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MANUFACTURE OF ARTICLES FROM STEEL ALLOYS

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6 Claims. (Cl. 75—123)

This application is a division of my application Serial Number 713,925, filed March 3, 1934.

This invention relates to the manufacture from steel alloys of articles which in their normal use are subjected to the attack of hydrogen at high hydrogen partial pressures and high temperatures. The invention is particularly applicable to the manufacture of apparatus and parts thereof which are used in the destructive hydrogenation of oil and coal, or in the synthesis of ammonia, and with which hydrogen or mixtures of gases containing hydrogen come into contact at high temperatures and pressures.

It has already been proposed to manufacture the parts exposed to pressure, of apparatus used in operating with hydrogen and gas mixtures containing hydrogen under pressure and at elevated temperatures, from alloyed steels which contain chromium, tungsten, molybdenum or vanadium and if desired nickel. Tests made with steel alloys containing vanadium, however, showed only a very slight increase of the resistance of the alloys to the attack of hydrogen. A steel alloy, for example, containing 0.25% C, 0.26% Si, 0.48% Mn, 2.08% Cr and 0.30% V has lost its carbon to a depth of 3.8 mm when subjected to the action of hydrogen for 59 hours at a temperature of 600° C. and a pressure of 300 at., whilst for example a steel containing 0.23% C, 0.26% Si, 0.50% Mn, 1.97% Cr and 0.44% Mo under equal conditions after 300 hours showed a depth of carbon removal of 2.1 mm only. The influence of the V-content on the resistance of the steel to carbon removing gases thus was only small, at any rate smaller than that of the molybdenum. It has been found, however, that vanadium imparts to the steel a very high resistance to the attack of carbon removing gases, if added to the steel in higher percentages than it is usual for improving mechanical properties of the steel. For, if so much vanadium is added to the steels, that the vanadium content amounts to at least four times the C-content; and in all cases, more than 0.3%, its effect on the resistance to the action of carbon removing gases is notably greater than the effect obtained by the addition of equal percentages of chromium, tungsten or molybdenum. Besides vanadium, also the remaining elements of group V. of the periodic table which form carbides in the steel, viz. columbium and tantalum, impart to the steel high resistance to the attack of hydrogen and hydrogen containing gases that attack and remove carbon.

The present invention therefore consists in the manufacture of articles of the class described

from steel alloys which contain at least one of the elements of group V. of the periodic table which form carbides in the steel, viz. vanadium, columbium and tantalum. In the case of a steel alloy in which the element of group V. which forms carbides in the steel is vanadium according to the invention, the vanadium content amounts to more than 0.3%.

Test bars of a cross section of 10 x 10 mm. made from steels of the following composition

0.09% C,	0.39% Si,	0.48% Mn,	0.62% V,
0.09% C,	0.39% Si,	0.54% Mn,	1.24% V,
0.10% C,	0.22% Si,	0.45% Mn,	0.87% Cb,
0.09% C,	0.25% Si,	0.48% Mn,	1.70% Ta

after having been exposed in a high pressure tube during 100 hours to the attack of hydrogen under pressure of 300 at and at a temperature of 600° C., showed no loss of carbon that could be detected analytically or metallographically. In contrast thereto steels of the compositions

0.10% C,	0.38% Si,	0.51% Mn,	1.96% Cr,
0.10% C,	0.38% Si,	0.55% Mn,	2.08% W,
0.13% C,	0.23% Si,	0.52% Mn,	1.22% Mo

when treated in the same manner were seriously attacked already after 10 hours and had lost the carbon nearly completely after 100 hours.

A particularly favorable influence of the vanadium is to be observed, if the vanadium content amounts at least about to four times the carbon content, so that a determined quantity of carbon is bound as vanadium carbide. The maximum resistance to the attack of the gases above-mentioned is obtained, if the V content amounts to at least about 5.6 times the C content, so that the whole of the carbon is bound to the vanadium as V_4C_3 .

The carbon content of the alloys used according to the invention preferably does not exceed 1%. The vanadium content preferably amounts to not over about 5%, but must be higher than 0.3%. Also the content of columbium or tantalum may amount to about 5%. The balance of the alloy being substantially iron with the normal contents of Mn and Si. The latter content, however, may amount up to 1.5%.

Furthermore, in order to improve the mechanical properties of the steel alloys and their resistance to scaling and corrosion, further alloy constituents may be added to the alloys used according to the invention, such as silicon, manganese, nickel, cobalt, chromium, tungsten and molybdenum. The total content of these elements, separate or mixed, may amount to about 30%. In general, however, a total content of not more than 15% thereof is found satis-

factory. Even when these additional elements are present in the alloy, the vanadium, columbium and tantalum remain the principal factor of the resistance to the removal of carbon, owing to their great affinity for carbon.

It has been found particularly suitable to make use of steels according to the invention which contain carbon in an amount not exceeding 0.4%, vanadium, columbium or tantalum in an amount not exceeding 2%, molybdenum in an amount not exceeding 3%, with or without chromium in an amount not exceeding 10%. For apparatus for the destructive hydrogenation of oil and coal as well as for the synthesis of ammonia the following steel alloys may, for example, be used:

1. A steel alloy containing about 0.10% C, 0.30% Si, 0.50% Mn, 0.80% V.

2. A steel alloy containing about 0.08% C, 0.30% Si, 0.50% Mn, 1.0% Cr, 0.50% V.

3. A steel alloy containing about 0.10% C, 1.5% Si, 0.50% Mn, 6.0% Cr, 0.4% Mo, 0.6% V.

I claim:

1. Articles which in their normal use are subjected to the attack of hydrogen at high hydrogen partial pressures and high temperatures, said articles being composed of a steel alloy consisting of carbon not over 1%, over 0.3% and not over 5% of one or more elements selected from the group vanadium, columbium, tantalum; the remainder substantially iron with silicon not over about 1.5% and a manganese content within the usual range for low alloy steels.

2. Articles which in their normal use are subjected to the attack of hydrogen at high hydrogen partial pressures and high temperatures, said articles being composed of a steel alloy consisting of carbon not over 1%; vanadium in an amount at least four times greater than the carbon content and not over 5%; the remainder substantially iron with silicon not over about 1.5%

and a manganese content within the usual range for low alloy steels.

3. Articles which in their normal use are subjected to the attack of hydrogen at high hydrogen partial pressures and high temperatures, said articles being composed of a steel alloy consisting of carbon not over 0.89%, vanadium in an amount at least 5.6 times greater than the carbon content and not over 5%; the remainder substantially iron with silicon not over about 1.5% and a manganese content within the usual range for low alloy steels.

4. Hydrogenating apparatus having its parts which are subjected to the attack of hydrogen at high pressure and temperature, composed of a steel alloy containing carbon not over 1%, over 0.3% and not over 5% of one or more elements selected from the group vanadium, columbium, tantalum; the remainder substantially iron.

5. A process which comprises subjecting a material to be hydrogenated to the influence of hydrogen at high hydrogen partial pressure and high temperature in a container composed of a steel alloy consisting of carbon not over 1%, over 0.3% and not over 5% of material from the group vanadium, columbium, tantalum; the remainder substantially iron with silicon not over about 1.5% and a manganese content within the usual range for low alloy steels.

6. A process which comprises subjecting a material to be hydrogenated to the influence of hydrogen at high hydrogen partial pressure and high temperature in a container composed of a steel alloy consisting of carbon not over 1%; vanadium in an amount at least four times greater than the carbon content and not over 5%; the remainder substantially iron with silicon not over about 1.5% and a manganese content within the usual range for low alloy steels.

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