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MANUFACTURE OF ARTICLES FROM STEEL ALLOYS

Friedrich Karl Naumann, Essen, Germany, assignor to Fried. Krupp Aktiengesellschaft, Essen-on-the-Ruhr, Germany

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This invention relates to the manufacture of articles that by their nature are subjected in use to, and must withstand the attack of, gases that attack and remove carbon. 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 is known to make such apparatus and parts thereof from so-called alloy steels containing chromium, tungsten, molybdenum, or vanadium, and in some cases nickel also.

It is also known in the manufacture of apparatus for cracking oil and tar to make use of steel alloys which contain up to 13% chromium, and which may also contain one or more elements as follows:—0.3 to 4% aluminum, 0.2 to 2.5% copper, and up to 2% silicon, molybdenum, vanadium, titanium or beryllium. The present invention is not concerned with the apparatus or parts thereof used in cracking processes but with regard to the treatment of oil and coal only with apparatus in which oil and coal are brought into reaction with hydrogen and the operation is carried on at high hydrogen partial pressures.

According to the present invention use is made for the manufacture of the articles in question of steel alloys which contain titanium and if desired one or more of the elements silicon, manganese, nickel, cobalt, chromium, tungsten, molybdenum and vanadium.

It has been found that titanium possesses to a much greater degree than chromium, tungsten, molybdenum and vanadium, the property of making steel resistant to the attack of gases that attack and remove carbon, such for instance as the attack of hydrogen at high temperatures and pressures. This greater capacity for resisting hydrogen at high temperatures and pressures is clearly illustrated by the result of the following experiments.

Tubes of external diameter of 30 mm. and internal diameter of 12 mm. were made from steel alloys of the following composition:—

1. 0.15% C, 0.24% Si, 0.38% Mn, 3.18% Cr, 0.39% Mo.

2. 0.11% C, 0.33% Si, 0.50% Mn, 0.46% Ti.

Hydrogen under a pressure of 300 atmospheres and at a temperature of 700° C. was led through these tubes. The tube made from steel No. 1 burst after 48 hours, and subsequent examination of the tube showed that carbon had been

removed to a depth of 2 mm. The tube made from steel No. 2 was still undamaged after being tested for 100 hours and showed no loss of carbon.

The carbon content of the alloys used according to the invention preferably does not exceed 1%. The titanium content preferably does not exceed 5%. It is particularly advantageous to make the titanium content at least four times as great as the carbon content so that the whole of the carbon is bound to the titanium as titanium carbide. However, if smaller titanium contents are used there is still a substantial increase in the resistance to hydrogen.

In order to improve the mechanical properties the steel alloys may contain besides titanium one or more of the elements silicon, manganese, nickel, cobalt, chromium, tungsten, molybdenum and vanadium, and the total content of these elements may amount to 30%. In general, however, a total content of not more than 15% is found desirable. Even when these additional elements are present the titanium remains the principal factor in imparting resistance to loss of carbon, and this is particularly the case when the titanium content is at least four times as great as the carbon content.

It has been found particularly suitable to make use of steel alloys which contain carbon in an amount not exceeding 0.4%, titanium in an amount not exceeding 2%, and molybdenum or vanadium or both in a total 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 0.15% C, 0.23% Si, 0.36% Mn, 0.80% Cr, 0.40% Mo and 0.83% Ti,

2. A steel alloy containing about 0.10% C, 0.50% Si, 0.40% Mn, 0.80% Cr, 2.2% Mo and 0.50% Ti,

3. A steel alloy containing about 0.10% C, 0.30% Si, 0.40% Mn, 0.5-1.0% Mo and 0.50% Ti,

4. A steel alloy containing about 0.10% C, 1.5% Si, 0.50% Mn, 6.0% Cr, 0.4% Mo and 0.50% Ti.

What I claim and desire to secure by Letters Patent is:—

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%; a small amount of silicon

not over about 1.5%; a small amount of manganese not over about 0.5%; an amount of titanium sufficient to protect the carbon, within the range of 0.4-5%; the remainder substantially iron.

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 about 0.11% C, 0.33% Si, 0.5% Mn, 0.46% Ti, and the remainder substantially iron.

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 1%; a small amount of silicon not over 1.5%; an amount of titanium sufficient to protect the carbon, within the range of 0.4-5%; the remainder substantially iron with a manganese content within the usual range for low alloy steels.

FRIEDRICH KARL NAUMANN.