an atmosphere of circulating ammonia, the temperature of the steel in the first stage being approximately 1200° Fahrenheit and the temperature of the second stage being approximately 1000° Fahrenheit, said first stage lasting about five to ten hours and the second stage lasting about ten to forty hours.

2. The improvement in the process of nitriding steel which consists in heat treating same in two stages in an atmosphere of circulating ammonia, the temperature of the steel in the first stage being approximately 1200° Fahrenheit and the temperature of the second stage being within approximately 100 degrees of 1000° Fahrenheit, and cooling said steel in the ammonia atmosphere, said first stage lasting about five to ten hours and the second stage lasting about ten to forty hours.

3. The process of surface-hardening steel which comprises exposing the same to an atmosphere of ammonia kept in motion at a temperature of from about 1150° Fahrenheit to 1300° Fahrenheit for a sufficient time to nitride the steel to the depth desired, continuing such exposure for about ten to forty hours at a temperature of from about 900° Fahrenheit to about 1050° Fahrenheit, and then cooling the same in the atmosphere of ammonia.

4. The process of surface-hardening steel which consists in heating and quenching the same to render it sorbitic, exposing the same to an atmosphere of ammonia kept in motion at a temperature of from about 1150° Fahrenheit to 1300° Fahrenheit for a sufficient time to nitride the steel to the depth desired, continuing such exposure for approximately from ten to forty hours at a temperature of from about 900° Fahrenheit to about 1100° Fahrenheit, and then cooling the same in the atmosphere of ammonia.

5. The process of surface-hardening steel which comprises exposing the same to an atmosphere of ammonia kept in motion at a temperature of about 1200° Fahrenheit for a sufficient time to nitride the steel to the depth desired, continuing such exposure for about ten to forty hours at a temperature of about 975° Fahrenheit, and then cooling the same in the atmosphere of ammonia.

6. The process of surface-hardening steel which comprises exposing the same for about ten hours to an atmosphere of ammonia at a temperature of about 1200° Fahrenheit and continuing such exposure for about fifteen hours at a temperature of about 975° Fahrenheit.

7. The process of surface-hardening steel which comprises heating the same in an atmosphere of ammonia to a temperature of approximately 1200° Fahrenheit at such a rate as to require at least half an hour to raise the temperature from 950° Fahrenheit to 1050° Fahrenheit, maintaining a temperature of approximately 1200° Fahrenheit for about ten hours, and then decreasing the temperature to about 975° Fahrenheit and continuing the treatment at that temperature for about fifteen hours.

8. The process of surface-hardening steel which comprises exposing the same for about ten hours to an atmosphere of ammonia at a temperature of about 1200° Fahrenheit, continuing such exposure for about fifteen hours at a temperature of about 975° Fahrenheit and then cooling the same in the atmosphere of ammonia.

Signed at Detroit, Michigan, this 5th day of June 1929.

HARRY W. McQUAID.