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CHROMIUM STEEL SEAMLESS TUBE

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3 Claims. (Cl. 138—47)

The invention relates to corrosion resistant and heat resistant chromium steel articles, and more especially to articles of this description suitable for use in superheaters, preheaters, soot blowers, hydrocarbon cracking apparatus, and analogous structures.

It is well known that low carbon steels containing about 15% to 35% chromium comprise, even in the wrought state, relatively large, coarse crystals which are bound together rather loosely. The crystal size of these steels may be reduced to some extent by proper hot working; but even under the most favorable conditions portions of the steel are quite likely to consist of large grains. Furthermore, if these steels are used at high temperatures, which is frequently the case, the crystal grains soon grow to a size sufficient to render the material brittle.

I have discovered that the addition of nitrogen to low carbon, high chromium steels in amounts considerably in excess of those heretofore permitted reduces greatly the grain size of the steels. The reduction in grain size is accompanied by a general improvement in the physical characteristics of the steels, and by an increase in ductility and strength both at low temperatures and at temperatures above 400° C. This discovery is described in Patents 1,990,589 and 1,990,590, issued to me on February 12, 1935.

I have further discovered that the presence of relatively large amounts of nitrogen in high chromium steels strongly inhibits grain growth in the metal at elevated temperatures between say about 850° C. and about 1100° C.

A still further effect of a large amount of nitrogen in these chromium steels is that it tends to inhibit carburizing of the metal at elevated temperatures in the presence of carbon and carbon compounds. Extensive carburizing of high chromium steels is frequently an important contributing cause of embrittlement in hydrocarbon cracking stills, soot blowers, and other apparatus.

The present invention is a useful application of these discoveries, and consists of apparatus and parts thereof designed for use at temperatures upward of about 400° C., for example seamless wrought steel tubes for hydrocarbon cracking, comprising about 15% to 35% chromium, about 0.05% to 0.50% carbon, at least about 0.15% but not more than about 0.65% nitrogen, remainder chiefly iron. Relatively large amounts of nickel may be added without departing from the invention. The presence of small amounts of other alloy constituents in the tubes in no way decreases the benefits to be derived from the use of nitrogen. In fact, up to about 2% of one or more of such elements as molybdenum and tungsten does not seem to change materially the properties of the tubes. The usual small amounts of manganese, silicon, sulfur, and phosphorus may of course be present.

Some benefit may be had by the use of a nitrogen content slightly less than 0.15%; but at least 0.15%, and preferably at least 0.20% nitrogen should be present to obtain a valuable benefit. It is difficult to state categorically the optimum percentage of nitrogen, because this depends to a great extent upon the chromium content; but the maximum amount of nitrogen which can be retained in stable combination by the steel at its casting temperature is usually preferred. This maximum is approximately 0.2% nitrogen for a 15% chromium steel, and approximately 0.65% for a 35% chromium steel.

Experiments which I have made demonstrate the novel and useful properties of the articles of the invention at elevated temperatures up to about 1100° C. For example, a steel containing 22.46% chromium, 0.46% manganese, 0.36% silicon, 0.08% carbon, and 0.032% nitrogen was embrittled after holding for about 40 hours at about 475° C., while a steel containing 22.67% chromium, 0.28% manganese, 0.65% silicon, 0.09% carbon, and 0.37% nitrogen did not become embrittled under the same treatment until after about 30 days.

In another test a steel containing about 28% chromium, 0.25% nitrogen, 0.30% carbon, and the balance substantially all iron, was held for about six months at temperatures in the vicinity of 900° C. with only a slight change in the grain size of the steel. A similar test on a steel having substantially the same contents of chromium, carbon, and iron, but only traces of nitrogen, increased the average grain size of the material markedly.

In another test, a steel containing about 25% chromium, 0.15% carbon, 0.20% nitrogen, and the balance substantially all iron, was appreciably ductile after it had been held for several hundred hours at about 1000° C. and then tested at room temperatures, whereas a similar steel containing only traces of nitrogen exhibited brittleness at room temperatures after the same treatment. The latter steel showed appreciable grain growth under the influence of the high temperature, and doubtless this growth con-

tributed in large part to the embrittlement of the metal.

Other experiments have been made on similar steels at temperatures in the neighborhood of 1100° C., and at these temperatures the higher nitrogen material again proved to be notably superior to the low nitrogen material in respect to grain growth and embrittlement.

As described in my above mentioned prior applications, the nitrogen must be distributed substantially uniformly throughout the metal, so that the steel has substantially the same concentration of nitrogen in all parts thereof.

I claim:

1. Corrosion and heat resistant wrought chromium steel seamless vessel designed for use at temperatures between about 850° C. and about 1100° C., and characterized by a substantial resistance to grain growth and carburization at said temperatures, said seamless vessel having substantially the composition: 15% to 35% chromium; 0.05% to 0.5% carbon; at least 0.15% but not more than 0.65% nitrogen; the remainder substantially all iron, the nitrogen concentration being substantially the same in all parts of the steel.

2. Seamless wrought steel tube designed for use at temperatures between about 850° C. and about 1100° C., and characterized by a substantial resistance to embrittlement caused by grain growth or carburization at said temperatures, said tube having substantially the composition: 15% to 35% chromium; 0.05% to 0.5% carbon; at least 0.2% but not more than 0.65% nitrogen; the remainder substantially all iron, the nitrogen concentration being substantially the same in all parts of the steel.

3. Seamless wrought steel tube highly resistant to carburizing action and designed for use at temperatures between about 850° C. and about 1100° C. in contact with carbon-containing material, said tube having substantially the composition: 15% to 35% chromium; 0.05% to 0.5% carbon; at least 0.2% but not more than 0.65% nitrogen; the remainder substantially all iron; and the nitrogen content being substantially the maximum that can be retained by the steel at the casting temperature thereof, the nitrogen concentration being substantially the same in all parts of the steel.

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