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# UNITED STATES PATENT OFFICE

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## METHOD OF TREATING GRAY CAST-IRON AND MALLEABLE IRON

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This invention has for its object the hardening and toughening of gray cast iron and malleable cast iron.

We have found that remarkable increases in hardness and tensile strength are obtained by heating gray cast iron to around 1550° to 1600° F., applying thereto a mixture of salts consisting chiefly of sodium chloride and a small amount of a cyanide, allowing the metal to cool to around 1300° F., quenching in water and finally drawing at 450° to 650° F.

The hardness is increased by such treatment from 175 Brinell to 300 to 400 Brinell, depending largely on the silicon content of the cat iron. With silicon low the hardness is high and vice versa.

Ordinarily the drawing of a metal decreases the hardness and increases the toughness. We have found, however, that the drawing after our salt treatment does not appreciably reduce the hardness whilst on the other hand it materially toughens the metal.

The hardening and drawing treatment results in increasing the tensile strength from 25 to 33% in both gray cast iron and malleable cast iron.

The essential characteristics of the salt mixture appear to be a salt fusible at 1550° to 1600° F. and a relatively much smaller amount of a cyanide.

Common salt or sodium chloride has a fusion point of about 1480° F. and is eminently suitable for forming the major portion of the mixture.

Potassium cyanide (KCN), ferrocyanide ($K_4Fe(CN)_6$) or ferricyanide ($K_3Fe(CN)_6$) or the corresponding sodium and other salts may be used. We prefer, however, to use potassium ferrocyanide, the yellow prussiate of potash of commerce.

We have found that if sodium chloride alone is used the hardness is increased almost as much as when the mixture of sodium chloride and ferrocyanide is employed, but the metal becomes very brittle. When sodium chloride is omitted the cyanide does not melt and coat the metal and has no appreciable effect on the properties of the latter.

The proportions of sodium chloride to cyanide are preferably about 16 to 1. If the cyanide is used in much larger amounts proportionately to the salt than those above given, the metal tends to crack on quenching.

In addition to common salt and ferrocyanide, we prefer to use also small amounts of potassium alum and potassium nitrate as these salts appear to have a cleansing action on the surface of the metal and aid the spreading of the fused salt like a flux. The alum possibly may form a fusible aluminum silicate with any sand adhering to the articles.

Ammonium carbonate is also useful in eliminating any tendency to crack on quenching.

In its preferred form my salt mixture has the following composition by weight:

| | Parts |
|---|---|
| Sodium chloride | 32 |
| Potassium ferrocyanide | 2 |
| Potassium nitrate | 4 |
| Potassium alum | 2 |
| Ammonium carbonate | 4 |

The exact cause of the advantageous results obtained is not known, but the increases in hardness and tensile strength are accompanied by marked changes in structure.

In treating gray cast iron containing about 3.5% total carbon, chemical analysis and microscopical analysis showed that after hardening the metal contained large quantities of free graphitic carbon. The flakes or plates of graphite were, however, only one fourth or one third the size of those in the metal prior to the hardening treatment.

In addition to the change in the size of the graphite flakes or plates there is also a change in the structure of the matrix containing such flakes of graphite. The original untreated gray iron shows large areas of ferrite in addition to pearlite. After treatment the entire ground mass appears to be composed of pearlite.

In the malleabilizing of cast iron two effects are produced, (1) decomposition of cementite into ferrite and graphite; (2) segregation of the graphite into small, rounded particles instead of the large flakes, often curved, present in gray cast iron.

On treating by our method there is a tendency to reform cementite from the ferrite and graphite and also to subdivide the particles of graphite, both of which have a hardening, toughening and strengthening effect.

These changes in structure are not merely in the surface of the metal treated, as in case hardening, but extend entirely through the mass treated provided that the heat treatment at 1550° to 1600° F. is of sufficient duration. The time factor, while appreciable, is not of long duration. Thus five minutes is sufficient to harden a half inch bar to its center.

In carrying out our invention the salt mixture may be applied to the hot metal by a spoon or the like, the heat of the metal fusing the mixture, causing it to flow over the surface of the metal and make a fluid coating thereover which soon solidifies, since the fusion point of sodium chloride is only slightly below the temperature of treatment.

Alternatively the articles to be hardened may be dipped, preferably pre-heated to the requisite temperature, in a molten bath of the salts employed.

In place of sodium chloride in the above salt mixture may be used calcium chloride, potassium chloride, a mixture of sodium and potassium carbonates, sodium or potassium nitrate, but in general these alternative salts or salt mixtures are not so satisfactory as common salt, sodium chloride.

We claim as our invention:

1. The process of hardening gray and malleable cast iron which comprises heating the iron in a fused salt mixture composed principally of about 16 parts by weight common salt, and 1 part of a cyanide.

2. The process of hardening gray and malleable cast iron which comprises heating the iron to a temperature of about 1550 to 1600° F. in a fused bath consisting principally of 16 parts by weight of sodium chloride and 1 part of a cyanide.

3. The process as in claim 2 wherein the cyanide is potassium ferrocyanide.

4. The process of hardening gray and malleable cast iron which comprises heating the iron to about 1550 to 1600° F. in a fused bath containing 16 parts by weight of common salt and 1 part of potassium ferrocyanide, cooling the iron to 1300° F., and quenching the iron.

5. The process of hardening gray and malleable cast iron which comprises heating the iron to about 1550 to 1600° F. in a fused bath containing 16 parts by weight of common salt and 1 part of potassium ferrocyanide, cooling the iron to 1300° F. quenching the iron in water and drawing the iron at about 400° to 650° F.

6. The process of hardening gray and malleable cast iron which comprises heating the iron in a fused mixture of sodium chloride, potassium ferrocyanide, potassium nitrate, ammonium carbonate and potassium alum, the sodium chloride being the principal ingredient of the mixture.

7. The process as defined in claim 6 wherein the heating is carried out at a temperature of about 1550° to 1600° F.

8. The process of hardening gray and malleable cast iron which comprises heating the iron to a temperature of about 1550 to 1600° F. in a fused mixture containing sodium chloride, potassium ferrocyanide, potassium nitrate, ammonium carbonate and potassium alum, the sodium chloride being the principal ingredient of the mixture, cooling the iron to 1300° F. quenching the iron, and drawing the iron at about 400 to 650° F.

9. The process of hardening gray and malleable cast iron which comprises heating the iron to a temperature of about 1550 to 1600° F. in a fused bath consisting of 32 parts by weight of sodium chloride, 2 parts of potassium ferrocyanide, 4 parts of potassium nitrate, 4 parts of ammonium carbonate and 2 parts of potassium alum.

10. As a new composition of matter, a mixture for hardening gray and malleable cast iron by heating, comprising 16 parts by weight of sodium chloride and 1 part of potassium ferrocyanide.

11. As a new composition of matter, a mixture for hardening gray and malleable cast iron by heating, comprising 32 parts by weight of sodium chloride, 2 parts of potassium ferrocyanide, 4 parts of potassium nitrate, 4 parts of ammonium carbonate and 2 parts of potassium alum.

In testimony whereof, we have hereunto subscribed our names.

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