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ALLOY STEEL AND METHOD OF PRODUCING THE SAME.

No Drawing.

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This invention relates to an alloy steel and the method of producing the same and it is designed more particularly for use in the production of steel castings.

One object of the invention is to provide a high tensile steel having an unusually high elastic ratio with suitable ductility.

A further object of the invention is to provide a steel for castings which will be of a hard tough character but will be easily machined; and which will have a relatively low shrinkage.

A further object of the invention is to provide such a steel which can be easily produced at a relatively low cost.

In carrying out the invention I first modify the constituent elements of the usual steel by adding thereto a quantity of copper. The steel which forms the basis of the alloy may be of any suitable character and may be produced by any suitable process. The other constituents of the steel are those usually present and while the percentage of the various constituents may vary the following range of percentages is a desirable one: carbon .20% to .60%; manganese .60% to .90%; sulphur and phosphorus under .05% and silicon .20% to .60%. The copper may be added to the steel either before or after melting and the percentage of copper which is contained in the alloy may vary greatly. Ordinarily the percentage of copper ranges from .50% to 5% and highly satisfactory results are obtained by the use of approximately .90% of copper. It will be understood, however, that the quantity of copper is not limited to the range of percentages here mentioned as the amount of copper may be very greatly in excess of 5% and may be less than .50%, this being determined, in part at least, by the character of the steel to which the copper is added and by the physical properties of the alloy which it is desired to obtain.

The molten metal is poured and the ingot or casting formed in the usual or any suitable manner. The alloy metal in the raw state, that is as it comes from the mold, is not ductile to any large extent and while its ultimate strength is comparatively high its elongation will in many instances be low, depending upon the carbon content. I have found, however, that proper heat treatment greatly changes the physical

properties of the steel and increases the yield point, ultimate strength, elongation, reduction of area and the Brinell hardness to a marked degree, thereby producing a hard steel having great strength and high elastic ratio and which can be easily machined. The manner of heat treating the castings may vary but I prefer to first normalize the casting by heating the casting to a relatively high temperature and then cooling the same slowly, preferably in air, and to then draw the normalized casting, that is, to re-heat it and again cool it slowly, as in air. In normalizing the casting the most satisfactory results have been obtained by heating the casting to approximately 1550 degrees F. for a time sufficient to insure the entire mass reaching this temperature, holding the same at this temperature for a relatively short period and then cooling in air. This treatment transforms the alloy into a ductile, easily machinable material having high ultimate strength and high elastic ratio. It will be noted that the temperature to which the casting is heated in the normalizing operation is low, as the ordinary carbon steels and many of the alloy steels require a temperature of from 1700 degrees F. to 1750 degrees F. to break up the original dendritic structure and produce a fine grained product. This low temperature has obvious advantages. It not only results in a material saving in time and fuel in the normalizing operation but it greatly reduces the scaling action which is encountered in the usual annealing furnace atmosphere.

The drawing or re-heating operation is preferably effected at a temperature materially less than that at which the normalizing of the casting is effected. Good results are obtained at temperatures between 950 and 1025 degrees F. and highly satisfactory results are had at a temperature of approximately 1000 degrees F. After having been re-heated to the prescribed temperature and held at that temperature for a relatively short time the casting is again cooled. The drawing of the casting as described after normalizing increases the yield point, ultimate strength, elongation, reduction of area and Brinell hardness, all to a marked degree. It is a well known fact that after air quenching or normalizing the

usual carbon or alloy steel is "let down" by re-heating, that is, the yield point, ultimate strength and Brinell hardness decrease on re-heating. With the present alloy steel these physical properties are increased on re-heating. To illustrate the effect of the heat treatment on the steel the following example may be given. Test bars from an electric furnace heat of this alloy steel analyzing carbon .40; manganese .74; silicon .41; copper .88; phosphorus .039; and sulphur .014, were heat treated, machined and pulled with the following results: When normalized at 1550 degrees F. the yield point was 67500; ultimate strength 102750; elongation 13.5; reduction of area 19.3; Brinell hardness 207. When normalized at 1550 degrees F. and then drawn at 1000 degrees F. the yield point was 81250; ultimate strength 114700; elongation 18.0; reduction of area 21.3; and Brinell hardness 228.

This increase in the yield point, ultimate strength, elongation, reduction of area and hardness, which results from the heat treatment, is important not only because of the highly desirable physical properties of the finished casting but also because of the fact that it makes possible the production of castings, meeting different specifications, from a single grade of metal. The normalized casting will in many instances have the physical properties necessary to meet one set of specifications without drawing the same, and, when drawn, castings from the same metal will have different physical properties which will meet the requirements of a second specification. Further, if the material is "off" in analysis and cannot be made to meet the first specifications by ordinary normalizing it may be drawn and in this way the yield and tensile raised to meet the specifications, and the castings thereby salvaged.

A further advantage which results from this alloy steel is found in the fact that the copper contained in the scrap is not lost but remains in the bath of metal, when melted down, so that it is not necessary to add copper to the full percentage required but only to add that amount of copper which, together with that contained in the steel, will aggregate the desired percentage. Further, this alloy when cast has a remarkably low shrinkage, thus enabling castings of different sections to be produced without excessive loss.

While a steel having the several physical properties above set forth is best produced, by the particular method described, it will be understood that this method may be varied and castings produced at a low cost, which have very valuable physical properties. For example, by first heating the casting and quenching the same quickly, as in water, and then drawing the same a very

hard tough casting is produced, which while not having all the physical properties of the castings produced by the first mentioned method, will nevertheless give just as satisfactory results as the usual high priced steels. Again, by heating the raw casting and cooling in the furnace a very large degree of ductility may be had which will enable castings so treated to be used in places which now require a special low carbon steel.

Thus it will be understood that my invention, in its first or larger aspect, comprehends the production of a steel alloy formed by combining, in a molten state, steel, in the ordinary acceptance of the term, with copper followed by normalizing this composition by means of the application thereto of heat at a degree of approximately 1550° F., whereby I obtain in the resultant product an increase in the elastic limit and an increase in the tensile strength, together with an increase in the Brinell hardness, all as compared with what is obtainable with respect to these qualities in the absence of my ingredient of copper; so that such a product is the resultant of the copper ingredient combined with the steel when normalized at approximately 1550° F.

My invention, in its further or next aspect, combined with the above aspect, comprehends the step of re-heating the normalized product within the range of temperatures stated above as between approximately 950° F. and approximately 1025° F. followed by a cooling step; by which re-heating I obtain the further qualities in the product of a greater increase in the elastic limit, a greater increase in the tensile strength and also a greater degree of Brinell hardness as compared with those obtained without the reheating step, while by the latter I obtain also an increase in the reduction of area and in the elongation.

And finally, my invention, in its remaining aspect, comprehends the composition, which I subjected to these steps of treatment, composed of steel, preferably that which is known as carbon steel, combined with copper from approximately one-half of one per cent up to approximately five per cent.

I have referred more particularly, in the foregoing description, to castings, but it will be understood that the alloy steel may be poured in ingots and then worked into finished parts, by forging, rolling or the like, and the finished parts will respond to the described heat treatment in the same manner as the castings, and the term "casting" as herein employed is intended to include parts so formed as well as those which are given their final shape in a mold.

Further, I have found that the addition of copper to iron will produce an alloy having very valuable physical properties.

Having now fully described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. The method of treating an alloy steel of a particular composition, to-wit, steel combined with copper, the latter in quantity from approximately one-half of one per cent up to approximately five per cent, which method comprises these steps, namely, combining the steel and copper by a melting heat; pouring an ingot or casting from such molten mass; normalizing said ingot or casting by sufficient heat less than 1700 degrees F. continued until the entire mass is reached and by cooling such ingot or casting.

2. The method of treating an alloy steel of a particular composition, to-wit, steel combined with copper, the latter in quantity from approximately one-half of one per cent up to approximately five per cent, which method comprises these steps, namely, combining the steel and copper by a melting heat; pouring an ingot or casting from such molten mass; normalizing such ingot or casting by heating it to approximately 1550° F. for a sufficient time to insure the entire mass being reached by the heat; air-cooling such ingot or casting; re-heating such ingot or casting at a temperature between approximately 950° F. and approximately 1025° F.; and again air-cooling such ingot or casting.

3. The method of treating an alloy steel of a particular composition, to-wit, steel

combined with copper, the latter in quantity from approximately one-half of one per cent up to approximately five per cent, which method comprises these steps, namely, combining by a melting heat carbon steel containing substantially .20 per cent to .60 per cent of carbon, .60 per cent to .90 per cent of manganese, under .05 per cent of sulphur and phosphorus, and .20 per cent to .60 per cent of silicon, with approximately one-half of one per cent up to approximately five per cent of copper; pouring an ingot or casting from such molten mass; normalizing such ingot or casting by heating it to approximately 1550° F. for sufficient time to insure the entire mass being reached by the heat; air cooling such ingot or casting; re-heating such ingot or casting at a temperature between 950° F. to 1025° F.; and in again air cooling such ingot or casting.

4. The method of treating an alloy steel of a particular composition, to-wit, steel combined with copper, the copper being in quantity from approximately one-half of one per cent to approximately five per cent, to increase the tensile strength, the elastic limit and the Brinell hardness, which method consists in normalizing such alloy by sufficient heat continued until the entire mass is reached; in re-heating it to approximately 1000° F.; and in cooling it.

In testimony whereof, I affix my signature hereto.

HARRY B. KINNEAR.