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HEATING BATH FOR HARDENING OF STEEL, ESPECIALLY TOOL STEEL

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This invention relates to a heating bath for the hardening of steel, especially tool steel by heating in molten liquid baths at high temperatures preferably exceeding 1000° C., with subsequent quenching and, if necessary, tempering.

It is known that in the hardening, for example of tool and high speed tool steels from the molten liquid salt baths, soft surface layers often form at high temperatures and following quenching and tempering, which layers are subject to rapid wear and are often called "soft skin".

It has already been proposed to add ferro-silicon to the hardening bath in order to prevent this soft skin which might very detrimentally affect the utility of the finished article. By this means a hard surface is certainly obtained but the decarbonization cannot reliably be prevented, so that the decarbonized layer again becomes soft during tempering or the use of the tool.

It has also been proposed to quench in a carbonizing salt bath the tools heated to a high temperature in ordinary barium chloride baths. The object was, by reintroduction of carbon to return its former hardness to the soft layer produced during the hardening in the barium chloride bath and which is due chiefly to decarbonization. Even if the decarbonization is undone, the characteristic high speed steel structure cannot be reestablished in this manner.

Seeing that it has been ascertained that quite pure barium chloride baths effect no or only very slight decarbonization, it has been proposed to entirely or almost entirely renew the barium chloride baths by fresh salt after they have been used a few times. This method is, however, uneconomical owing to the high consumption of salt and is further accompanied by technical difficulties.

The formation of soft skin is avoided according to the invention by employing a heating bath composed of neutral salts or salt mixtures, such as barium chloride, mixtures of barium chloride with alkaline chlorides and the like, allowing a heating to high temperatures, such as 700 to 1500° C. and more, and of small quantities of metallic oxides, such as magnesium oxide, aluminium oxide, beryllium oxide, zirconium oxide, cerium oxide or mixtures of such oxides, and also small quantities of boron compounds, especially borax or other substances, such as phosphorous compounds especially pyrophosphates, acting in the same sense, and especially favouring the dissolving of the metallic oxides in the molten mass and the action thereof on the surface of the material to be hardened. Substances, which are suitable for forming the oxides in question, for example magnesium carbonate, chloride obtained from cerite, and the like can be employed instead of the metallic compounds, such as magnesium oxide and the like.

The quantity of the metallic oxides to be added to the bath depends chiefly upon the working conditions, such as bath composition, treating temperature, quantity of working charge and the like. The addition of metallic oxides may be for example about 1 to 10%, preferably about 2 to 7%.

The percentage of the substances, such as boron compounds, assisting the dissolving and, in conjunction with the metallic oxides, preventing the formation of soft skins, depends chiefly upon the quantity of added metallic oxides and the composition of the neutral salt mixture; it generally does not amount to more than 20%, and preferably not more than about 12%.

The effect of the metallic oxides is probably chiefly due to the fact that they prevent the decomposition of the neutral salts, for example of the barium chloride, whereas the substances to be added, such as borax, serve, besides for assisting dissolving, also for counteracting decarbonization and thus, together with the metallic oxides, prevent the formation of a soft skin on the hardened material even in the case of subsequent tempering treatment.

The hardening is generally carried out at bath temperatures between 730 and 1400° C.; the hardening of tool steels generally takes place at temperatures between 730 and 850° C. and the hardening of high-speed tool steels at temperatures between 1000 and 1400° C., preferably at about 1300° C.

The invention is carried out for example in the following manner: The articles of high-speed tool steel are subjected to a short heat treatment at a temperature of about 1000–1350° C., the duration of which depends on the size of the articles, in a bath consisting of 85 parts by weight of barium chloride and containing, besides 2.5 to 7 parts of magnesium oxide, about 9 to 12 parts of crystalline borax, whereupon they are quenched in known manner and then tempered. The tempering temperatures are determined by the composition of the steel. As, however, contrary to the known processes, complicated workpieces can be hardened, without danger of decarbonization, at the maximum temperature most suitable for the steel, in the case of high speed tool steel for example at 1300° C., the tempering temperature can consequently be also very much increased; in

the case of high speed tool steel, for example to 550 to 580° C. and more.

For producing the bath barium chloride preferably comes into question as neutral salt for hardening high speed tool steels and for tool steel chiefly sodium chloride and potassium chloride, if necessary mixed with barium chloride.

The following baths are, for example, suitable for carrying out the process according to the invention:—

		Parts by weight
(1)	Barium chloride	71
	Sodium chloride	20
	Borax	8
	Magnesium oxide	1

		Parts by weight
(2)	Barium chloride free from water	88.3
	Magnesium oxide (burned and ground)	6.7
	Borax (crystalline)	9

In addition to or instead of magnesium oxide other metallic oxides of the above mentioned kind can be employed, and instead of or in addition to borax other boron compounds, fluorine compounds and the like.

The baths have a practically unlimited life; as a rule only quantities of salt have to be added which have been removed from the bath by evaporation and by losses due to adhesion. When working with the baths claimed, it is possible to produce in a simple continuous process which is easy to control, steels of particular qualities and perfect hardness, whilst reliably avoiding the formation of soft skins.

We claim:—

1. A heating bath for hardening steels which comprises an alkaline earth chloride, as a major portion thereof, a small quantity of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide, and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides.

2. A heating bath for hardening steels which comprises a mixture of an alkaline earth chloride, as a major portion thereof, and a chloride of an alkali metal, a small quantity of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides.

3. A heating bath for hardening steels which comprises barium chloride, as a major portion thereof, a small quantity of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide, and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides.

4. A heating bath for hardening steels which comprises barium chloride, as a major portion thereof, and a chloride of an alkali metal, a small quantity of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides.

5. A heating bath for hardening steels which comprises an alkaline earth chloride, as a major portion thereof, not more than about 10% of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides.

6. A heating bath for hardening steels which comprises an alkaline earth chloride, as a major portion thereof, not more than about 12% of an oxygen-containing compound of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides.

7. A heating bath for hardening steels which comprises an alkaline earth chloride, as a major portion thereof, not more than about 10% of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide, and not more than about 12% of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides.

8. A heating bath for hardening steels which comprises an alkaline earth chloride, as a major portion thereof, a small quantity of magnesium oxide and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides.

9. A heating bath for hardening steels which comprises an alkaline earth chloride, as a major portion thereof, a small quantity of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide and a small quantity of borax.

10. A process for hardening steels by heating in molten baths which comprises establishing a molten bath of an alkaline earth chloride, as a major portion thereof, a small quantity of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides, maintaining a temperature between about 700° C. and about 1500° C. in said bath, immersing a steel article in said bath to heat the same, and subsequently quenching the heated steel article.

11. A process for hardening steels by heating in molten baths which comprises establishing a molten bath of an alkaline earth chloride, as a

major portion thereof, and a chloride of an alkali metal, a small quantity of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides, maintaining a temperature between about 700° C. and about 1500° C. in said bath, immersing a steel article in said bath to heat the same, and subsequently quenching the heated steel article.

12. A process for hardening steels by heating in molten baths which comprises establishing a molten bath of barium chloride, as a major portion thereof, a small quantity of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides, maintaining a temperature between about 700° C. and about 1500° C. in said bath, immersing a steel article in said bath to heat the same, and subsequently quenching the heated steel article.

13. A process for hardening steels by heating in molten baths which comprises establishing a molten bath of barium chloride, as a major portion thereof, and chloride of an alkali metal, a small quantity of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides, maintaining a temperature between about 700° C. and about 1500° C. in said bath, immersing a steel article in said bath to heat the same and subsequently quenching the heated steel article.

14. A process for hardening tool steels which comprises establishing a molten bath of an alkaline earth chloride, as a major portion thereof, a small quantity of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides, maintaining a temperature between about 730° C. to about 850° C. in said bath, immersing a steel article in said bath to heat the same, and subsequently quenching the heated steel article.

15. A process for hardening high speed tool steels by heating in molten baths which comprises establishing a molten bath of an alkaline earth chloride, as a major portion thereof, a small quantity of a metallic oxide of the group consisting of beryllium oxide, magnesium oxide, aluminum oxide, cerium oxide and zirconium oxide, and a small quantity of an oxygen-containing compound of the group consisting of an oxygen-containing boron compound and a pyrophosphate, said oxygen-containing compound when fused being capable of dissolving metallic oxides, maintaining a temperature between about 1000° C. to about 1400° C. in said bath, immersing a steel article in said bath to heat the same, and subsequently quenching the heated steel article.

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