Patented June 17, 1924. 1,498,071

UNITED STATES PATENT OFFICE.

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ALLOY STEEL.

No Drawing. Application filed December 5, 1923. Serial No. 678,783.

To all whom it may concern:

Be it known that I, W NORMAN BRATTON, a citizen of the United States, residing at New York, in the county of New York, State of New York, have invented certain new and useful Improvements in Alloy Steel; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to improvements in alloy steels and provides a commercial composition of alloy steel presenting many advantages.

The improved alloy steel of the present invention is a manganese steel containing a relatively high content of manganese, e. g. from 1 to 2.5%, and also containing nickel and molybdenum.

It has heretofore been proposed to add nickel to manganese steels, but with nickel and manganese alone, the steel has a limited range of treatment which it is necessary to control carefully, and segregation often reduces or nullifies the improved physical properties.

The improved alloy steel of the present invention is an improvement upon nickel-manganese steels, possessing improved physical properties, and making these improved properties available for commercial uses. The limitations and disadvantages of nickel-manganese steels are overcome, the range of treatment is widened out, and danger of segregation relieved, through the incorporation of molybdenum in the nickel-manganese steel.

The new alloy steels in general contain from 1 to 2.5% manganese, from a fraction of a per cent up to about 1.25% of molybdenum, and from a fraction of a per cent up to about 3.5% nickel. The steel may contain varying amounts of the other usual ingredients such as carbon, silicon, etc., and may also contain other alloying metals.

The new alloy steel has the advantage from a manufacturing standpoint that two of the elements, molybdenum and nickel, are practically loss proof with both basic and acid slags so that the molybdenum and nickel may be added at the outset and may remain in the molten metal throughout the manufacture of the steel, or they may be added during the process of manufacture and before the process is completed. Consequently, when the steel is ready to be tapped, and when the molybdenum and nickel have been already added, the only calculations and additions necessary are for giving to the steel the desired content of manganese, and the desired content of other ingredients such as carbon and silicon. These additions at the time of tapping simplify the steel making process and make it similar to a plain carbon steel process. That is, the molybdenum and nickel can be added in the desired amounts during the furnace process, and the manganese, carbon and silicon can be added as the result of a final calculation similar to that employed in the case of plain carbon steel. This simple process nevertheless enables the desired molybdenum-nickel-manganese steel to be produced with a high manganese content and with the desired content of molybdenum and nickel, while it also permits the content of other ingredients such as carbon and silicon to be regulated and controlled.

Nickel toughens the steel and manganese strengthens it, while the nickel and manganese throughout the steel amplify the toughness, strength and resistance to wear-producing properties of the highly active molybdenum, or vice versa, or these three metals otherwise interact with each other and with the other ingredients of the steel to give the improved physical properties, such as toughness and strength. Nickel and manganese lower the temperature at which the carbon changes from one state (austenite) to another state (pearlite), which action is one of the responsible causes for setting and deepening of the hardening effect; while molybdenum strongly intensifies the hardening effect. Molybdenum and manganese are also highly powerful elements in delaying the dissociation of the hardening carbon condition.

One of the advantages of the stability of this carbon condition in the steel is the resistance to wear of the surface of the steel, especially under conditions where the surface is heated. Another advantage of the stability of this carbon condition in the steel is that cooling strains within the steel are relieved by the time and heat necessary to dissociate this carbon condition. Another important advantage is the finely divided

and uniform agglomeration and distribution of the hardening carbon or its dissociates throughout the steel, producing a structure highly conducive to withstanding both longitudinal and transverse stresses and to uniform wear.

The advantages resulting from the use of molybdenum, nickel and manganese together are such that a steel of improved physical properties can be produced at low cost and by a simple method of manufacture, containing a small percentage of molybdenum, a small percentage of nickel, and a high percentage of manganese.

While the proportions of molybdenum, nickel and manganese in the new alloy steel can be varied, it is advantageous for many purposes, to have the nickel content higher than the manganese content, or higher than the molybdenum content, or to have the molybdenum content higher than the nickel content. Where cost is not a controlling consideration, the limiting percentages of molybdenum, nickel and manganese will be where the improved physical properties of the molybdenum-nickel-manganese combinations decline.

The carbon content of the new alloy steels can vary from a fraction of 1% up to in excess of 1%. For softer steels a carbon content of from for example 0.1 or 0.2% up to 0.5 or 0.8% can be used. For other purposes a higher carbon content can be used, e. g. around 1% or from about 0.8 to about 1.4%, giving a harder steel; while for still harder steels the carbon content may be increased above 1.4% up to an amount approximating the cast iron range.

The silicon content of the alloy can also be varied and regulated. The alloy may contain only the normal content of steels or a small increase thereover, e. g. from less than 0.1% up to 0.2% or 0.4%; or a much higher silicon content may be used, e. g. around 0.75% or 1%, or even higher.

The steel will also contain the impurities present in small amount in commercial steels such as sulfur, phosphorus, etc. The steel may be deoxidized with suitable deoxidizers and commercial deoxidizers may be used for this purpose, or special deoxidizers such as zirconium, etc., may be used. The alloy steel may also contain varying amounts of other alloying metals in addition to the nickel, molybdenum and manganese.

The invention will be further illustrated by the following specific examples of compositions or ratios of the ingredients suitable for wide usages. When the molybdenum content is about 0.25%, the ratio of the molybdenum, nickel and manganese may advantageously be about 1:4:6, that is, containing about 1% of nickel and about 1.5% of manganese. Instead of using the molybdenum, nickel and manganese in these proportions, the molybdenum may be for example about 0.25%, the nickel about 0.5% or less, and the manganese about 1.5%.

Another advantageous ratio of the molybdenum nickel and manganese, where the molybdenum content is about 0.5%, is the ratio of 1:2:3, that is, with about 1% of nickel and about 1.5% of manganese. Instead of using about 1% of nickel, a smaller amount can be used, i. e., a fraction of 1% where the molybdenum content is about 0.5% and the manganese about 1.5%.

The combination of alloys in the proportions used in these specific examples are low in cost of manufacture and possess important properties in the way of toughness, strength, wide range of heat treatment, etc.

I claim:

1. An alloy steel containing about 1% to 2½% of manganese and also containing small but substantial amounts of nickel and molybdenum.

2. An alloy steel containing about 1% to 2½% of manganese and also containing nickel and molybdenum in small but substantial amounts, both the nickel and molybdenum contents being less than that of the manganese.

3. An alloy steel containing from a small but substantial fraction of 1% up to about 1.25% of molybdenum, from a small but substantial fraction of 1% up to about 3.5% of nickel and from 1% to about 2.5% of manganese.

4. An alloy steel containing from a small but substantial fraction of 1% up to about 1.25% of molybdenum, from a small but substantial fraction of 1% up to about 3.5% of nickel, from 1% to about 2.5% of manganese, and containing up to about 0.8% of carbon.

5. An alloy steel containing from a small but substantial fraction of 1% up to about 1.25% of molybdenum, from a small but substantial fraction of 1% up to about 3.5% of nickel, from 1% to about 2.5% of manganese, and containing from about 0.8% to about 1.4% of carbon.

6. An alloy steel containing from a small but substantial fraction of 1% up to about 1.25% of molybdenum, from a small but substantial fraction of 1% up to about 3.5% of nickel, from 1% to about 2.5% of manganese, and containing a carbon content in excess of 1.4%.

7. An alloy steel containing molybdenum, nickel and manganese in small but substantial amounts, the nickel content being in excess of the molybdenum content, and the manganese content being in excess of the nickel and molybdenum contents, the manganese content being from about 1% to about 2½%.

8. An alloy steel containing molybdenum, nickel and manganese, the nickel content

being in excess of the molybdenum content and the manganese content being in excess of both the nickel and the molybdenum contents together, the manganese content being from about 1% to about 2½%, and the molybdenum and nickel being present in small but substantial percentages.

9. An alloy steel containing molybdenum, nickel and manganese in the proportions of about 1 part of molybdenum, 1 to 4 parts of nickel, and 3 to 6 parts of manganese, the molybdenum being present in amounts varying from a small but substantial fraction of 1% up to about 1.25%.

10. An alloy steel containing molybdenum, nickel and manganese in the proportions of 1 part of molybdenum, 2 to 4 parts of nickel, and 3 to 6 parts of manganese, the molybdenum being present in amounts varying from a small but substantial fraction of 1% up to about 1.25%.

11. An alloy steel containing molybdenum, nickel and manganese in the proportions of about 1 part of molybdenum, 6 parts of manganese, and from 4 to less than 2 parts of nickel, the molybdenum being present in amounts varying from a small but substantial fraction of 1% up to about 1.25%.

12. An alloy steel containing molybdenum, nickel and manganese in the proportions of about 1 part of molybdenum, 3 parts of manganese, and 2 or less than 2 parts of nickel, the molybdenum being present in amounts varying from a small but substantial fraction of 1% up to about 1.25%.

13. An alloy steel containing about 0.25% molybdenum, about 1.5% manganese, and up to about 1% of nickel.

14. An alloy steel containing about 0.5% molybdenum, about 1.5% manganese, and up to about 1% of nickel.

In testimony whereof I affix my signature.

W NORMAN BRATTON.