Hydrogen power and technogenic hydrogen cycle as a basis of the consolidated development fueling branches and atomic engineering

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Possible scales of hydrogen reception, problem of scale development of this technology in respect of sustainable development are shown. Arguments that only together with scale atomic engineering the hydrogen power can be developed.

Keywords: **atomic engineering, hydrogen production, consumption forecast, hydrocarbons.**

I. INTRODUCTION

Now in the field of power safety such global calls as limitation of accessible hydrocarbonic raw materials (HRM) and threat of climatic changes are marked.

Mass switching on energy sources and technologies with smaller issue of hotbed gases would be an essential improving measure in respect of the decision of these problems. Among those it is possible to list:

- Atomic engineering
- Renewed sources (hydro-power, a wind, the sun, inflow, geothemia)
- Hydrogen power
- Power savings.

At high state levels of the different countries recently are declared in quality of prospect: «hydrogen power»; «hydrogen economy»; «a hydrogen civilisation». As the major variant of the decision is offered «power ecological revolution».

Except a problem of decrease in emissions this «hydrogen vector» is aimed at preservation of natural resources of oil and gas for the future generations and as valuable raw materials for manufacture of plastic and other chemical production, and also fuel for transports.

While the most accessible possibilities of mass switching on the energy sources which are not emitting hotbed gases, the Atomic engineering - as quasirenewed power technology in the presence of fuel breeding technology possesses.

Hydrogen represents the secondary energy carrier (a carrier, the accumulator of energy and a chemical reagent), but not a power source since it is necessary to spend primary energy for its reception: while translating in conditional fuel it turns out that on manufacture 1 m^3 hydrogen (having an equivalent ~ 400 g.c.e.) by a way of electroliz it is spent 5,5-6 kw.h the electric power (or 1750-1880 g.c.t.).

In this sheaf there are interfaced problems - effective production of hydrogen, storage, transportation, an effective utilisation, institutional problems.

II. THE BASIC WAYS OF TECHNOLOGICAL APPLICATION OF HYDROGEN

In structure of hydrogen use are two mainstreams: as a chemical product and as the energy carrier.

Till now a mainstream, on consumption volumes hydrogen use in the chemical and petrochemical industries is. And on prospect motor transport and fuel elements for independent consumers (an order of 300 kw) are considered. In table 1 the structure of world consumption of hydrogen is resulted.

As fuel hydrogen was applied to the carrier rocket "Energy".

Hydrogen addition to a fuel composition of gas turbine installations (GTI) raises their efficiency.

TABLE 1. STRUCTURE OF WORLD CONSUMPTION OF HYDROGEN

Technologies consuming hydrogen	Share, %
Ammonia synthesis	30-60
Hydrohenization hydroclearing	15-25
Hydro-cracking	10-22
Synthesis of methanol	5-10
Petrochemical synthesis	3-7
Various chemical manufactures, metallurgy, liquid hydrogen, etc.	2-14

As a perspective direction it is possible to consider hydrogen use in a complex with elektronno-accelerating technics for manufacture of light hydrocarbons (synthetic motor fuel) from not conventional oil and other organic raw materials.

On immediate prospects the most actual is hydrogen use:

- As a universal reagent for clearing of petroleum-refining industry products from sulphur,
- For processing of heavy fractions of oil (black oils) to its light components. The basic way of development of oil refining is connected with growth of consumption of the hydrogen, allowing to deepen processes of clearing and cracking.
- And also motor transport and fuel elements for independent consumers.

Hydrogen naturally can be formed only in processes of photosynthesis or be allocated from geological formations. The condition and the forecast of annual consumption of hydrogen in the world, and also power inputs for its manufacture are presented in table 2.

In the near future the requirement for hydrogen can come nearer to requirement for an electricity as power measurement.

III. THE REVIEW OF TECHNOLOGIES OF H_2 PRODUCTIONFND CONCOMITANT FACTORS

The most widespread technology of hydrogen production today - steam conversion of methane:

$$\text{(stage 1) } CH_4 + H_2O = CO + 3H_2;$$

$$\text{(stage 2) } CO + H_2O = CO2 + H_2.$$

It characterize a rather low cost - 1,0-1,5 dollars/kg H_2. Today in the USA it is made in a year nearby 10^6 t of hydrogen, on what is spent ~ 5 % of full consumption of natural gas and emitted about 100 million t CO_2. But for large-scale manufacture of hydrogen it is impossible to consider use of natural gas comprehensible as gas is a self-valuable product.

The most comprehensible should consider production technology H_2 from water by electriliz or direct restoration by means of high-temperature processes: full thermal water pyrolysis on hydrogen and oxygen

$$H_2O \rightarrow H_2 + ½\ O_2.$$

It is possible at temperatures of 2500-3000 ^{oC}. But the problem consists that it is power-reach (not power-effective) technologies and for their realisation necessary constructional materials while are absent.

Absence of the materials, capable to maintain high temperatures compels to go by the way of thermochemical splitting of water in the presence of catalysts at temperatures 600 - 1000 ^{oC}:

- It, first, low-temperature electroliz - are used electrolizers from efficiency coefficient to 75 %; cost of a made product 4-6 dollars/kg of hydrogen (the given technology is suitable for application in a mode of accumulation of energy from the atomic power station working in a base mode for its delivery in peak modes or sale of hydrogen in the market).
- Secondly, it is high-temperature electroliz of pair at level of temperatures of process ~ 800 ^{oC}. An effective utilisation of an electricity and heat from the

atomic power station with high-temperature reactors at full efficiency coefficient ~ 50 %.

- And, thirdly, this thermochemical or thermoelectrochemical decomposition of water by means of a number of chemical reactions with recycling reagents. For example, a sulfur-iodic cycle - a range of processes temperature from 350 and to 850 ^{oC}. It is important to notice that productivity of these reactions basically is defined by volume of the chemical reactor. With use of modular reactors VTGR estimation of cost of received hydrogen will make 1,5-2,0 dollars/kg.

Therefore it is necessary to approach to a technology choice from system positions, considering the big future requirements for hydrogen and expenses for it production.

TABLE 2.

MANUFACTURE/CONSUMPTION OF HYDROGEN AND NECESSARY POWER INPUTS

Years	1978	1985	2005	2025
Consumption, million t./year	11,5	13,6	50,0	170-230
Power equivalent, million toe	33	39	140	490-660
Necessary energy for manufacture, million toe: -minimum -average	66 100	78 120	280 520	980-1320 1500-2000
The minimum demanded thermal capacity of the atomic power station with HTR, GW at φ=0,8;	110	130	460	1600-2200

IV. ENERGY SOURCES FOR HYDROGEN PRODUCTION

Most logically for reception of such non-polluting energy carrier as hydrogen to use renewed energy sources (RES).

The *inquiry. H_2 from renewed energy sources: by calculations of association "Bellona" that to 2010 all cars sold in Europe could work on hydrogen, installation approximately 65000 new wind-driven generators annually, or introduction of additional capacities in solar power nearby 200 GW in a year is required that in 2700 times exceeds the existing.*

Unique looks realistic variant of application RES for manufacture H_2 in Russia is creation of large tidal power station in the Penzhinsky lip with the organization electroliz manufactures of hydrogen and transportation its by sea to consumers (including in the countries ATR).

Other perspective source of a net energy for large-scale manufacture of hydrogen is the atomic engineering (NE).

IV.I. Axioms for statement of a problem of large-scale manufacture of hydrogen

- The epoch of cheap power resources comes to the end. It is necessary the difficult period of adaptation of economy to expensive power resources.
- Atomic engineering as youngest of scale power technologies, is to the greatest degree ready to it.
- At scale development AE helps a society to increase a time interval of this transition because:
  - It will incur a part of power manufacture,
  - With its help probably involving in sphere of effective managing of bad quality and remote resources of organic fuel.

Necessity of the decision **of the system problem** connected with reception of hydrogen, pure water and energy is obvious at performance of requirements on ecology and safety. Thus economic efficiency of separate technological process or even technology can be and not optimum as at the system approach the defining indicator is efficiency of all system on all life cycle.

What does such statement of a system problem mean? And that the basic problems of hydro-

gen economy - production technologies, storages, the transportations, the prepared water (desalination) - all it demands power inputs and through the chosen power source has corresponding ecological consequences. Also get great value **institutional questions** (infrastructural), defining "game rules".

Absence of the necessary **institutional environment** and industrial infrastructure of supply consumers with hydrogen will be one of the basic deterrents of development of hydrogen power:

- **institutional approach** to the decision of this strategic problem - all phenomena to consider together with political and social displays;
- **institutional system** should promote a unification of interests federal and regional, legislative and executive power to attraction of the large capital; to co-ordinate the general efforts of the state, business and a science on development of hydrogen economy.

The institutional environment includes:

- - standard-legal base of hydrogen power;
- - legislation improvement; reduction of the regional economic legislation in conformity with federal (and may be on the contrary);
- A transparency of the property relations;
- Security of the enterprises from any threats;
- account of interests of co-operating subjects - state-private partnership; business involving in strategic directions of economic development;
- Formation, population information support;
- Scientifically-analytical methods of revealing of weak links and power safety threats in regions;
- Intellectual property protection;
- Stimulation of development of an infrastructure of deliveries of hydrogen to consumers.

IV.II. Necessity of power branches consolidation

The ***Fuel and energy complex (FEC)*** is backbone basis for as national economy as the world one. Therefore a determinative at all the profit from extraction and sale of resources here should be. The history of economy development shows that grow rich not those who extracts resources, but those who effectively uses them. The zealous owner is the one who uses resources according to their unique properties: gas, oil - as raw materials for organic synthesis, uranium - as a power resource.

It is necessary to search for such ways of development at which the power and FEC as uniform "organism" allow to develop in the best way each component:

- Oil and gas are used as high quality raw materials for chemistry, transport and a source of export receipts;
- Coal is used as an energy source for manufacture of an electricity, supply by heat of house economy, in metallurgy, for manufacture of liquid and gaseous secondary energy carriers etc.;
- "Multiproduct" atomic engineering for oil and gas replacement in manufacture of the cheap electric power, for manufacture synthetic motor топлив, reliable supply by energy of remote areas, for export of high technologies.

IV.III. The Atomic energy Role in FEC and scale production of hydrogen

If to accept as a postulate that the basic source of H2reception should be not from natural gas, but from water, then priority there are electroliz technologies at the expense of a cheap electricity or direct piroliz by means of high-temperature nuclear reactors. Therefore scale «the hydrogen power» should be identified with «atomic-hydrogen power».

The atomic energy in the general strategy of FEC is not alternative and not the competitor, but as the potential of preservation of effi-

ciency of an oil and gas complex for many long years, able to raise reliability and safety of power supply. AE becomes «a source of source» to energy and other resources.

Cooperation of organic power industry and atomic engineering can include also:

- Extraction, clearing, swapping, liquation and gas transport;
- intensification of extraction and oil and gas refining;
- coal liquation and gasification;
- Reproduction and improvement of consumer quality of huge stocks of substandard organic resources (for example, transformation of coal and heavy oil into motor fuel by means of hydrogen);
- Scale manufacture of hydrogen from water.

AE can incur manufacture more than half of added heat for maintenance of effective course of coal gasification processes.

The combination in a power technological complex the NPP for reception of various types of energy, manufacture of H2, pure water and motor fuels can represent an independent power technological complex for ability to live maintenance in the remote regions.

The atomic-hydrogen power engineering is a conversion of energy of heavy nuclear elements fusion into secondary energy carriers (through H2 to sintfuel), more habitual for use in already habitual technologies and infrastructures.

Almost unlimited AE resource base can be realised by means of fast breeder reactors and the closed nuclear fuel cycle.

V. BASE JUDGEMENTS ABOUT THE ORGANISATION OF MULTIPRODUCT ATOMIC POWER SYSTEM

- Nuclear power - unique existing power resources which can be use the next decades in the necessary scales;
- Reproduction of modern AE structure does not solve power problems. It is necessary to organise a full-scale fuel cycle to involve uranium-238 power resources;
- Existing, developed and offered reactor concepts do not possess separately by necessary characteristics, physical and mathematical models, experimental and technological bases, therefore it is necessary to create system of AE.

VI. THE CONCLUSION

As the further scope of works in a direction to «a hydrogen civilisation» it is possible to consider the following:

- organisation of works under the profound analysis of spheres of consolidation of Atomic engineering and FEC for expansion of hydrocarbon resource base at the expense of involving bad quality stocks by means of AE;
- Carrying out of technical-economic researches of possible changes in structure of hydrocarbons material streams (coal, gas and oil branches) at consolidation with AE (considering secondary energy carriers);
- Performance of estimations to posses possibilities of AE application in extracting complexes in remote areas;
- Consideration of technical and economic possibilities of AE application for an intensification of resources extraction on existing and old deposits;
- An estimation of possibility of AE participation by manufacture synthetic motor fuels;
- Demonstration stabilising role of АЭ at joint development with traditional power technologies;
- Organisation of mutually advantageous dialogue of FEC and AE representatives the purpose of the joint decision of general problems FEC and AE on realisation of the system approach in creation of safe closed nuclear fuel cycle.

VII. THE BIOGRAPHIC DATA

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