

Results of researches on creation of coal-hydrogen non-polluting power station with the high-temperature steam turbine (with steam temperature 850–1500°C)

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By present time sharp growth of fuel cost and the requirement to ecological parameters have created the conditions, inducing to introduce highly effective "know-how" of the electric power generation with efficiency ($\eta_{\text{э}}$) 50% and more. Existing large (more than 300 MBт) steam — gas power plants have $\eta_{\text{э}}$ up to 60%. Initial temperatures of gas on input of gas turbine 1500°C are accustomed. Steam and gas plants with temperature up to 1700°C and water steam cooling of a turbine stages are projected.

Further increase $\eta_{\text{э}}$ of power plants up to 70% is planned to achieve due to use of the preincluded high-temperature electrochemical generators. However their operation resource does not exceed now several thousand hours, and individual capacity — 300 kw. There is information (Reuters), that prince of Abu-Dhabi has declared preparation of competition on creation of ecological hydrogen power station.

By present time three offers on creation of power stations with hydrogen fuel are published. To them concern:

1. The project of Japanese corporation Toshiba with the high-temperature steam turbine with hydrogen fuel.
2. The project steam and gas cycle of concern Siemens under the order of the ministry the USA with synthesis — gas received from coal.
3. The project which is carried out under order Rosnauka by a research-and-production consortium with the high-temperature steam turbine and application of coal-hydrogen fuel.

A number of new technical decisions are put in a basis of the Russian project of complex use of organic and hydrogen fuel:

1. H_2 — generation at power station platform by conversion from natural gas (coal) and O_2 — by of division of air will exclude systems of transport and storage of hydrogen, and also serially produced equipment will enable to applying.
2. Burning hydrogen with oxygen in the environment water steam with temperature of the mix steam stream on input the turbine up to 850°C for not cooled turbine stages and up to 1500–1700°C for its cooled stages at initial pressure up to 30 MPa.
3. Using of expensive hydrogen only for superheat water steam after it generation in traditional steam boilers.
4. Using in new scheme regeneration water steam superheating on output of the turbine, arising at high temperatures steam on input of the turbine;
5. Using as steam condensers for the big concentration of explosive gases heat exchangers with constant speed steam and gas mixes on a path its movement without formation of stagnant zones.

Electric efficiency of such power stations with steam turbine plant by capacity more

than 100 MWt on the combined fuel in view of expenses for manufacture H_2 and O_2 will make about 55% in recalculation on organic fuel. At use of similar plants in steam — gas cycles their efficiency 65% can achieve.

Basic elements of the thermal scheme of power station on the combined fuel are the steam boiler, high temperature condensation steam turbine (HTCST) with the electrogenerator, the condenser and other traditional auxiliaries. The systems of production H_2 from CH_4 (or coal) by a method of conversion and O_2 from air and also high-temperature hydrogen superheater (SH) are included in the scheme

HTHSH allows to increase initial steam temperature on input of the turbine (with 600–620 up to 1500–1700°C), that is impossible at burning organic fuel in traditional steam boilers because of overburning pipes. It is important, that as a result of combustion H_2 and O_2 and on an output of the turbine is formed water steam, having created vacuum. So it is possible to provide condensation steam and removal of not condensed explosive gases.

Total impurity of not condensed gases in hydrogen and oxygen should be no more than 0,5% on volume, and on an input in HTHSH, an output from the steam boiler and outputs from systems of reception of hydrogen and oxygen it is necessary to support charges on H_2 and O_2 in the proportions close to stoichiometric. It will provide full combustion of hydrogen with oxygen in the water steam environment without intermediate heat exchanging surfaces.

Due to increase of steam temperature on input in the turbine and creations of vacuum on output from the steam turbine thermal efficiency of a cycle grows and the losses connected with the advent of damp steam in last steps of the turbine decrease.

Now the research-and-production consortium including the organizations of the Russian Academy of Sciences, leading universities and technical institutes in Russia, enterprises of "Rosatom" and Shipbuilding industry is created.

The experimental researches confirming steady burning H_2 and O_2 in the water steam environment with completeness of combustion of fuel more of 99% (volumetric) are carried out, the unique data on burning coal and titan alloys in the water steam environment and on condensation steam and gas mixes inside pipes with a cross-section cooling flow water are received. New manufacturing techniques blading of steam turbines and high-temperature condensation of new generation from materials such as "Graphlex" are developed. The design of the steam turbine by capacity 300 MWt with reference steam temperature 1000°C and $\eta_3 \approx 55\%$ is offered. The prototype of the steam turbine with reference temperature 850°C is created.

Present technical designs are protected by Russian and international patents.