

UNITED STATES PATENT OFFICE

2,013,443

HIGH SILICON AND HIGH MANGANESE
STEEL

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No Drawing. Original application November 7, 1930, Serial No. 494,192. Divided and this application November 24, 1933, Serial No. 699,567

3 Claims. (Cl. 75—1)

This invention relates to steel products. This application is a division of my application, Serial No. 494,192, filed November 7, 1930, Patent #1,941,556 of January 2, 1934. Steel castings may be obtained from the steel that is produced by this invention which are substantially free from porosity or gas holes without the use of such an amount of aluminum as would be in danger of impairing physical properties of the steel, such as ductility, for example. Steel may be made in an electric furnace by this invention having less than about 0.20% of carbon, not more than about 3.00% of manganese, about 0.50% to 3.00% of silicon, and less than 0.06% each of sulphur and phosphorus.

It is well known that when carbon steel is to be poured into green sand molds to form medium size and small castings, it must be superheated to bring it to a sufficiently fluid condition for this purpose. When such steel is poured into molds, it comes into contact with oxygen of the air and moisture in the molds, with the result that iron oxide and gases, such as carbon monoxide and carbon dioxide, are formed and dissolved in the steel. As the steel cools in the mold, its ability to hold gases in solution decreases, thus causing the gases to be released, resulting in pinholes or blowholes. It also is probably true that the iron oxides dissolved react with the carbon of the steel as the affinities of the elements of the steel change with drop in temperature, when in the molten condition. This is especially true of light sections of steel castings where a proportionately large surface area is exposed to the moist sand of the mold. Such sections are apt to show considerable porosity or pinholes.

It has been found that this trouble of porosity can be avoided by the addition of aluminum to the molten steel, but the addition of sufficient aluminum to take care of this condition often results in decreased ductility of the steel.

By the present invention, silicon-manganese steel is produced having the desired physical properties in which the trouble of porosity is obviated without the use of a deleterious amount of aluminum. The process is carried out so that the final product will contain less than about 0.20% of carbon and in such a way that the steel is deoxidized and degasified during its production by carbon and the introduction of silicon and manganese so that dissolved gases are removed and castings free from porosity can be obtained.

The following is given as a specific example of practicing this invention, but it is to be understood that the proportions can be varied over a consider-

able range: Steel scrap of about 0.20% to 0.30% carbon content is melted in an acid electric furnace. Before the charge is completely melted, sufficient iron ore is introduced into the bath so that the carbon content after the reaction brought about by the ore, will be about .12%. After the charge is completely melted, a sufficient amount of silica sand is added to make the slag more siliceous and therefore less oxidizing. This increases its ability to hold iron oxides and thus decreases the amount of iron oxides in the bath metal. When the temperature reaches the point where the carbon reacts with the dissolved iron oxides obtained from the ore additions, the bath boils due to the formation of carbon monoxide gas which passes through the slag and reacts with oxides therein, forming carbon dioxide and thus reduces the oxidized condition of the slag by decreasing its oxide content.

As the carbon gets lower to, say, about 0.12% in the molten bath, the reaction slows down due to the fact that the amounts of carbon and iron oxide in the bath decrease and the steel has a sufficiently great affinity for the remaining carbon to prevent further reaction of the carbon with the iron oxide in the bath.

When the boiling subsides, more carbon is added to the bath, preferably in the form of low silicon pig iron or wash metal, the latter being iron containing only about 4% of combined carbon. The carbon that is added reacts with more of the iron oxide of the bath and the bath is rabbled after the carbon is added to promote reaction between the carbon and iron oxide. The amount of pig iron or other iron containing carbon is about 1½% of the molten batch. Additional reaction between carbon and iron oxide takes place using up about half of the added carbon which passes off as a gas in the form of an oxide of carbon. At the same time, other gases that may be present in the molten batch are swept out mechanically and non-metallic impurities are carried off and rise and become part of the slag.

As soon as the second boiling subsides, which usually requires about five or six minutes after the proper amount of pig iron or wash metal has been added with the desired carbon content, about 1% or sixty pounds of low carbon silico-manganese per five thousand pounds of metal is added and the bath rabbled for about a minute after the introduction of the silico-manganese to distribute it uniformly throughout the bath. The oxygen content of the bath is thereby further reduced and the products of deoxidation in the relatively shal-

low bath of the electric furnace rise and enter the slag and manganese silicate is also formed, which rises and enters the slag. It has been found that the silicon content of the bath at this stage will be about 0.50%.

About ten minutes is permitted for the silicon-manganese reaction to take place and exercise its cleansing effect upon the bath and then the temperature of the bath is slowly increased until the metal reaches approximately the temperature that is suitable for pouring small castings care being exercised to prevent the steel from becoming overheated.

After the temperature of the bath has been increased almost to the temperature hot enough for pouring the castings, about 1¼% or seventy pounds of silico-manganese to five thousand pounds of metal is added, together with an equal amount of 50% ferro-silicon. The amount of silico-manganese and ferro-silicon introduced at this stage can be varied considerably, depending upon the final composition that is desired. The bath is rabbled about a minute after the last addition to distribute the silicon and manganese throughout the steel and the furnace is tapped about two minutes after rabbling. By having the silicon and manganese distributed throughout the steel, very little, if any, iron oxide is formed when the molten metal passes from the furnace into the ladle, as oxygen from the air combines with the manganese and silicon rather than with the iron. If desired, an additional amount of silicon may be introduced into the ladle. The amount of silicon introduced into the ladle should not exceed more than about 2% of the charge by weight because of the danger of chilling the steel. The presence of the silicon and manganese not only helps to prevent the formation of iron oxide in the steel, but their presence also imparts high tensile strength and a high elastic limit to the steel notwithstanding the fact that its carbon content is low.

An analysis of a sample of steel made in accordance with the example given above showed a carbon content of 0.12%, silicon 1.76%, manganese 1.53%, sulphur 0.045% and phosphorous 0.040%. It showed a tensile strength of 77,750 pounds per square inch, a yield point of 53,000

pounds per square inch, an elongation of 32.8%, a reduction of area of 64.7% and withstood a bend test of 180° around a pin one inch in diameter. As an additional insurance against unusual conditions of the mold that might result in porous castings, a small amount of aluminum may be introduced into the ladle after it has been filled, without changing the physical properties of the steel very much.

By this invention steel is made that has a low carbon content and a high silicon and high manganese content which can be poured into green sand molds to produce small size castings that are free from porosity. The steel is very ductile with high tensile strength and high ratio of yield point and elastic limit to tensile strength.

Ferro silicon and low carbon manganese can be substituted for silico-manganese, but the best results were obtained with silico-manganese.

I claim:

1. Steel of high tensile strength and ductility containing about 0.12% carbon, 1.76% silicon, 1.53% manganese, less than 0.06% of sulphur and phosphorous each, and the remainder substantially all iron, said steel being capable of being cast into green sand molds when melted without becoming porous when it freezes.

2. Steel of high tensile strength and ductility containing about 0.12% carbon, about 1.76% silicon, about 1.53% manganese, less than 0.06% of sulphur and phosphorous each, and the remainder substantially all iron, said steel being capable of being cast into green sand molds when melted without becoming porous when it freezes, said steel having a tensile strength over 75,000 pounds per square inch.

3. Steel of high tensile strength and ductility containing about 0.12% carbon, about 1.76% silicon, about 1.53% manganese, less than 0.06% of sulphur and phosphorous each, and the remainder principally all iron, said steel being capable of being cast into green sand molds when melted without becoming porous when it freezes, said steel having a tensile strength over 75,000 pounds per square inch and a yield point of about 53,000 pounds per square inch.

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