Technology of hydrogen and steam-hydrogen mixture through hydrolysis of aluminum powders for self-contained combined plants

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Technology of hydrogen and steam-hydrogen mixture through hydrolysis of aluminum powders have been developed /1,2/. Continuous operation plant was installed at capacity of 100 nm^3/hour of high pure hydrogen and up to 200 kg/hour of steam.Commercial

coarse-grained aluminum powder ASD-1, mixed with water in ratio H_2O: Al =7–8, is delivered by high pressure pump into reactor of peculiar design, in which it is completely (100%) oxidized at temperature 300 °C and pressure 10–11 MPa.

Outlined view of hydrogen generation plant is given on Picture.

Picture. View of the plant in action

Steam-hydrogen mixture from reactor is entering into condenser, where hydrogen is separated from water, then coming into drier and conveying to consumer. Condensed water is returned to operation.

Solid yeild of technological process — high dispersed alumina hydroxide (bemite) with partical size 1−5 mcm is separated from water in cyclone and collected in reservoir.Bemite itself is byproduct of special interest for secondary application /3/.

At aluminum flow rate up to 25 g /s 1 g hydrogen output from 9 g aluminum is obtained according stoichiometry of reaction. Automatic remote control of plant operation makes sure of safety maintenance.

Mathematical model of reactor is worked out, permiting to make correct estimated optimization of reactor characteristics and operation parameters at given hydrogen output.

Calculating analysis of thermodinamic efficiency of combined energy-producing plants is executed. Effectiveness of reactor is estimated by exergetic method on the base of experimental data; exergetic efficiency of reactor is too high (0.8), what allows to create energy-producing plants on the base of above mentioned reaction.

As the basic version is proposed the above depictured pilot plant furnished with steam — hydrogen turbine and fuel cell /3,4/ for generation of hydrogen and steam, running in RSC "Applied Chemistry"; it is intended for combined generation of electric power and heat.

In fuel cell for generation of electric power flow of chemical exergy of hydrogen is discharged mainly, in turbine electric generator flow of physical exergy of working fluid is partly converted into electric power.

Lay out of steam-hydrogen turbine plant with fuel cell of PAFC type is developed /4/.

Steam-hydrogen mixture outcoming from reactor is expanded up to given pressure. Under this pressure (near 0.5 MPa) vapor condensation is occurred. Then hydrogen is conveyed through drying unit into fuel cell.

Heat liberating at vapor condensation can be used for heating systems.

General characteristics of combined power plant for two hydrogen outputs (8 kg / hour in pilot plant and 40 kg /hour in industrial one) are given in Table. Modifications of fuel cell operation with air and oxygen are investigated.

Fuel cell efficiency is admitted as 60%.

Table 1. Characteristics of combined energy plants

Aluminum powder flow rate, kg / hour	72	360
Working flow rate of turbine, kg / hour H_2O H_2	380 8	1900 40
Temperature of vapor condensation,°C	96	96
Power of fuel cell, kW	160	1800
Power of steam-hydrogen turbine, kW	49	250

Power of energy plant, kW	209	1050

Fulfilled calculation demonstrates that regarded plants are competitive concerning modern steam power central heating plants.

Developed technical solutions permit to create fully self-contained and ecologicaly safety energy plant without extra power.

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