The Russian R&D in the field of Hydrogen Technologies

S.P. Malyshenko
Laboratory for Hydrogen Energy Technologies
Joint Institute for High Temperatures
(IVTAN H2Lab)

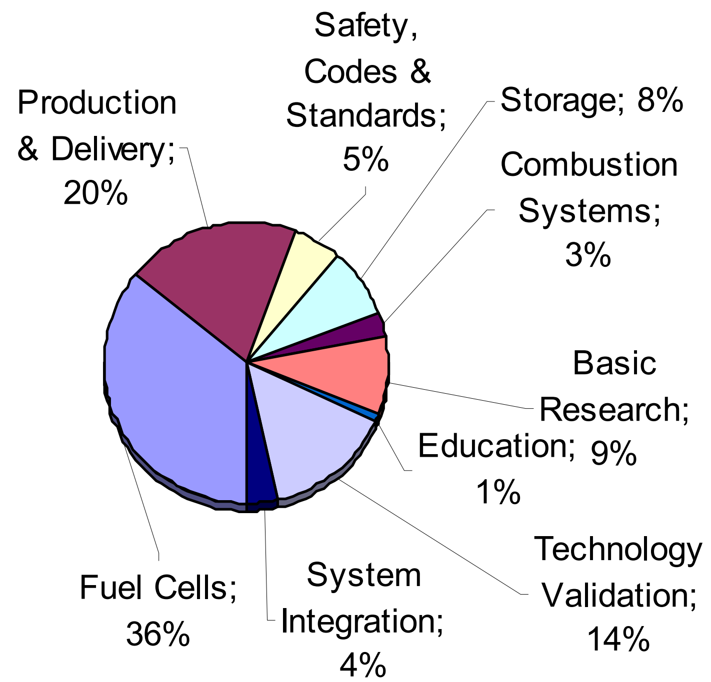
Predicted hydrogen production and prices on Russian market

	2025	2035	2045	2055
Production, 10^6 toe				
European part	2-3	15-50	20-30	15-25
Ural and Western Siberia	14-17	15-40	20-25	15-20
Eastern Siberia and Far East	5-6	10-15	15-20	20-25
Total	21-26	40-105	55-75	50-70
Prices, $/toe				
European part	245-250	260-270	350-370	470-490
Ural and Western Siberia	215-220	245-250	295-310	470-490
Eastern Siberia and Far East	165-175	185-195	200-215	240-260

2006, Nekrasov A.S., Sinyak Yu.V.
RAS

Russian Hydrogen Program: 2005-2006 Federal Budget

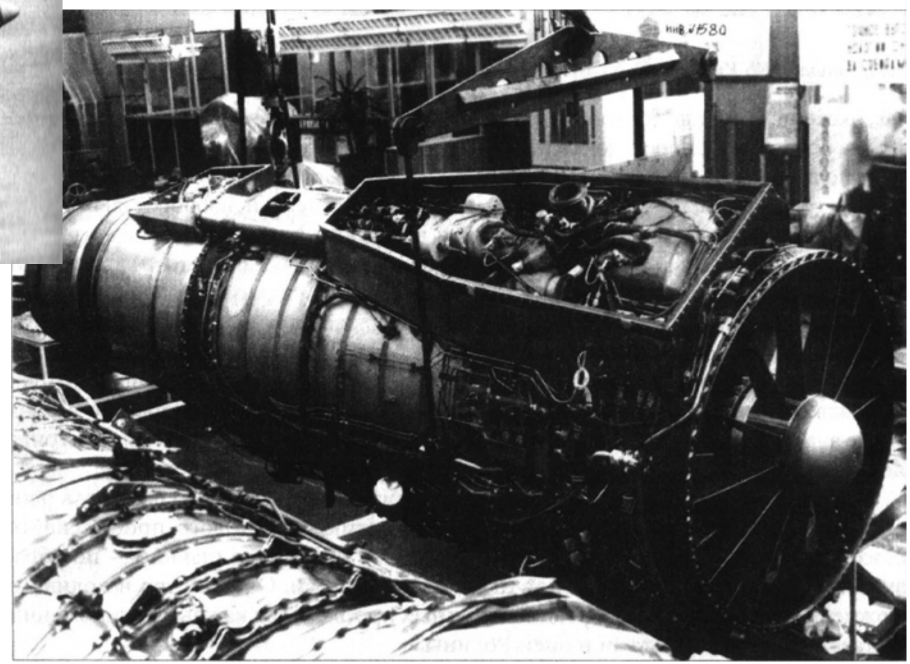
• Ministry of Education and Science, Federal Agency for Science and Innovations (FASI) • Russian Academy of Sciences • Russian Foundation for Basic Research • Federal Agency for Nuclear Energy (Minatom) • Federal Space Agency	• Federal Program Research and Innovations in Priority Trends of Scientific and Technical Development for 2002-2006 • Educational Programs • Basic Research Projects • Technology Oriented Projects



Total: ~$15 M annual

Additional funding:
private companies (Norilskii Nickel, Gazprom, etc.), Moscow government

Aerospace Hydrogen Technologies Experience

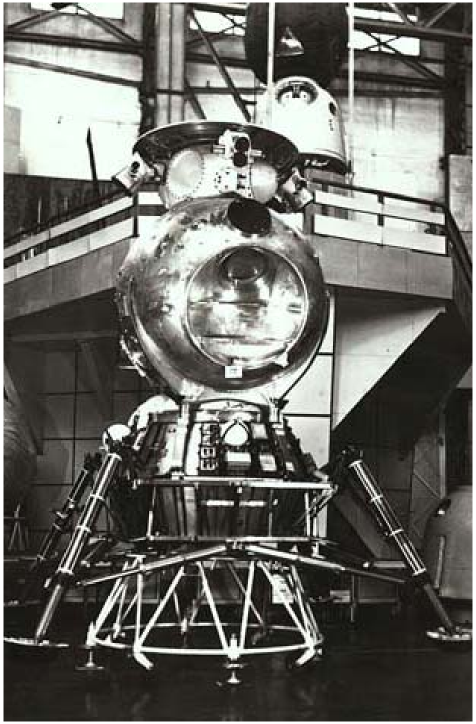


Hydrogen engine NK-88

1988. First hydrogen flight. Tu-155.

Hydrogen for space program

1972
Automatic flight to the Moon



- **HYDROGEN – 20 KG**
- **OXYGEN – 200 KG**

FUEL CELL POWER UNIT

1987
Energia

HYDROGEN – 106 TONNS
OXYGEN – 1540 TONNS
ROCKET ENGINES

1988
Energia-Buran

- **HYDROGEN – 110 KG**
- **OXYGEN – 900 KG**

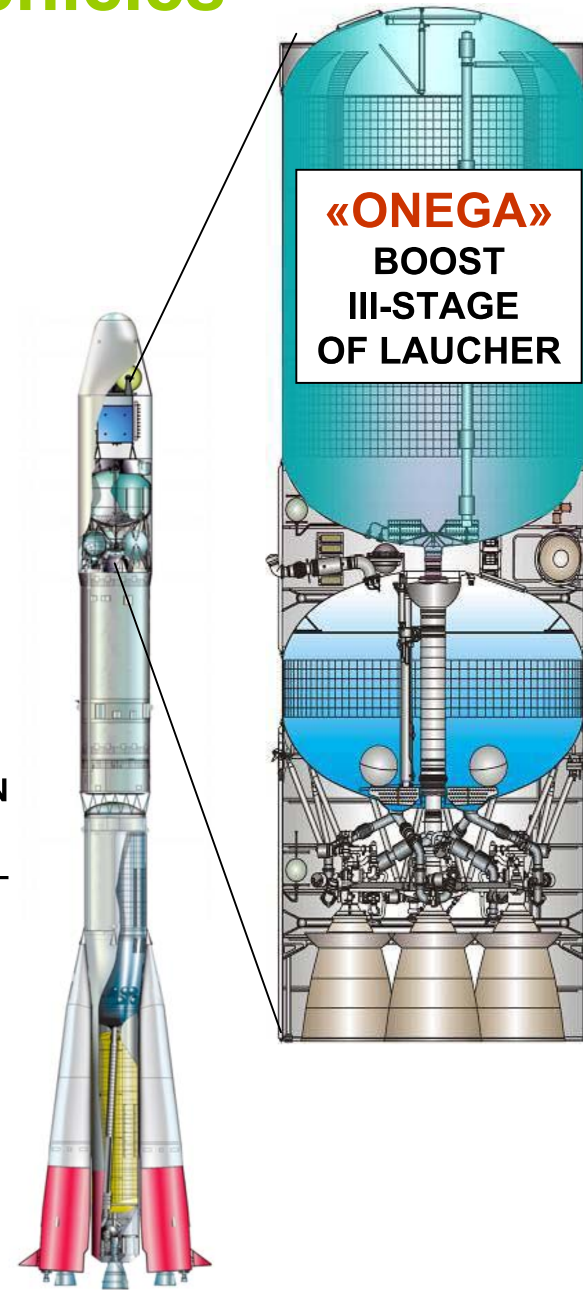
FUEL CELL POWER UNIT

Hydrogen engines

Chemical Automatics Design Bureau, Russian Space Agency

Modernization of space launch vehicles

	«SOUZ-FG»	«ONEGA»
SPACE LAUNCH VEHICLES	BAIKONUR	BAIKONUR
WEIGHT, T	308,0	391
USEFULL LOAD, T:		
• circular orbit=200 KM	7,44	15,6
• GEO	-	2,7
• GTO (ΔV=1500 M/S)	1,5	4,8
ENGINES		
• I STAGE	14Д22	РД-120.10Ф
• II STAGE	14Д21	РД-191
• III STAGE	11Д55	РД 0146Э
FUEL	OXYGEN + KEROSINE	I, II STAGES – OXYGEN + KEROSINE III STAGE AND BOOST - **OXYGEN + HYDROGEN**



Federal Agency for Science and Innovations

- Program: Research and Innovations in Priority Trends of Scientific and Technical Development for 2002-2006
- Priority direction: Energy and Energy Saving

Total: $15 M for R&D in Hydrogen Technologies in 2005-2006

FASI Hydrogen Program 2005-2006 Projects

- Modular Power Units with 10 kW SPE FC
- Power Production System with 5 kW SO FC
- Portable and micro FC
- Portable FC Processors for Hydrogen Power Supply Systems with FC
- Reversible Solid State Hydrogen Storage and Purification Systems for FC
- Reversible Solid Oxide Electrochemical Devices (electrolyzer – FC system)
- Non-Pt Catalysts for FC
- H_2/O_2 Steam Generators for Steam-Turbine Power Units
- Autonomous Power Supply Systems on the Base of Renewable Energy Sources with Hydrogen Energy Accumulation
- Safety and Standards for Hydrogen Energy
- Education

International Co-operation

- ☞IPHE Collaborative Projects
- ☞The International Science and Technology Center (ISTC), ISTC Fuel Cell Initiative
- ☞ US Civilian Research and Development Foundation
- ☞ EU Framework Program (FP6)
- ☞ by-lateral cooperation

NEW HYDROGEN PRODUCTION TECHNOLOGIES

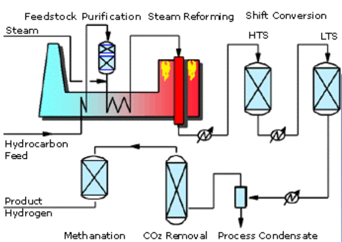
INNOVATIVE NATURAL GAS REFORMING FOR HYDROGEN PRODUCTION

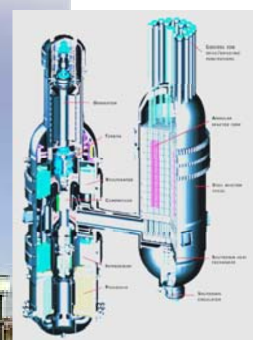
RRC "Kurchatov Institute"

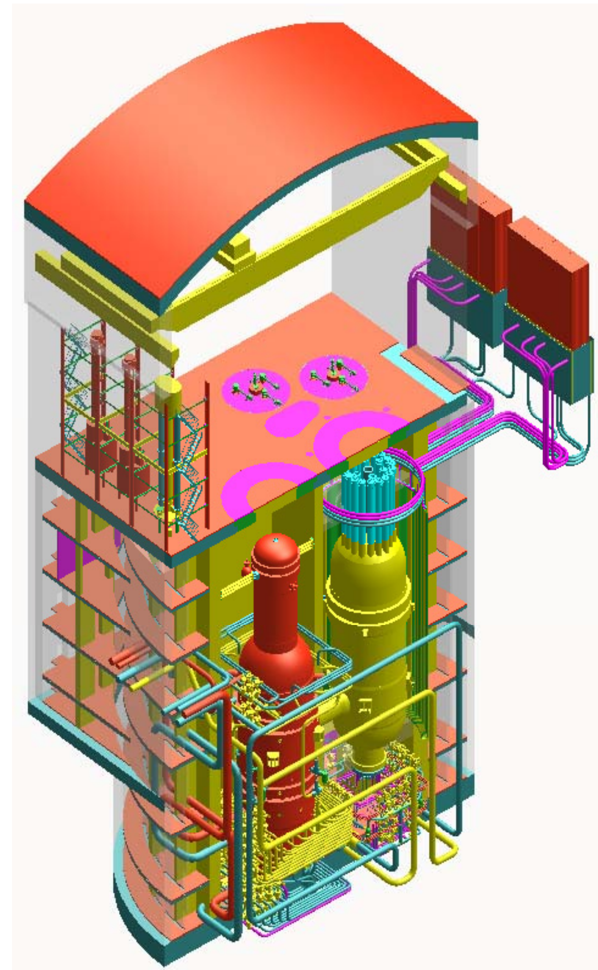
Hydrogen Energy & Plasma Technology Institute

Steam conversion of methane in MGR-T

- $CH_4 + 2H_2O + $ +heat (>800 ^{0}C) $\Rightarrow CO_2 + 4\ H_2$



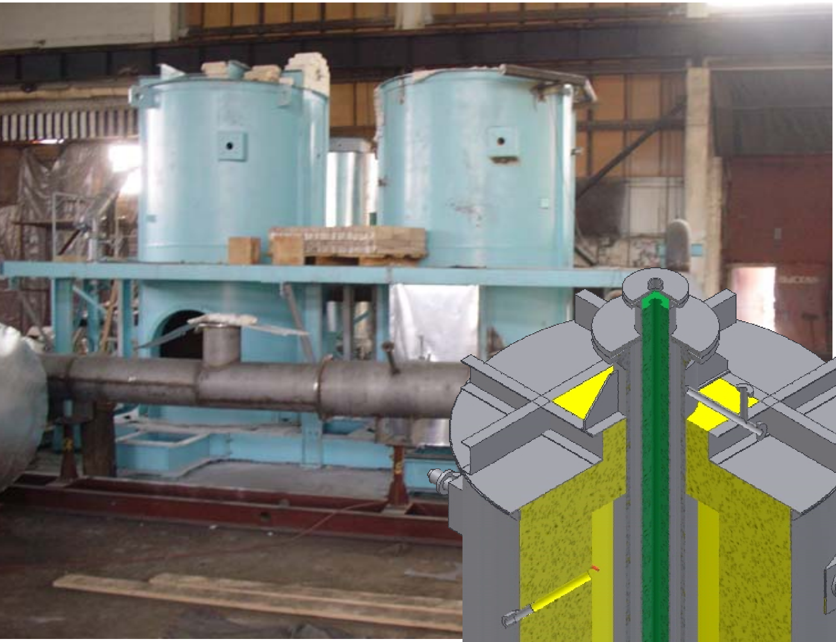


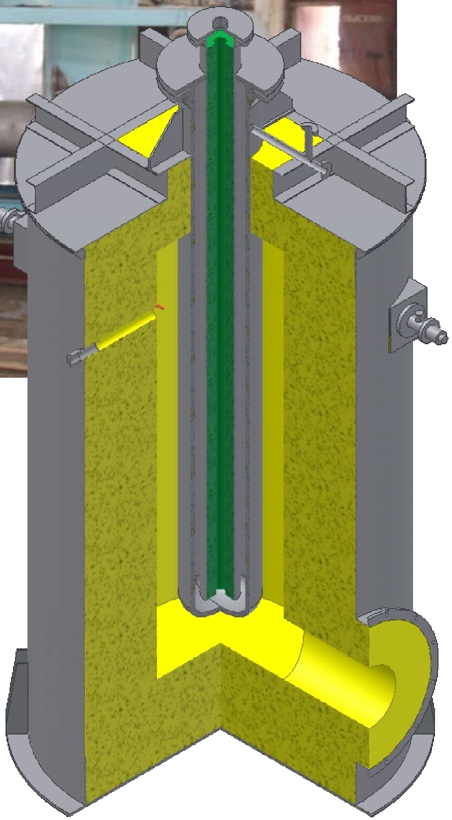


- H_2 yield two times higher than for pyrolysis of methane

Hydrogen production

Mashprom





Steam reformer

Productivity	250 s m^3/h
Purity	99,98% *
Hydrogen pressure in receiver	0,5-1,0 MPa
Energy consumption	60 kW h
CO_2 production	150 kg/h
Dimensions, m:	
conversion block	12 x 8 x 4,5
purification block	8,5 x 8 x 4,5
PSA purification	10 x 8 x 6
Weight, t :	
conversion block	60
purification block	27
PSA purification	20

NATURAL GAS PROCESSING

FOR PRODUCTION OF HYDROGEN AND PURE CARBON MATERIALS

Institute for Hugh Temperatures RAS

On the basis of two-stage pyrolysis of natural gas the technology to produce hydrogen from natural gas simultaneously with pure carbon material for broad commercial applications has been developed.

As a porous carbon skeleton for pyrocarbon stuffing other carbon containing materials can be used (e.g. wood waste products, generally the vegetable origin waste).

Address: IVTAN, 125412, Izhorskaya 13/19, Moscow
E-mail: zaitch@oivtran.iitp.ru

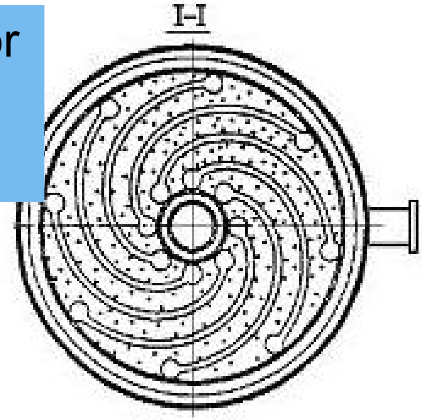
0.01	Moisture content,%	0.52
0.43	Volatile, %	1.12
0.04	Ash, %	1.54
0.02	Sulphite, %	0.30
99.56	C,%	97.38
0.25	H, %	0.27
33.18	Calorific value, MJ/kg	32.57
1.62	Density, g/cm^3	0.743

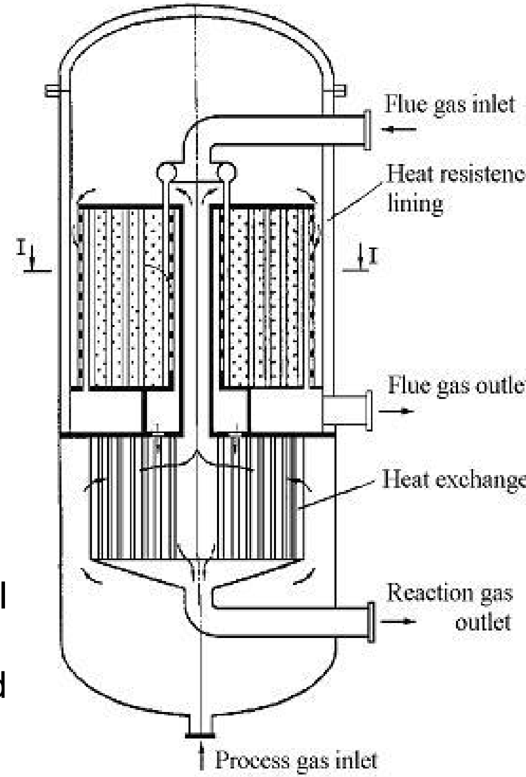
COMPACT HIGH EFFECTIVE HYDROGEN PRODUCTION BY STEAM NATURAL GAS CONVERSION

FAST ENGINEERING Ltd.

Pilot synthesis gas production unit for under 6,4 MPa.

FAST ENGINEERING® PROCESS



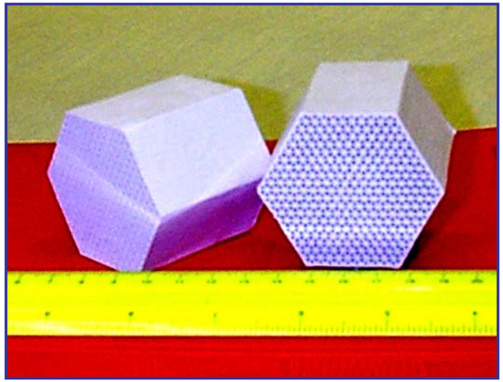


- •No oxygen using
- • The using the most active fine-grained catalyst for steam natural gas conversion keeping low pressure drop in the granular bed and allowing to increase a few time volume wear rate
- •Required heat supply for carrying out endothermic reaction of steam conversion
- •Reducing of operation costs
- • An opportunity to create steam conversion for required capacity
- • Reducing pollution to environmental
- • Compactness

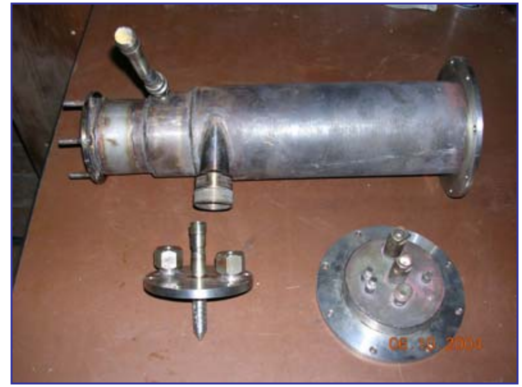
«FAST ENGINEERING», Moscow, 117218, RUSSIA
Tel./Fax: +7 495 718-8196, astanovsky@fastmail.ru;
http://www.fastmail.ru/~astanovsky

Catalysts and reactors for partial oxidation of natural gas into a mixture of H_2 and CO

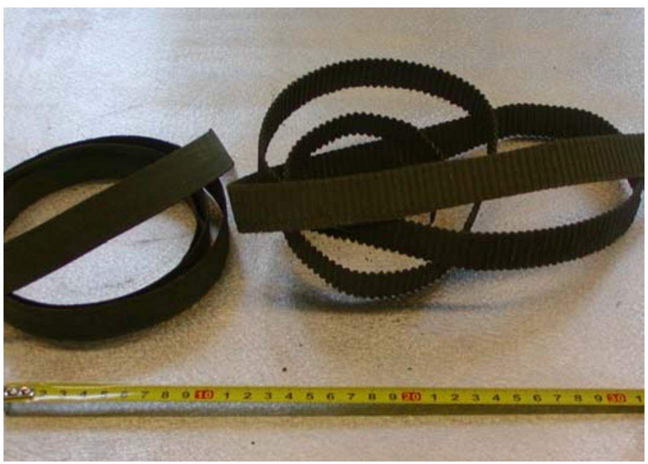
Boreskov Institute of Catalysis, Novosibirsk, Russia



Monolithic catalysts



Monolithic catalyst reactor



Tape catalyst

Tape catalyst reactor of the syngas capacity ca. 5 m^3/hour

A prototype of the fuel processor based on an integrated reformer unit for steam reforming of natural gas in a 5 kW_e SOFC plant

Fuel processor

The fuel processor includes:

- **A unit for desulfurization of natural gas**
- **An integrated reforming unit**
- **A system for feeding natural gas, water, air**
- **Control sensors for temperature, pressure, reagent consumption**
- **An automated control system for the fuel processor (monitoring of temperature, pressure, consumption, as well as control of reagent consumption, stop and switch valves, a starting device)**

Test data for the fuel processor:

- **Stable operation on varying the natural gas consumption from 0.1 to 0.9 m^3/h**
- **Capacity up to 5 m^3/h for synthesis gas**
- **Hydrogen content up to 75 vol % in synthesis gas**

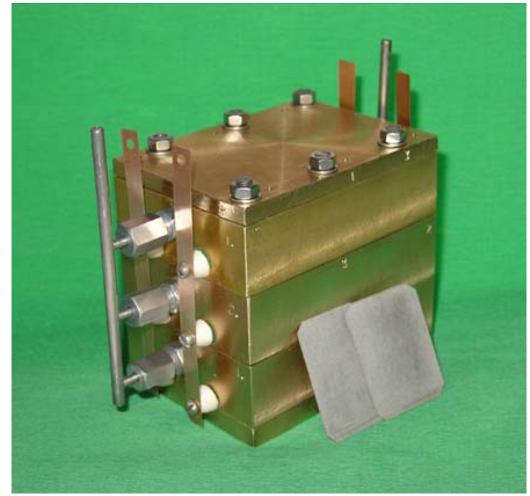
Developers : BIC & Russian Federal Nuclear Center

Microcatalytic hydrogen production systems and reactor for steam conversion of methanol

Boreskov Institute of Catalysis, Novosibirsk, Russia

icroreactor with external heating

Microreactor with heat exchanger



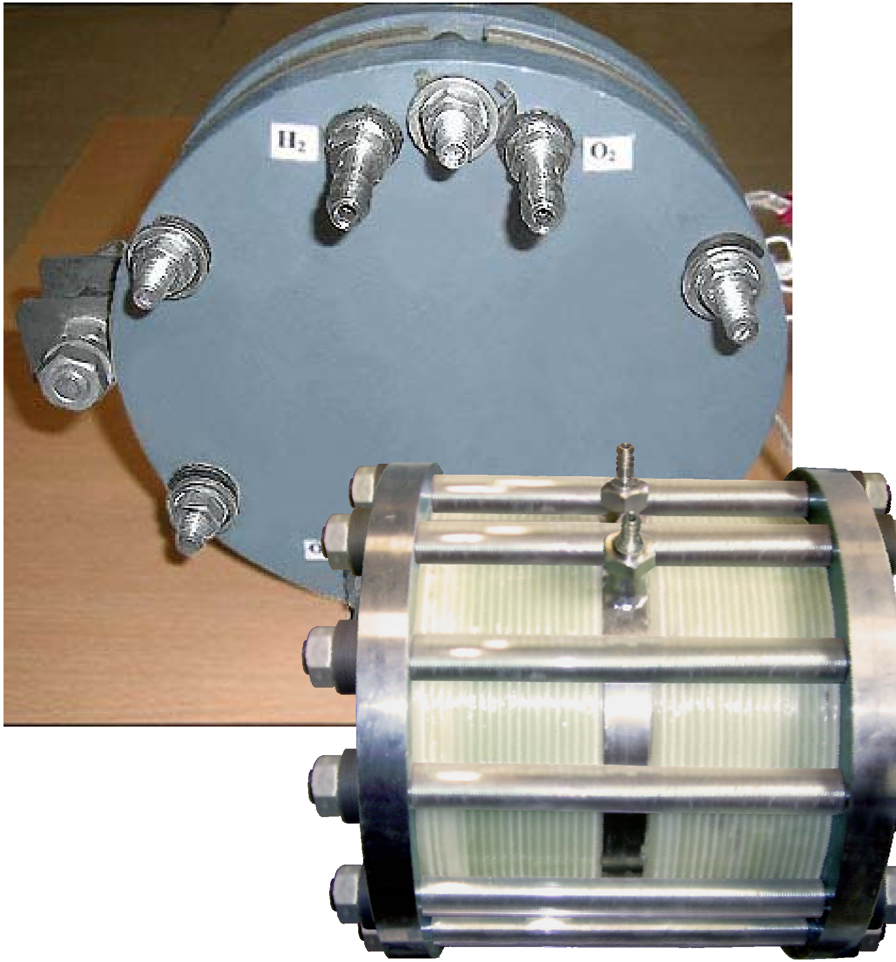
Sectioned high power reactor

Characteristics

	Dimensions	
∅30 h=60mm	**∅40 h=35 mm**	**65×90×85 mm**
	Microchannel plate	
∅28 δ=0,3 mm	**∅35 δ=0,3 mm**	**30×40 mm**
	Hydrogen output and heat power	
130 l/h; 300 W	**32 l/h; 73 W**	**320 l/h; 750 W**

ALKALI ELECTROLYSIS

Moscow Power Engineering Institute (TU)
Joint-Stock Company “UralChemMash”



New alkaline electrolysis cell

High effective electrodes without precious metals content
Power consumption 4,2 kW-hour/s M^3 under current density 3 kA/M2
Purity of hydrogen at battery output up to 99,7 %
Absence of asbestos diaphragm
Compactness
Possibility of hydrogen consumption regulation at wide range

New battery for alkali electrolysis

Productivity – 1 s M^3 H_2/hour
Power consumption 4,2 kW-hour/s M^3 under current density 3 kA/M^2
Purity of hydrogen at battery output up to 99,7 %
Compactness
Possibility of hydrogen consumption regulation at wide range

PEM Electrolyzers for high purity hydrogen production

t present time the fields of applications of PEM-electrolyzers are: fuel cells, gas chromatography, ater-chemical regime correction systems of nuclear reactors, hydrogen welding, metallurgy, ectronic industry, analytical chemistry, etc.

EM-electrolyzer and plants on its base with various productivity (from several ml to tens cubic eters per hour) and purposes have been developed

echnical performances of PEM electrolyzers:

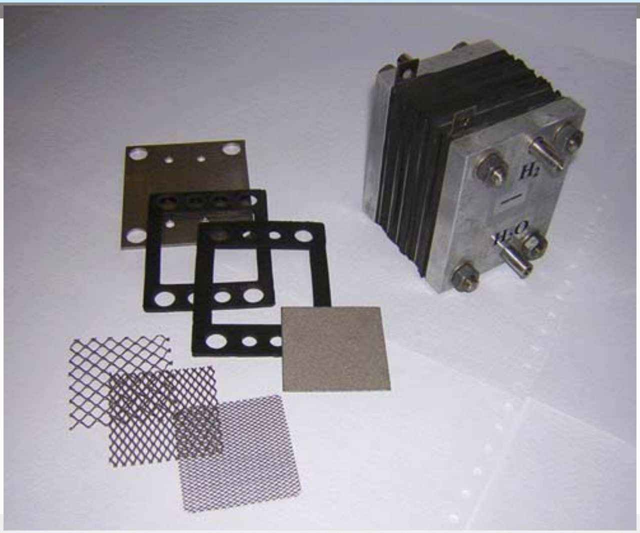
Power consumption 3.9-4.1 kW·hour/1m^3 of H_2

Voltage on the cell 1.67-1.72 V at current density 1 A/cm^2 and t=90°C

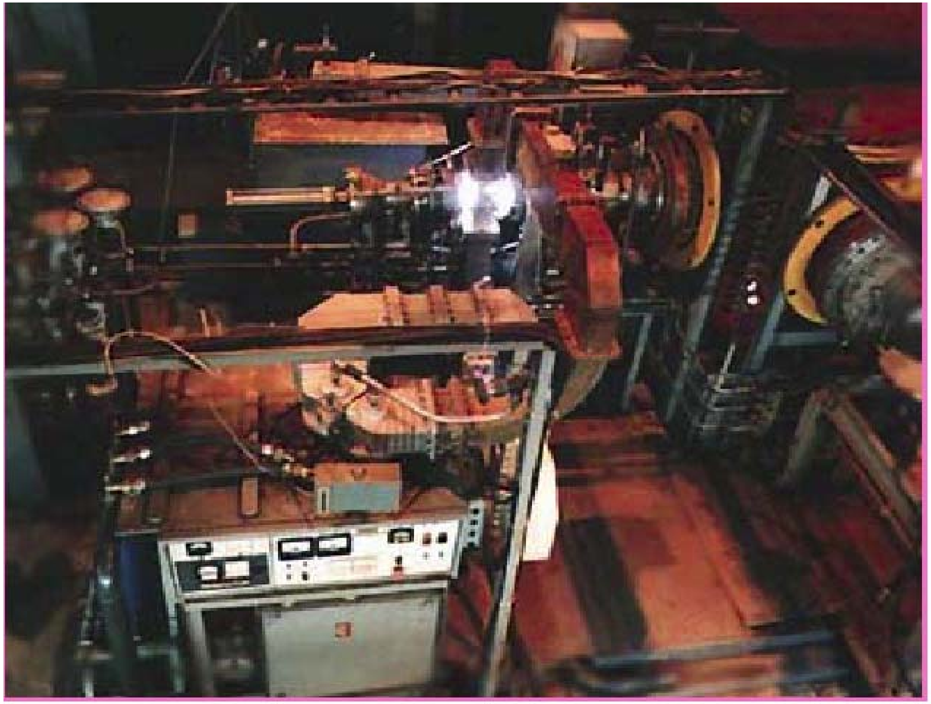
Operating pressure up to 3,0 MPa

Hydrogen purity > 99.99%

Life time (average life) > 5000 hours



RRC “Kurchatov Institute’s” Test Facility “POVOD” for Development and Scaling of Plasma Assisted Processes of Hydrogen and Syn-Gas Production



“POVOD” demonstration unit at RRC “Kurchatov Institute” was designed to investigate and demonstrate the whole set of gas-phase plasma chemical processes under effect of stationary microwave discharge with power range from 10kW to 1,000 kW at microwave frequency 915 MHz. Air, nitrogen, water vapor, carbon dioxide, methane, propane-butane, oxygen, argon with a flow rate up to 2,000 m^3/h at pressure between 0.005 atm – 1.0 atm can be used to burn MW discharge.

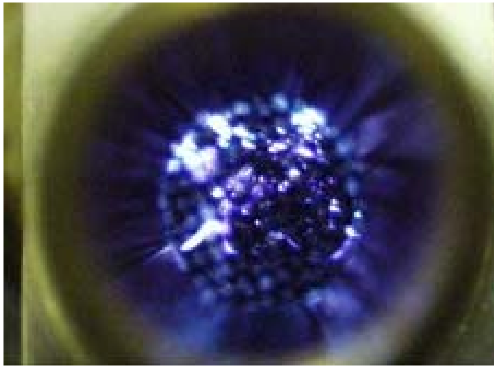
Address: HEPTI RRC “Kurchatov Institute”, 123182, Moscow, Russia
Tel: (7-495)1969439; Fax: (7-495)1966278
E-mail: s.korobtsev@hepti.kiae.ru

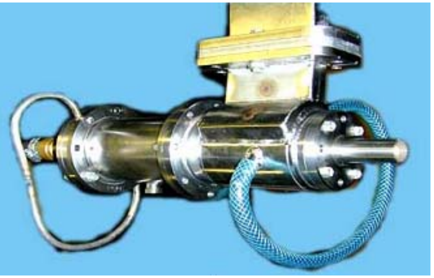
RRC “Kurchatov Institute”

Hydrogen Energy & Plasma Technology Institute

Microwave reformers of hydrogen raw material conversion into synthesis gas

Two converter types have been developed: based on the impulse periodical microwave discharge, and on the stationary discharge.





Stationary converter

Synthesis gas production: 20 nm^3/hour;

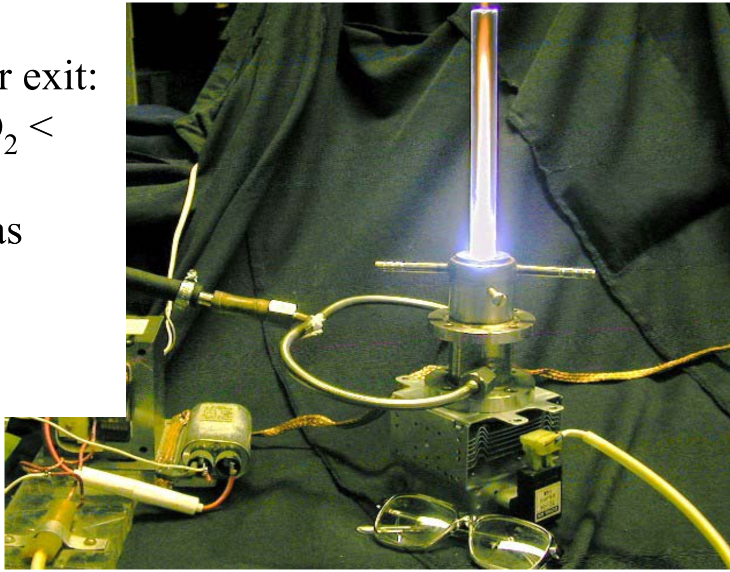
Converter size: below 350 x 500 x 500 mm,

Mass: 31.5 kg, converter volume: 0.1 m^3.

Typical gas composition at reactor exit: N_2 < 54.2%; Syngas > 40.0%; CO_2 < 2.5%; $CH_4 + C_2H_4 + C_2H_2$ <3.3%

Electric power expenses for syngas production 0.15 kWh/m^3

Conversion efficiency (with heat recuperation) is 94%.



123182, Moscow, Russia
Tel: (7-495)1969439; Fax: (7-495)1966278
s.korobtsev@hepti.kiae.ru

HYDROGEN GENERATION FROM LOW-COST ALUMINUM

System for high temperature (up to 1000^0 C) Hydrogen generation.

4 м^3/h of H_2 (0.363 kg/h) and

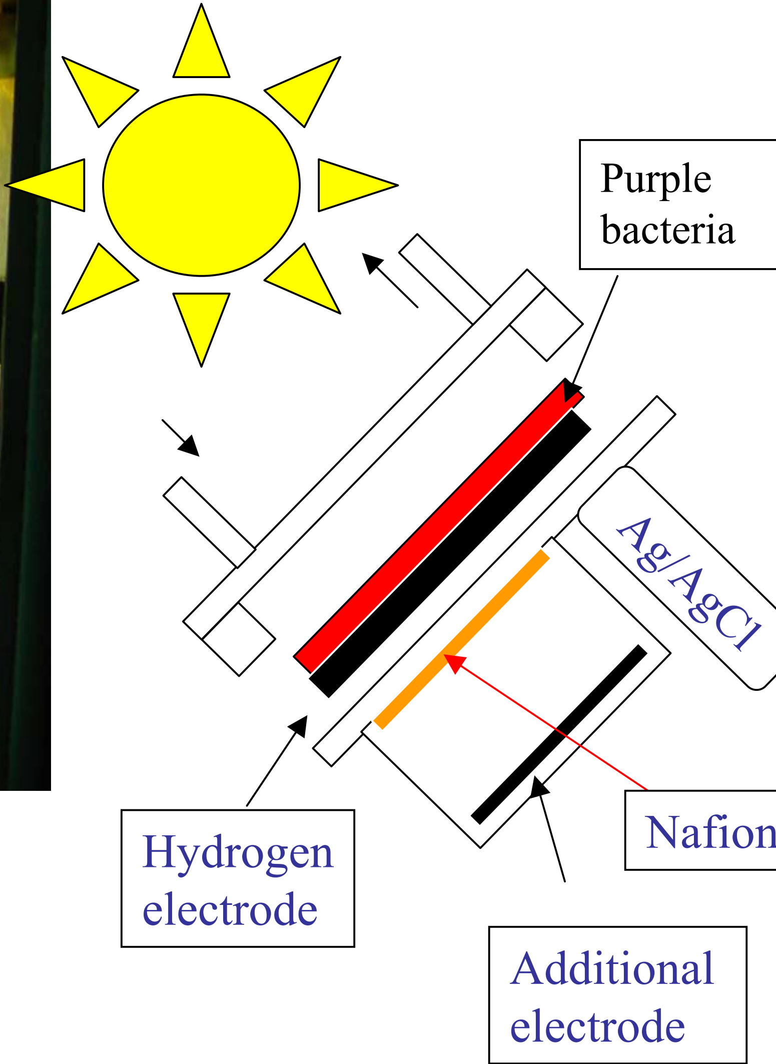
6 kg/h of nanocrystalline Al – hydroxide.

Science and Engineering Center for Energy Saving Processes and Equipment. Russian Academy of Science (SEC ESPE)

BIOCONVERTION OF REVERSIBLE ENERGY SOURCES

Institute of Fundamental Problems of Biology, RAS

Photobioreactors with immobilized micro-algae



FUEL CELLS

International Project on Fuel Cells Based on Nanoporous Structures

Association for Advanced Technologies `ASPECT`

Institute of Physical Chemistry and Electro-Chemistry after Frumkin (IPCEC)

Institute for High Temperature (IHT)

Institute of Petrol-Chemical Synthesis after Topchiev (IPCS)

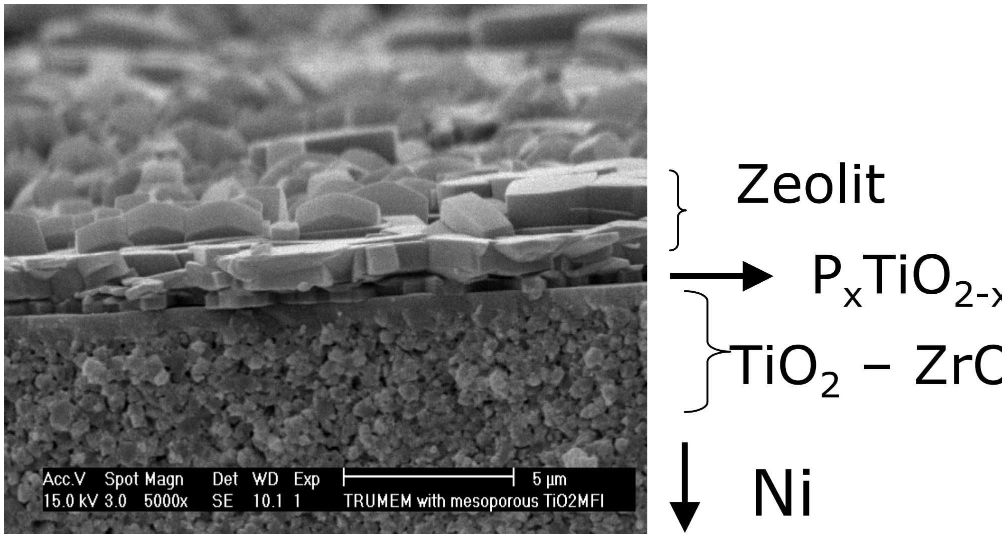
Institute of Chemical Physics Research (ICPR)

Institute of Problems of Micro-electronics Technology and High Purity Materials (IPM)

Moscow Power Engineering Institute (MEI)

Academy for Fine Chemistry Technologies (MINCT)

- CMR Fuel Cells (UK)
- Lawrence Livermore National Laboratory (USA)
- National Physical Laboratory (UK)
- Fraunhofer Institute (Germany)
- Waterloo University (Canada)



Electrochemical Generator "Cascade-IP"

Independent Power Technologies, Ltd.

The generator is based on advanced Alkaline Fuel Cell modules. One of the unique features of the generator is a patented zero-waste regenerative scrubber used for the removal of carbon dioxide from the incoming air. The scrubber reduces the operational cost and increases the overall serviceability of the generator.

Performance

Maximum power: 6.0 kW; Voltage: 30.0 – 42.5 V
Maximum current: 200 A; Fuel: Hydrogen
H_2 consumption < 4.5 m^3/h; Air consumption < 36 m^3/h
Pressure: Atmospheric

Operating conditions

Ambient temperature: -20 to +40 °C
Relative humidity (max): 98% at 25 °C

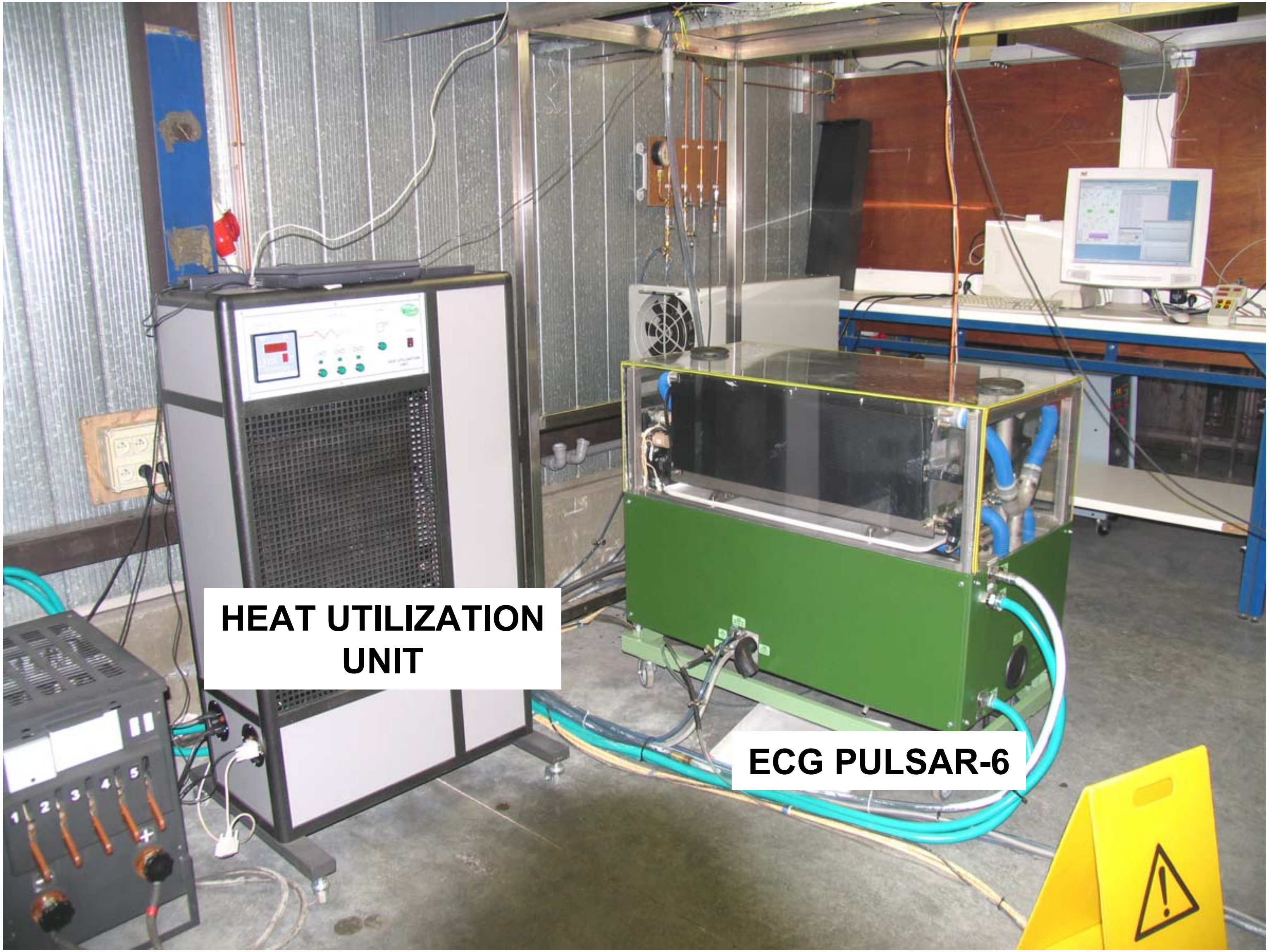
The scrubber

General

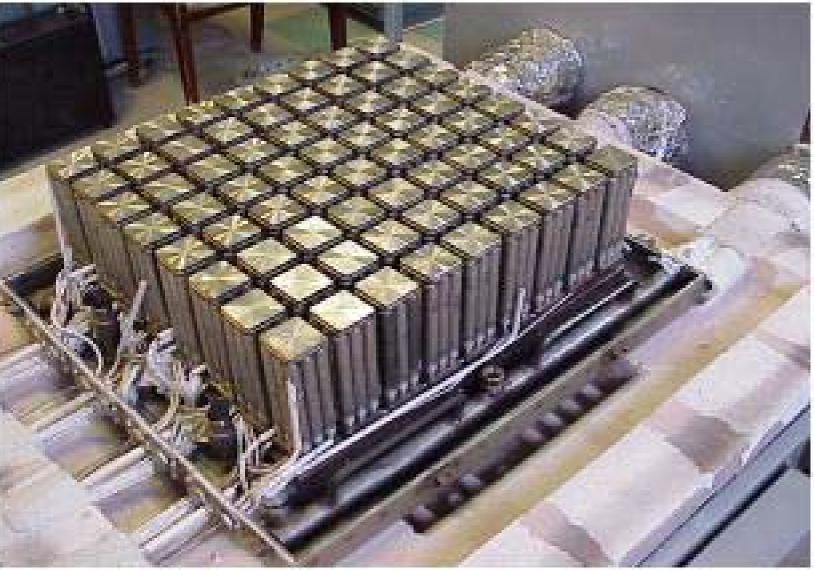
Dimensions: 1250 x 582 x 863 mm; Gross weight: 240 kg
CO_2 scrubber: built-in, regenerative
Start-up: self-starting with built-in hydrogen burner < 15 min at 20 °C
Electrolyte: 6.6 M KOH (aqueous solution)

Independent Power Technologies Ltd
Address: 3-d Mytishchinskaya 16, bldg 60 129626, Moscow, Russia
Tel: (7-095)2312109; Fax: (7-095)2312078; E-mail: karichev@ independentpower.biz

PULSAR-6 CO-GENERATOR



Solid Oxide Fuel Cell



Nominal Power 2,5 kW

Voltage 43,2 V

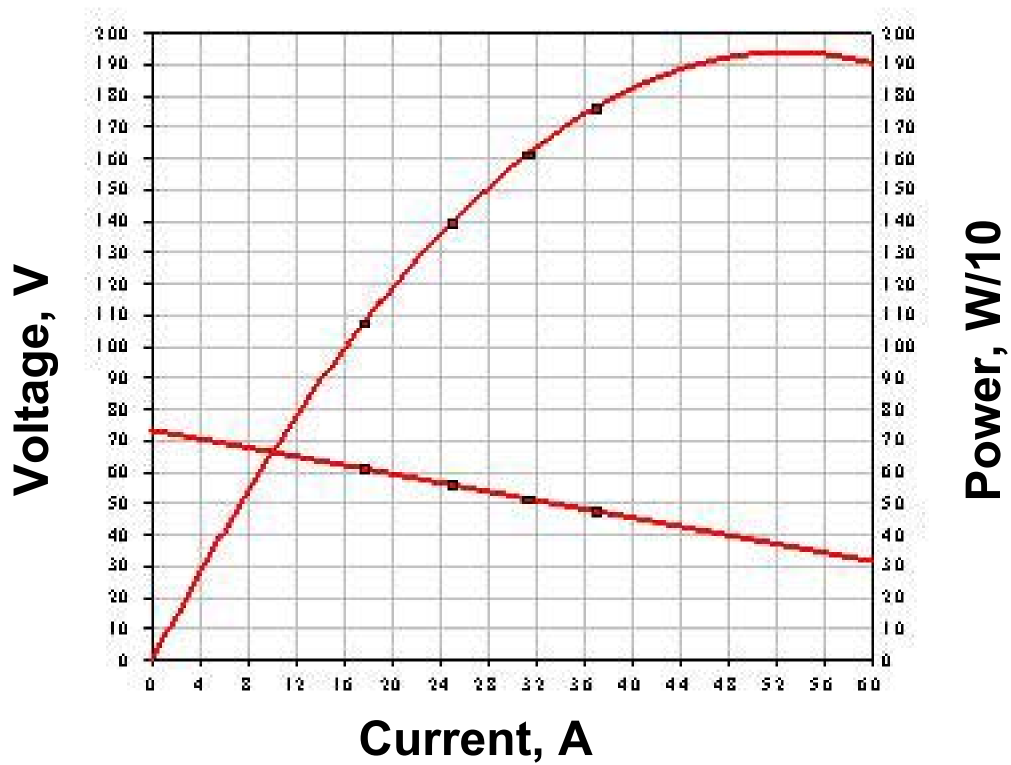
Reached Power 2 kW
at 36 V

P.O. 245, Snezhinsk, Chelyabinsk reg.
456770 Russian Federation
+7(351-46)54367 fax: +7(351-46)55566
www.vniitf.ru

Solid Oxide Fuel Cell

Power unit

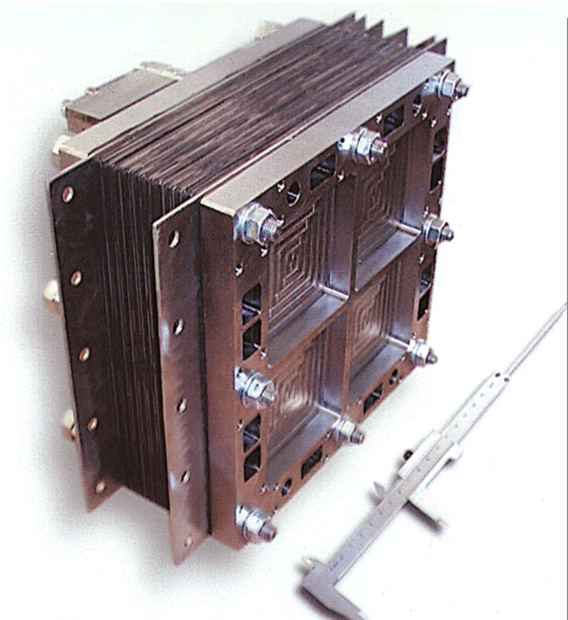
Test results



PEM hydrogen fuel cells

Hydrogen – Air fuel cell.

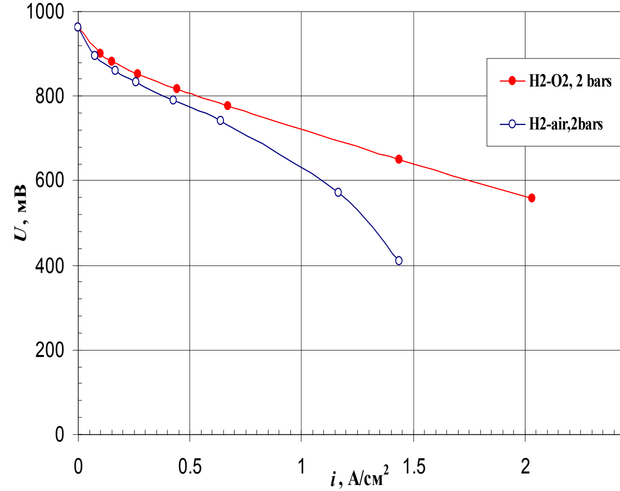
Power 1kW



Hydrogen – Air fuel cell.

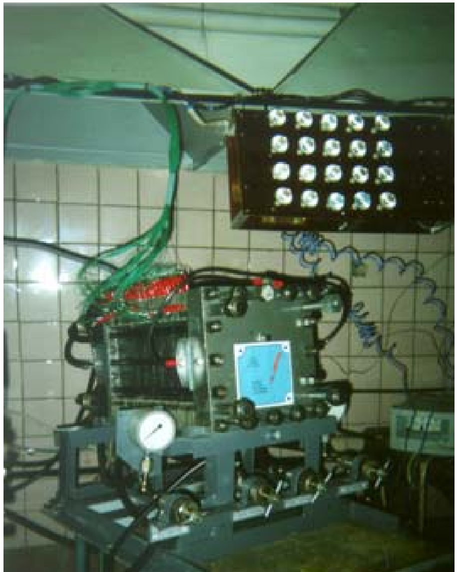
Power 0.2 kW

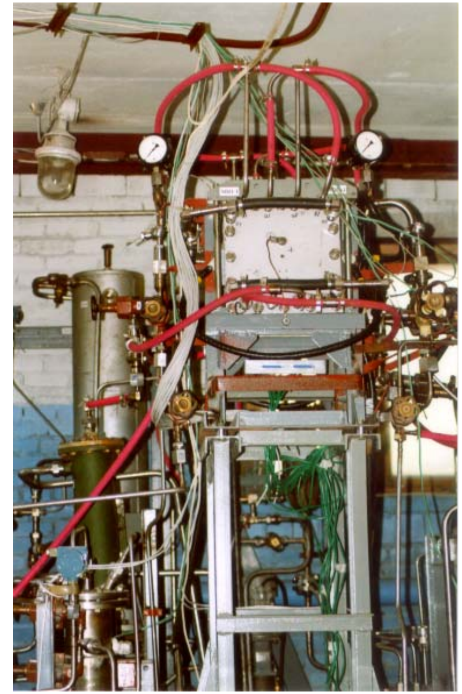
Polarization curves for PEMFC (Typical MEA performance)

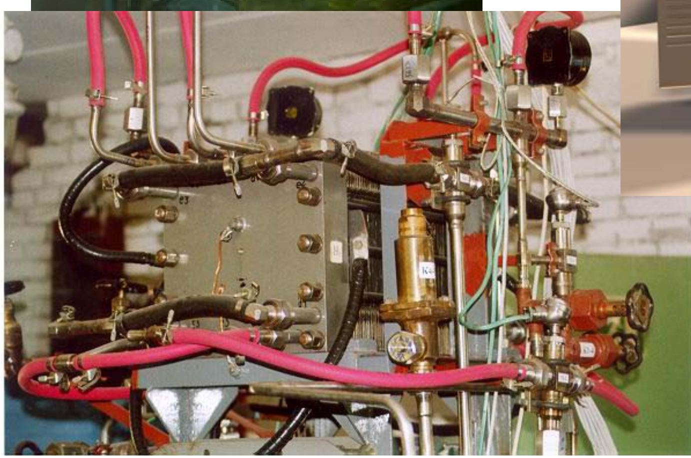


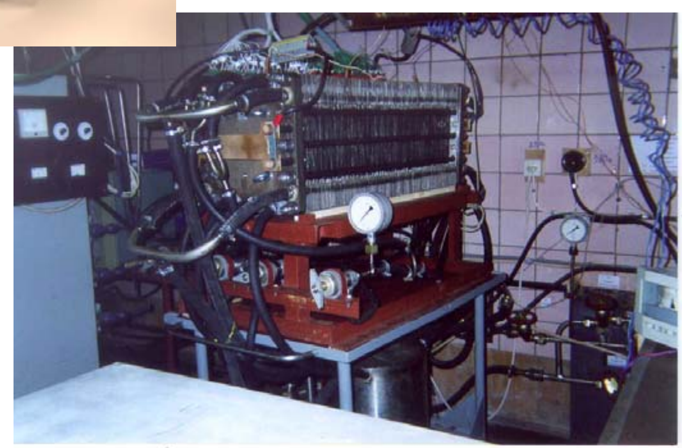
PEM hydrogen fuel cells

Central Research Institute for Ship Electric Engineering and Technology, Saint-Petersburg









196128 Saint-Petersburg, Blagodatnaya 6
set@sp.ru

Hydrogen Storage

FASI Program in Hydrogen Storage

Program: Research and Innovations in Priority Trends of Scientific and Technical Development for 2002-2006

Priority direction: Energy and Energy Saving

Project: **R&D of new technologies of safe solid-state hydrogen storage on the base of reversible metal hydrides and nanostructured composites**

Participants**:**

- Joint Institute for High Temperatures RAS,
- Institute for Problems of Chemical Physics RAS,
- Ural Institute of Metal Physics RAS,
- Moscow State University,
- Moscow Power Engineering Institute.

IPHE International Project

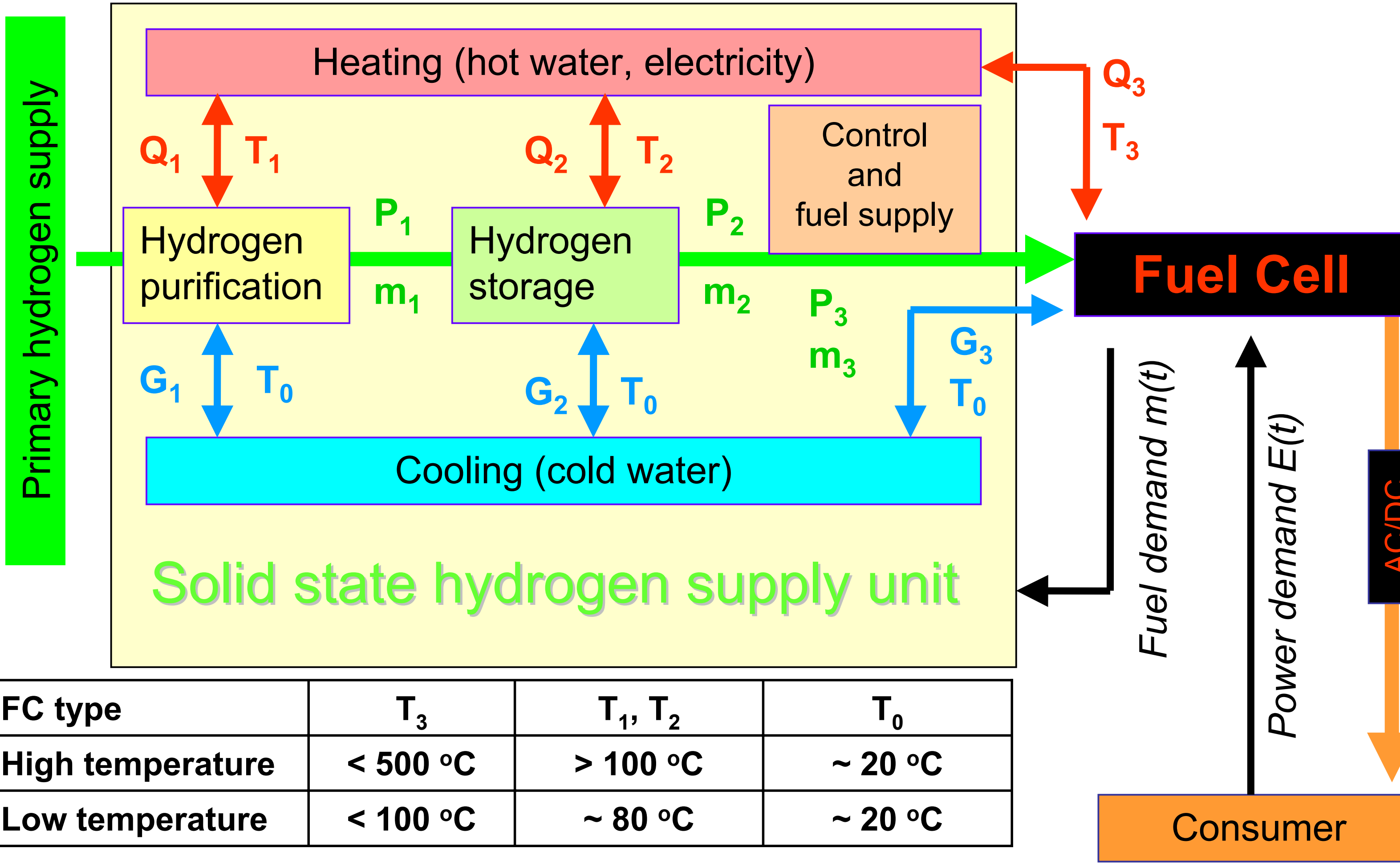
Development of reversible solid state hydrogen storage system for fuel cell power supply system

Joint Institute for High Temperatures RAS

IPHE Contact Person: Dr. Stanislav Malyshenko
Project Coordinator: Vasily Borzenko,
Joint Institute for High temperatures RAS (IVTAN)
Krasnokazarmennaya 17a, Moscow, 111116 Russia
litp@dataforce.net www.litp.ru

Dr. Dmitry Dunikov, Joint Institute for High Temperatures, RAS (Russia)
Dr. Boris Tarasov, Institute for Problems of Chemical Physics RAS (Russia),
Prof. Anatoly Yermakov, Ural Institute of Metal Physics RAS (Russia),
Dr. Sergey Mitrokhin, Moscow State University (Russia),
Dr. Georgy Yankov, Moscow Power Engineering Institute (Russia),
Prof. John R. Lloyd, Michigan State University (US),
Prof. James Wang, Sandia Nat'l Labs (US),
Prof. Peixue Jiang, Tsinghua University (China),
Prof. Volodymyr A. Yartys, Institute for Energy Technology (Norway),
Prof. Thorsteinn I. Sigfusson, University Iceland (Iceland),
Prof. Hirohisa Uchida, Tokai University (Japan),
Prof. Allan Schroeder Pedersen, Risoe National Laboratory (Denmark),
Prof. Kee Suk Nahm, Chonbuk National University (Rep. of Korea).

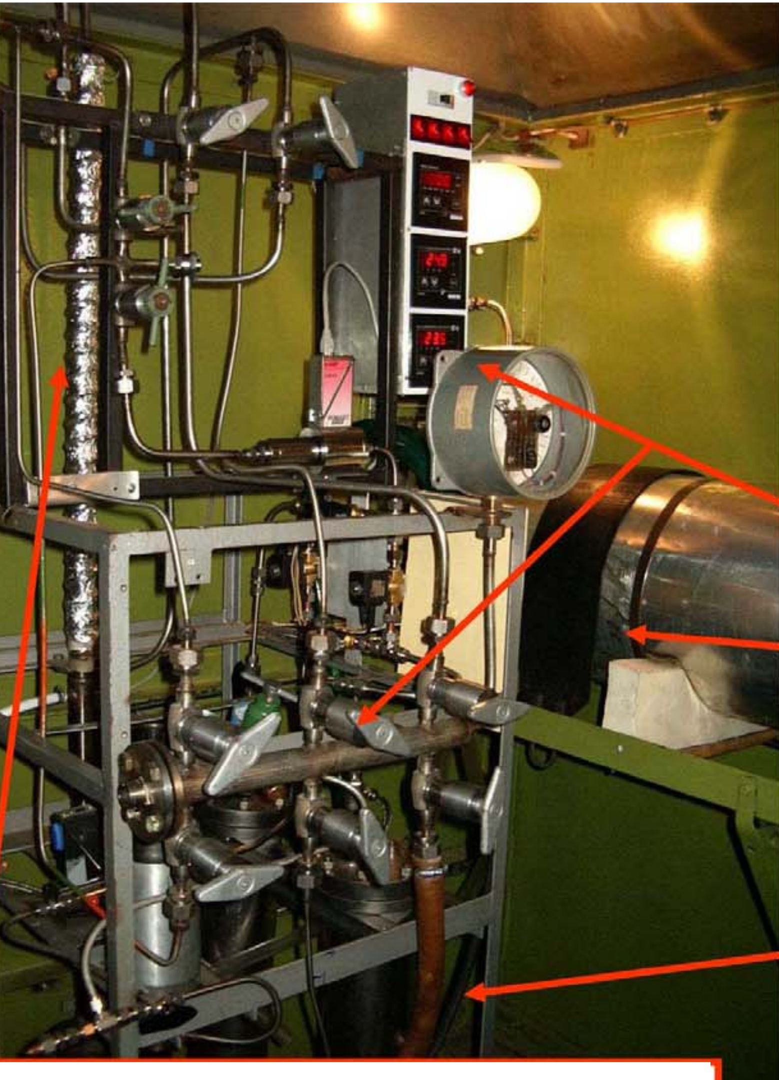
Development of reversible solid state hydrogen storage system for fuel cell power supply system

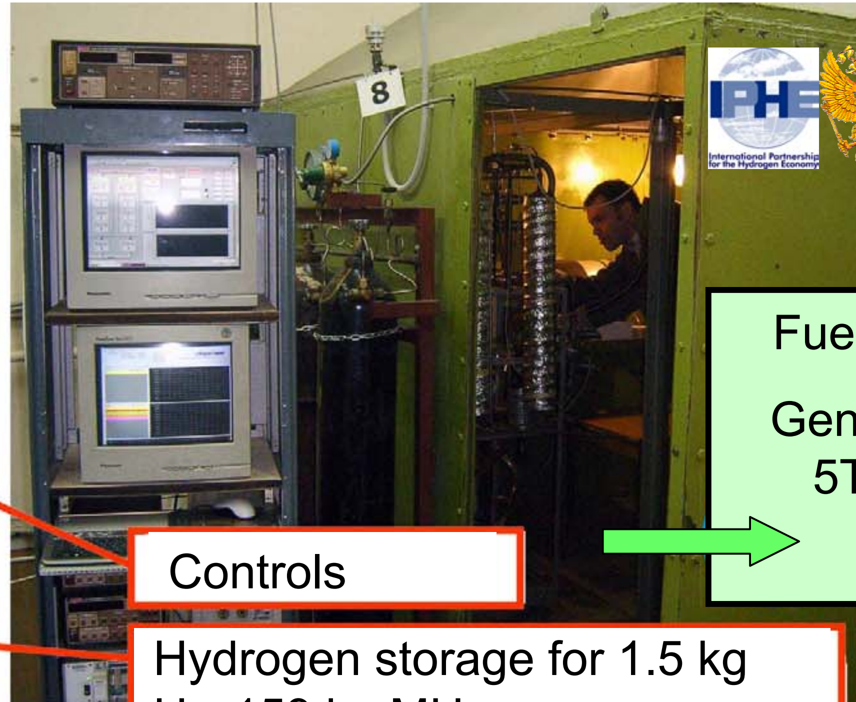


FC type	T_3	T_1, T_2	T_0
High temperature	**< 500 °C**	**> 100 °C**	**~ 20 °C**
Low temperature	**< 100 °C**	**~ 80 °C**	**~ 20 °C**

Concept of FC power supply unit with solid state hydrogen storage

VTAN H2Lab experimental facility for complex investigations of solid-tate reversible hydrogen storage and purification systems



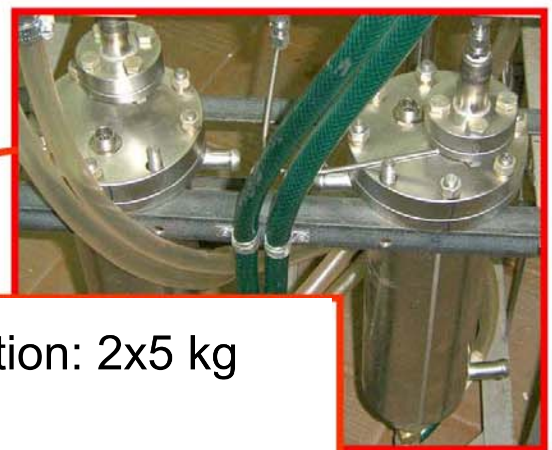


Fuel Cell

GenCore 5T48

Controls

Hydrogen storage for 1.5 kg H_2, 159 kg MH

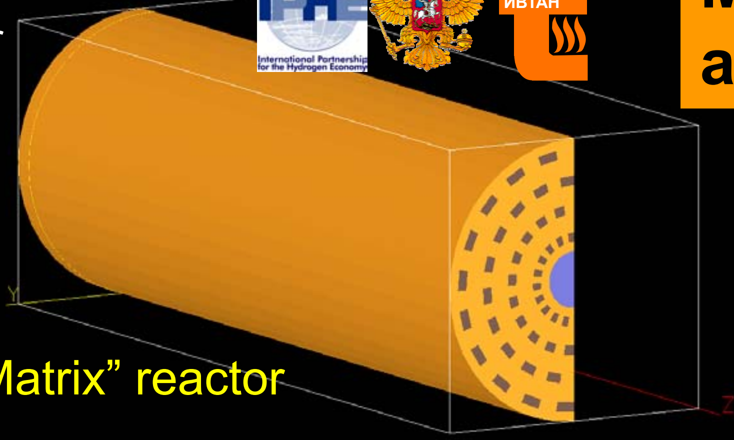


Preliminary purification: catalytic burner and dryers

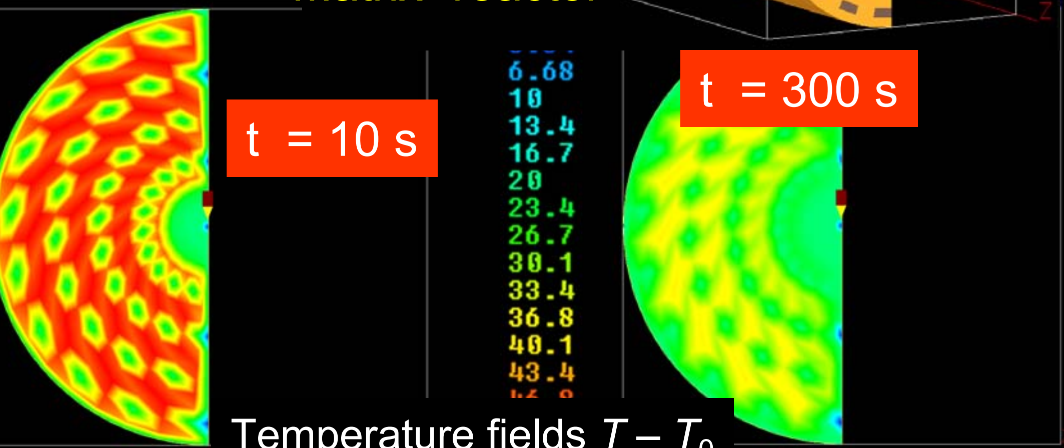
Fine purification: 2x5 kg MH reactors

Mathematical modeling and reactor optimization

ylindrical reactor
ed with MH powder
ellow), water
ooling T_0 = 20 °C –
bes and outer
erimeter, hydrogen
let – inner porous
be (blue)

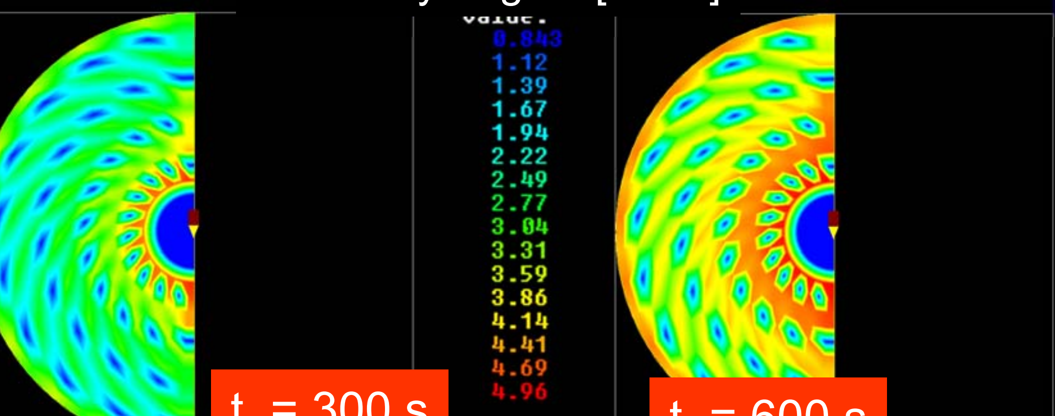


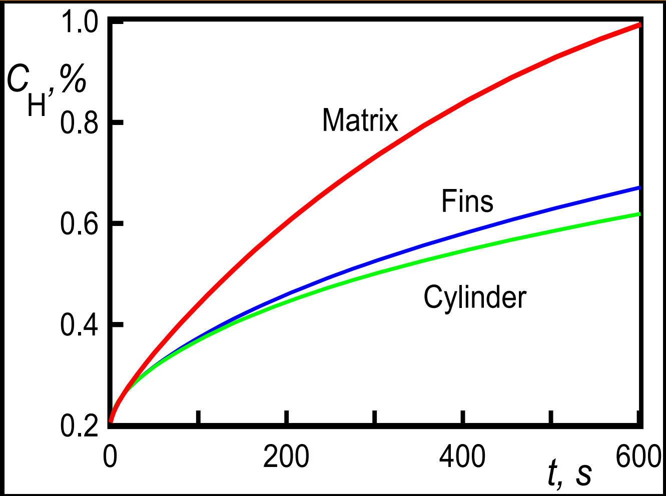
"Matrix" reactor



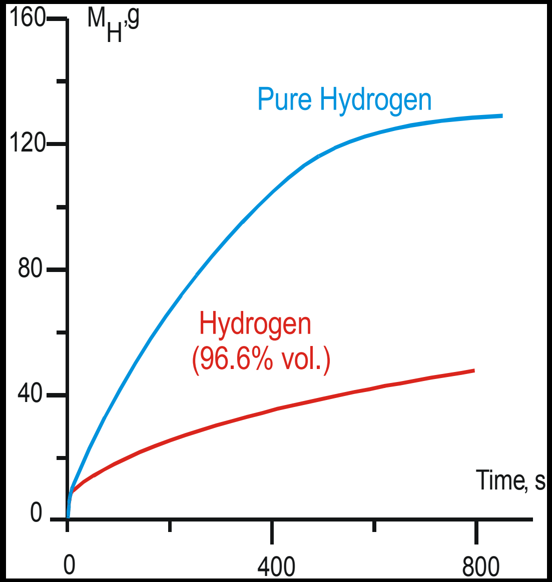
Temperature fields $T - T_0$

Stored hydrogen [H/Me]





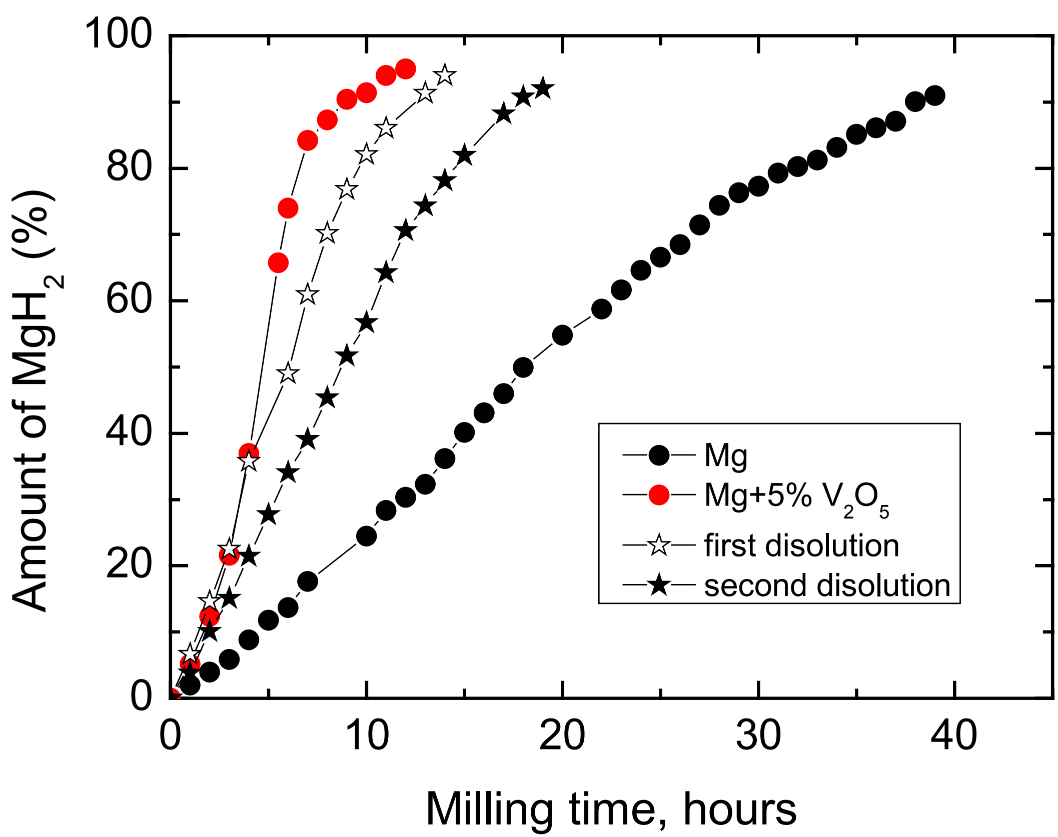
Effect of heat transfer enhancement



Presence of impurities dramatically

Hydrogen Storage Materials

Ural Institute of Metal Physics RAS



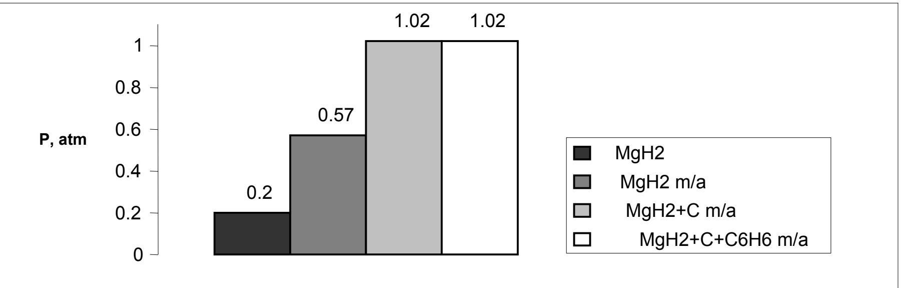
Hydrogen uptake at MA of pure Mg with different content of a catalyst under H_2 pressure 15 bar

Hydrogen Storage Materials

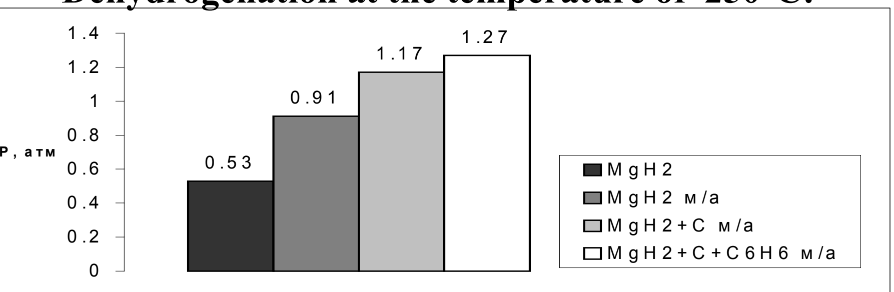
Institute for Problems of Chemical Physics RAS

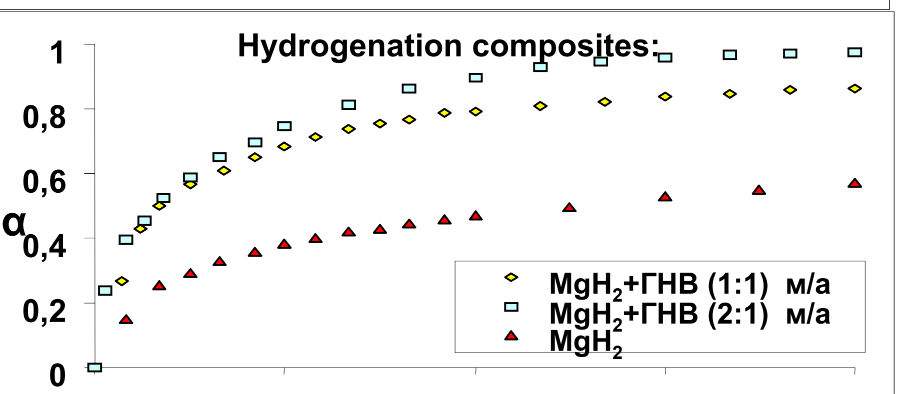
Composites based on magnesium hydride and carbon

Dehydrogenation at the temperature of 150°C:



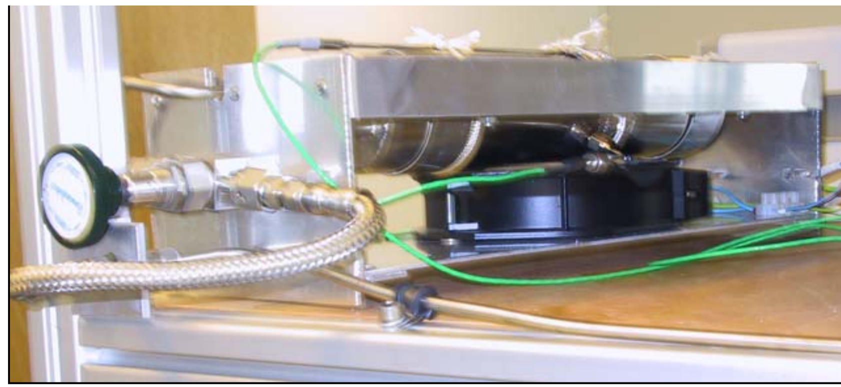
Dehydrogenation at the temperature of 250°C:





- Volume – 600 cm^3
- Loading density MH – 60% (1.26 g/cm^3)
- Weight MH – 500 g
- Calculated hydrogen capacity – 280

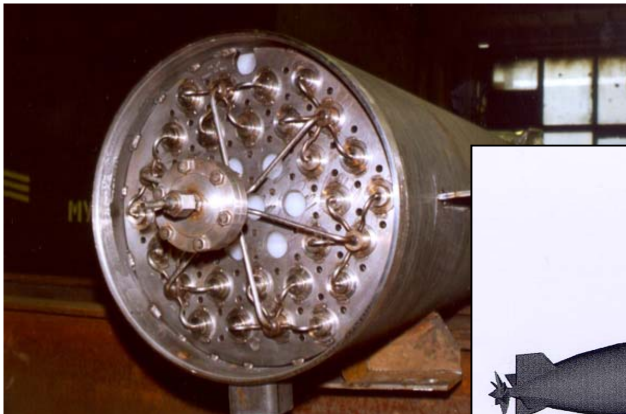
Characteristics of a hydrogen accumulator based on magnesium alloy

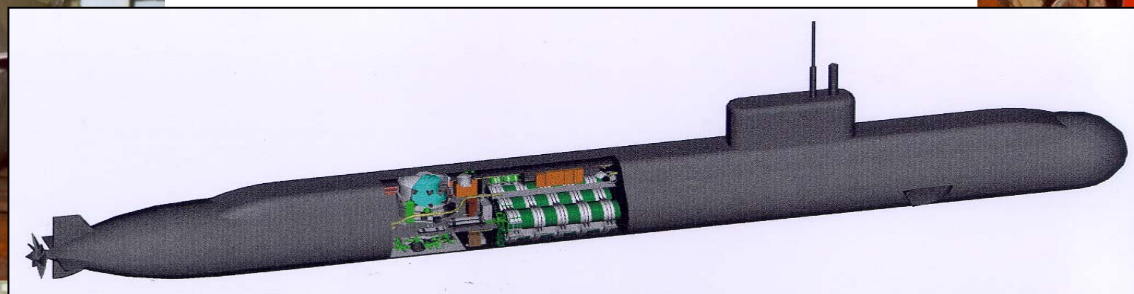


- Hydrogen soprtion – 250 ^oC / 10 bar
- Hydrogen desorption – 350 ^oC / 0-2 bar
- Duration of 90% charge - < 10 min.
- Duration of 90% discharge - 30 min.
- Reversible capacity – 200 l
- Total capacity – 280 l

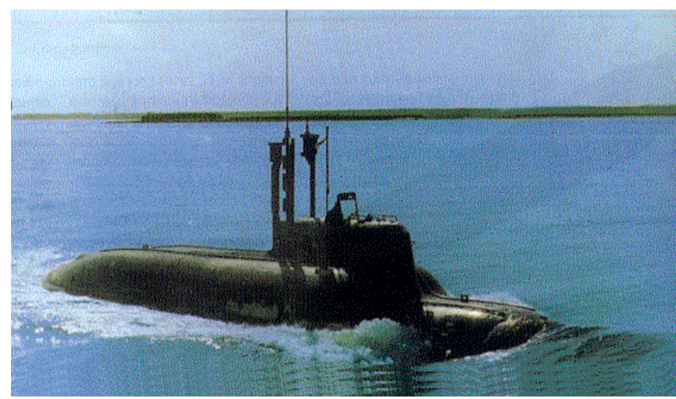
Hydrogen Storage

Central Research Institute for Ship Electric Engineering and Technology, Saint-Petersburg





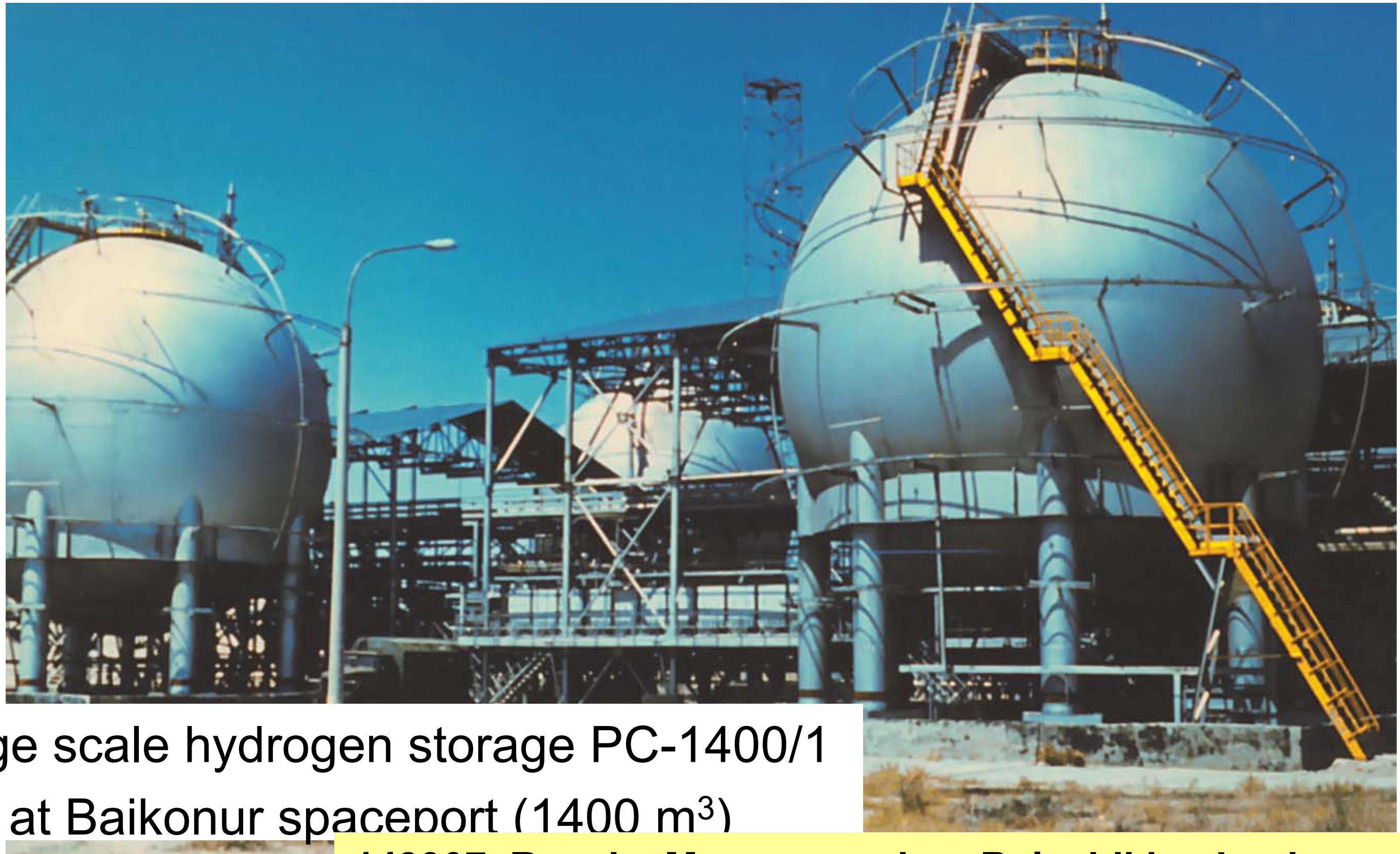
Hydrogen storage systems for more than 1,000 kg of intermetallic alloy



196128 Saint-Petersburg, Blagodatnaya 6
set@sp.ru

CRYOGENIC HYDROGEN STORAGE

JCR Cryogenmash



Large scale hydrogen storage PC-1400/1 at Baikonur spaceport (1400 m^3)

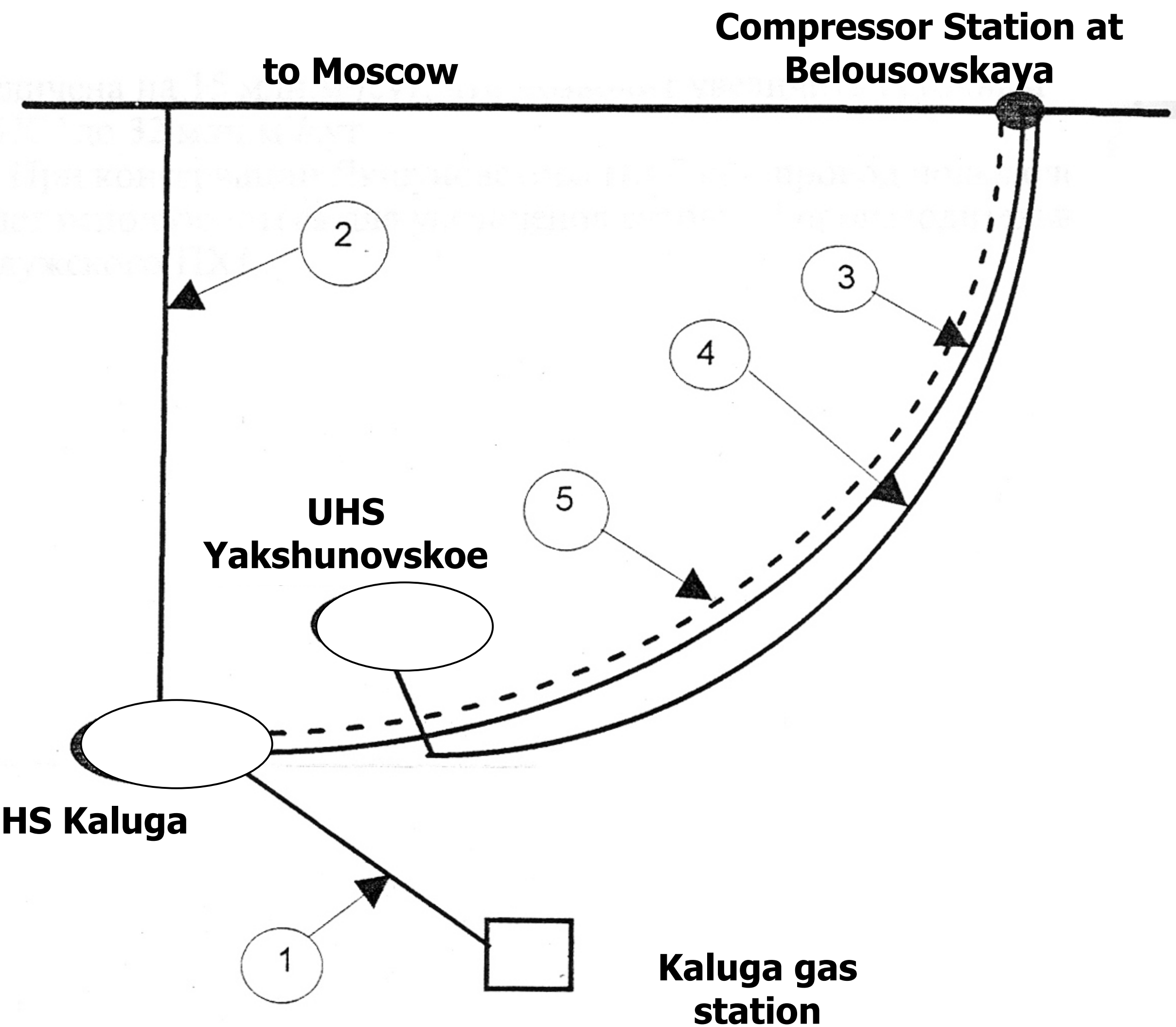
143907, Russia, Moscow region, Balashikha, Lenin av. 67
+7 495 521-5722
e-mail: root@cryogenmash.ru ww.cryogenmash.ru

Cryogenic hydrogen tanks characteristics JSC "Cryogenmash"

Parameter	РЦВ-63/0.5	РЦГ-250/1	РЦГ-250/0.8	РСВ-1400/1	ЦТВ-25/0.6 t	ЦТВ-45/1.0 t
Capacity, m^3	66.3	246	246	1,437	25	45
Working pressure,MPa	0.5	1.0	0.85	1.05	0.7	1.0
Product mass,t	4.43	15.7	15.7	96.79	1.5	2.74
Evaporation loss daily, %	0.52	0.3	0.35	0.13	1.2	1.0
Dimensions, m						
length		36.35	36.35	-	14.35	15.7
width	3.68	3.7	37.4	-	2.75	2.5
height	12.65	3.92	3.92	20.1	3.92	3.7
Tank mass, t	22	72	72	360	19	21.76

143907, Russia, Moscow region, Balashikha, Lenin av. 67
+7 495 521-5722
e-mail: root@cryogenmash.ru ww.cryogenmash.ru

Underground Hydrogen Storage (UHS) in Kaluga Region



1 – UHS Kaluga – Kaluga GS;

2 – UHS Kaluga – Moscow;

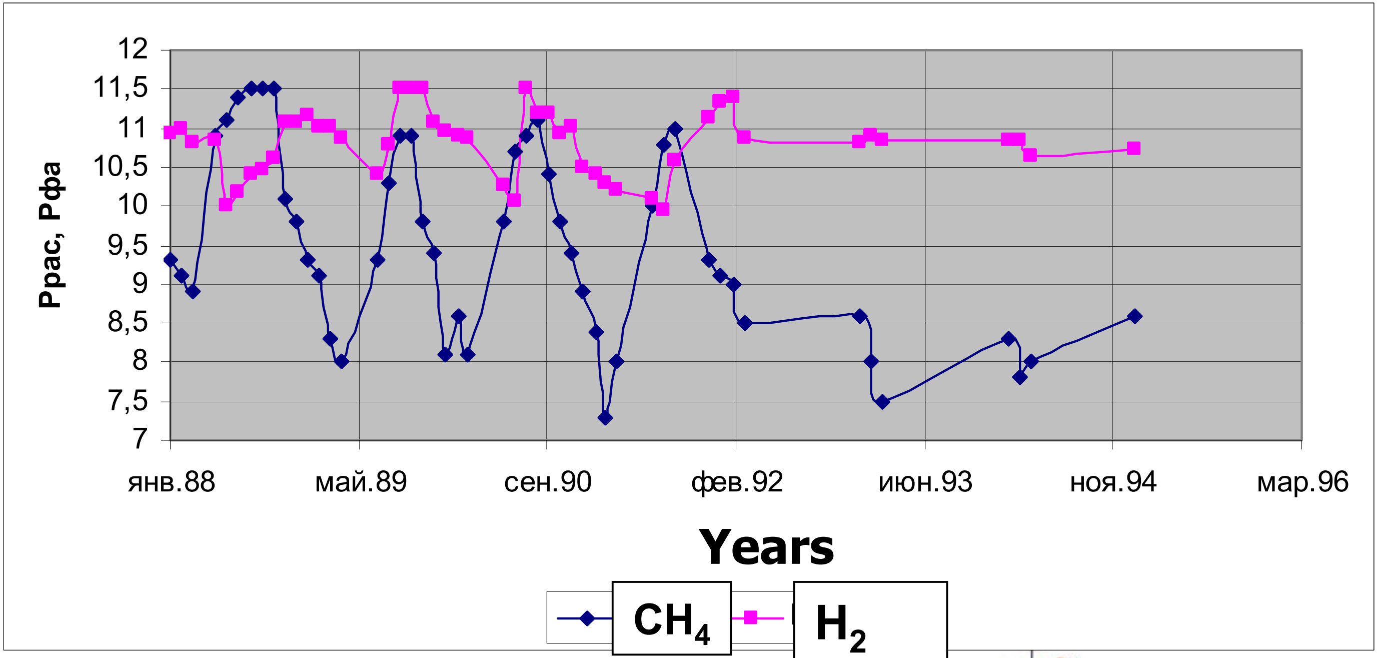
3 – UHS Kaluga - CS Belousovskaya;

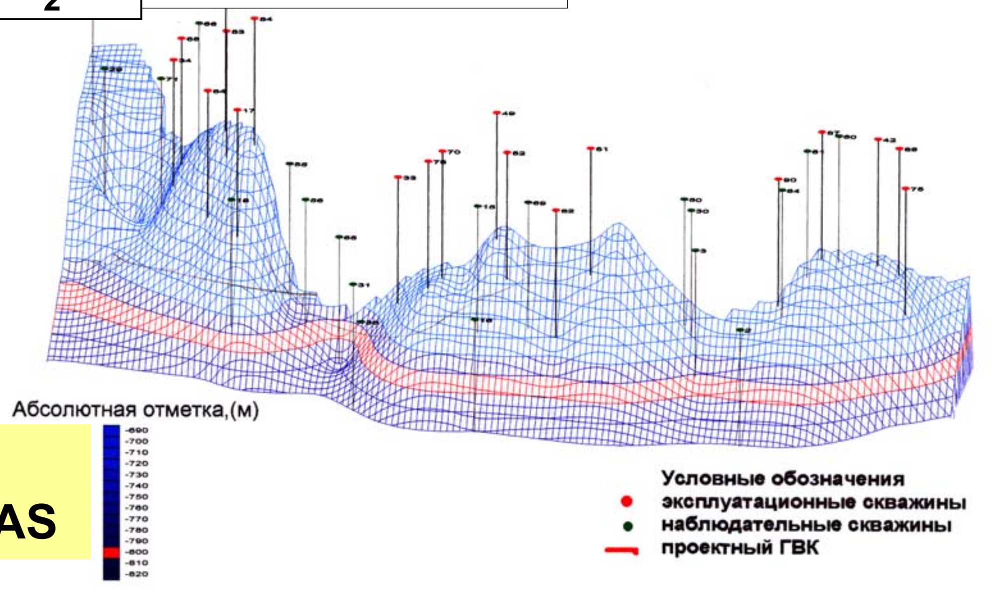
4 – UHS Yakshunovsko CS Belousovskaya

5 – UHS Kaluga- CS Belousovskaya (under construction)

Gubkin Oil and Gas Institute
Institute for Oil and Gas Problems, RAS

Load/Reload of H_2 и CH_4 on UHS “Yakshunovskoe”



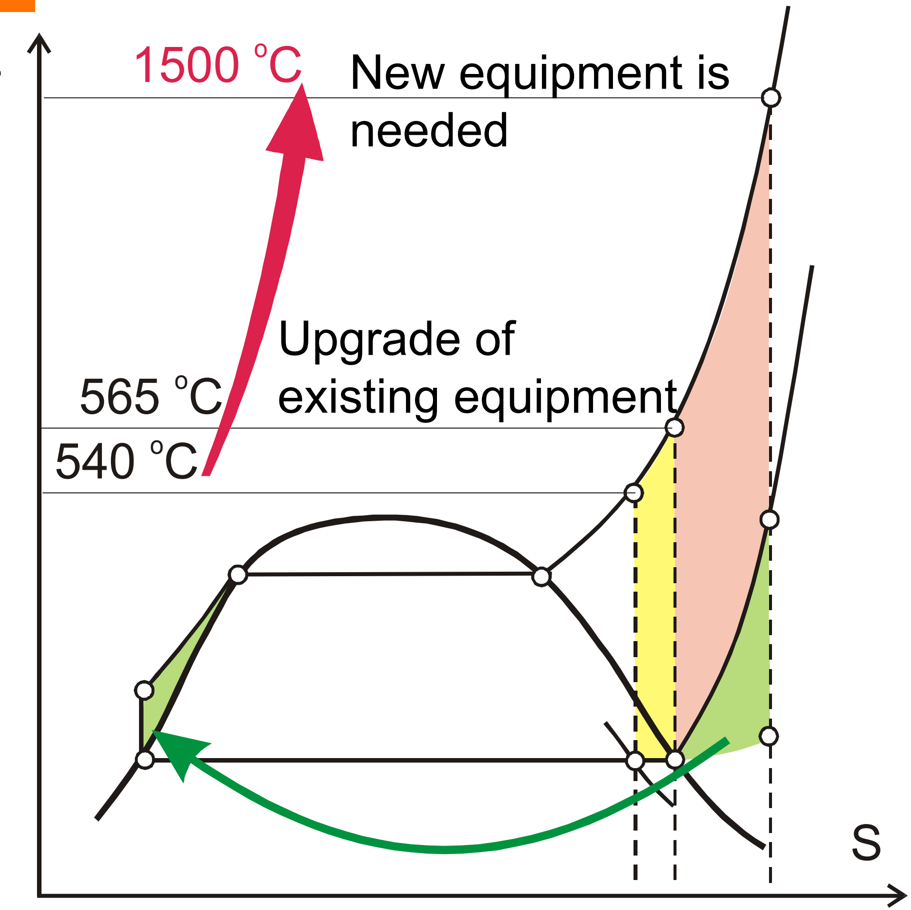


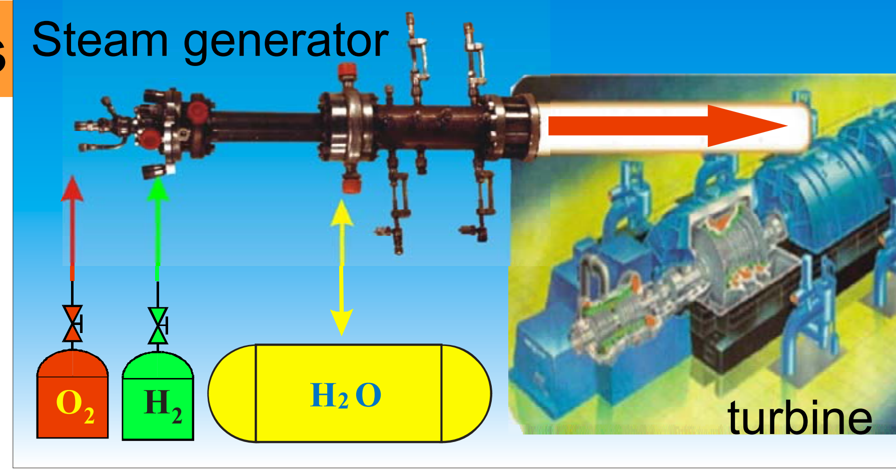
ubkin Oil and Gas Institute
nstitute for Oil and Gas Problems, RAS

Hydrogen Combustion Systems

Hydrogen combustion systems

Institute for High Temperatures RAS





Upgrade of existing equipment with hydrogen-oxygen steam generators will he to increase of overall power plant efficienc with high efficiency of hydrogen utilization

Development of new high temperature steam turbines and heat regeneration systems will result in great increase of overall power plant efficiency with high efficiency of hydrogen utilization

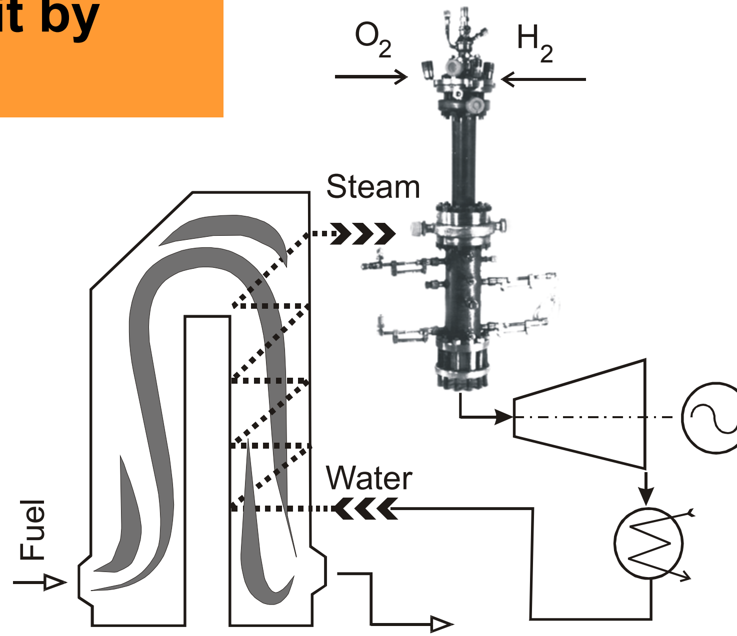
Key problem: to create high temperature and high pressure hydrogen-oxygen generators working on the stoichiometry component mixture

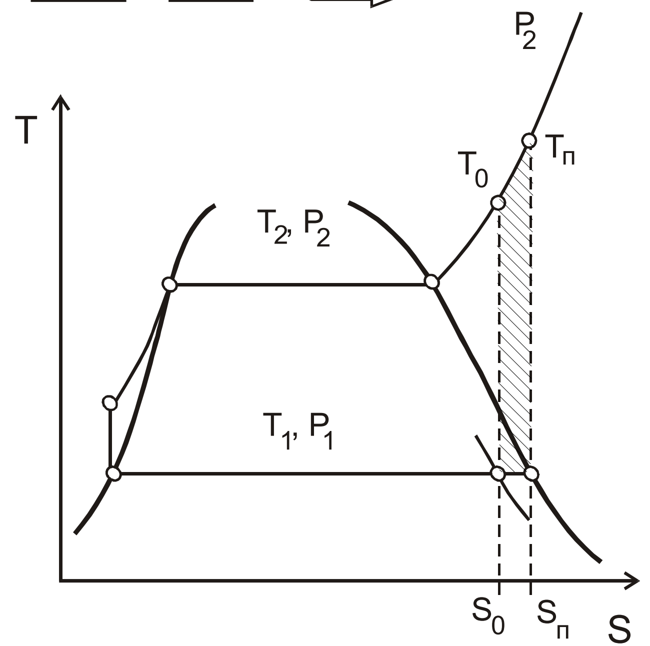
pgrade of K-200-130 steam turbine power unit by ydrogen superheating of steam

Power plant:

Steam production – 640 t/h, power – 200 MW,
P = 130 atm, T = 540 ^{0}C,
Fuel consumption – 275 g.c.e./kW h

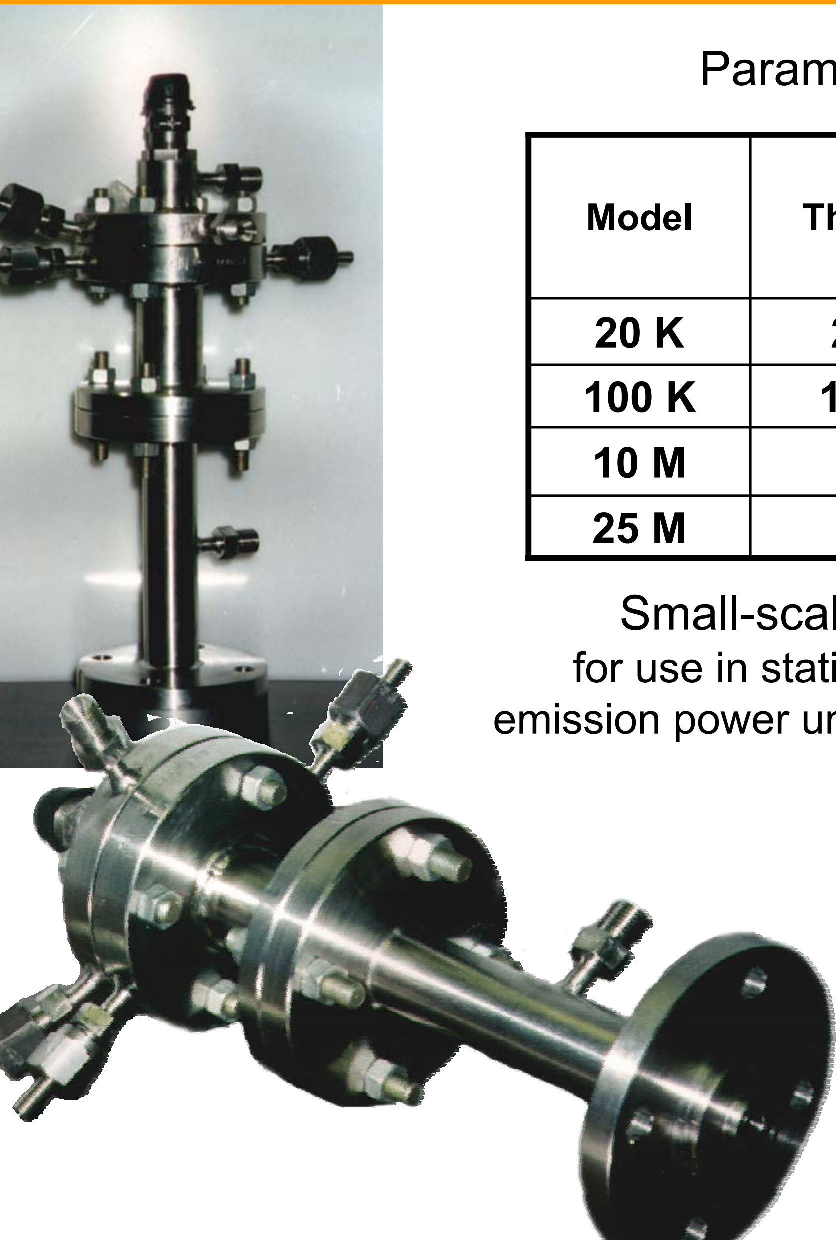
Superheating from 540°C to 565°C	
H_2/O_2 gas consumption, 10^3 st.m^3/h	11.5/5.82
Additional power ΔW, MW	20.1
Fuel consumption, g.c.e./kW h	262
Overall efficiency without hydrogen superheating, %	40.3
Overall efficiency with hydrogen superheating, %	42.3
Efficiency of hydrogen utilization, %	57.5





Joint Institute for High Temperatures RAS

Experimental high-pressure H_2/O_2-steam generators



Parameters of experimental fire blocks

Model	Thermal power	Steam parameters	
		T, K	*P*, MPa
20 K	20-100 kW	1100	0,5
100 K	100-150 kW	1000	4
10 M	10-20 MW	1200	7
25 M	25-30 MW	1200	10

Small-scale high-pressure H_2/O_2-steam generators for use in stationary and mobile autonomous hydrogen zero emission power units (ZEPU) based on 30-150 kW mini-turbine.

The main features of experimental device:

working pressure, MPa: 1-4

steam temperature, K: 600-1000

thermal capacity, kW: 40-156

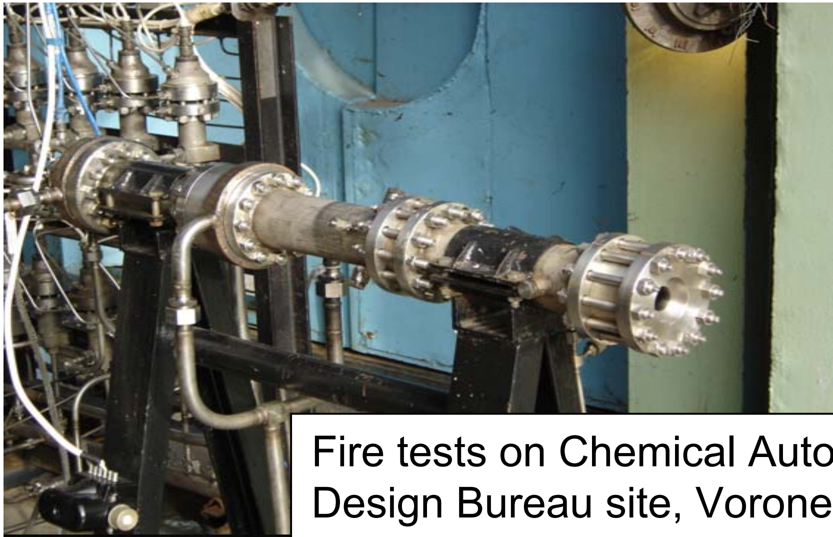
length, mm: 300

max diameter, mm: 90.

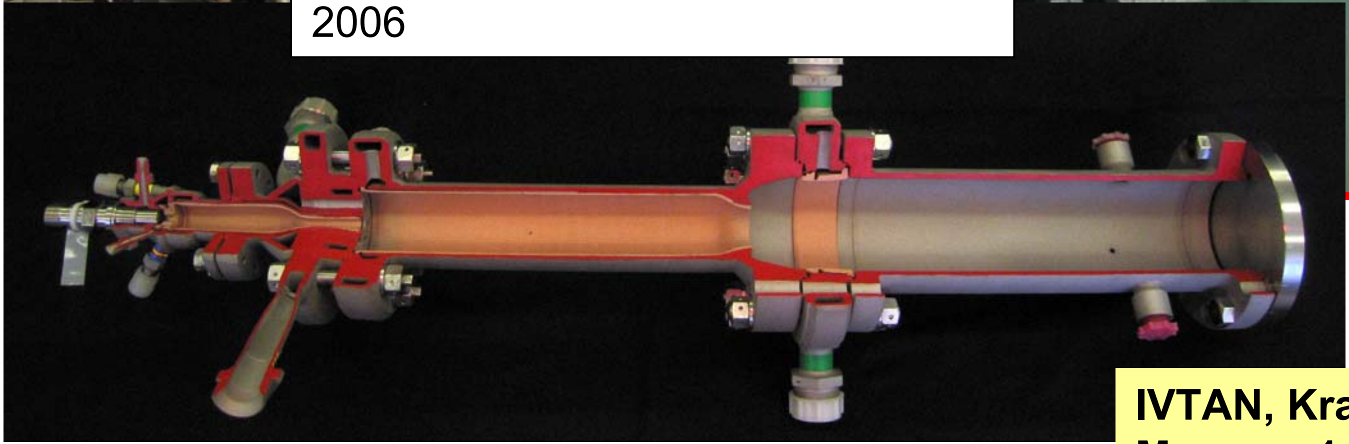
Joint Institute for High Temperatures RA
Chemical Automatics Design Bureau
Keldysh Center

Experimental MW class steam generators

Joint Institute for High Temperatures RAS



Fire tests on Chemical Automatics Design Bureau site, Voronezh, 2006



IVTAN, Krasnokazarmennaya 17a
Moscow 111116 Russia
litp@dataforce.net

hemical Automatics Design Bureau, Russian Space Agency

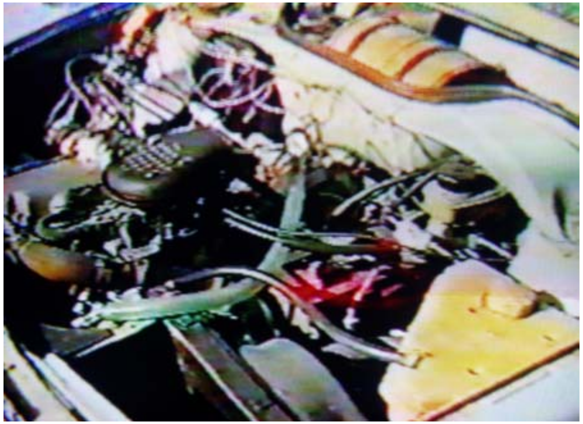
Liquid hydrogen Production facility. View of construction site.

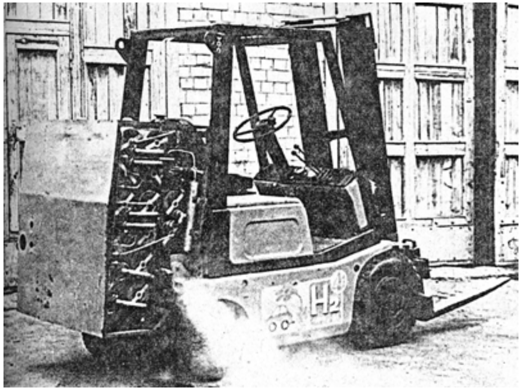
Firing tests of rocket engines at tilted test stand

Contact: Chemical Automatics Design Bureau, Russian Space Agency
Address: Voroshilova st. 22, Voronezh, 394006 Russia
Tel.: (7-0732) 333673 Fax: (7-0732) 334122 E-mail: cadb@comch.ru

Hydrogen for Vehicles

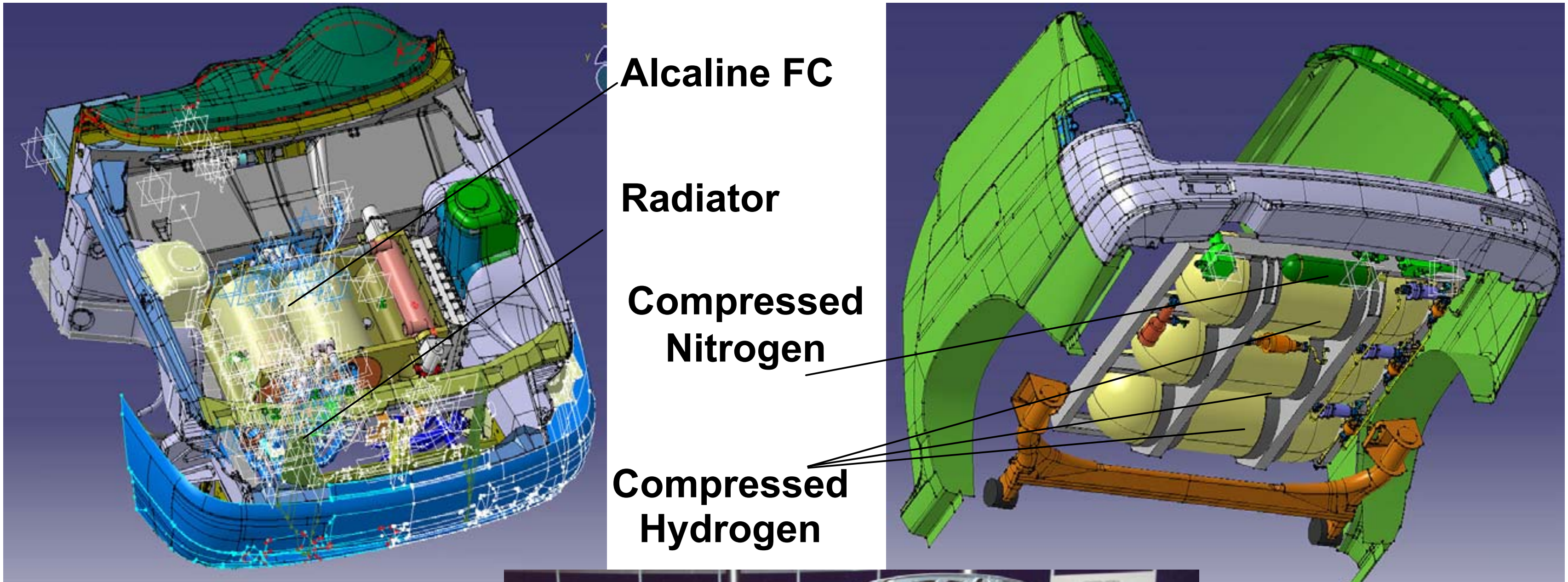
Internal Combustion vehicles





Fuel Cell Vehicles

RCC Energia, UEChC, Autovaz



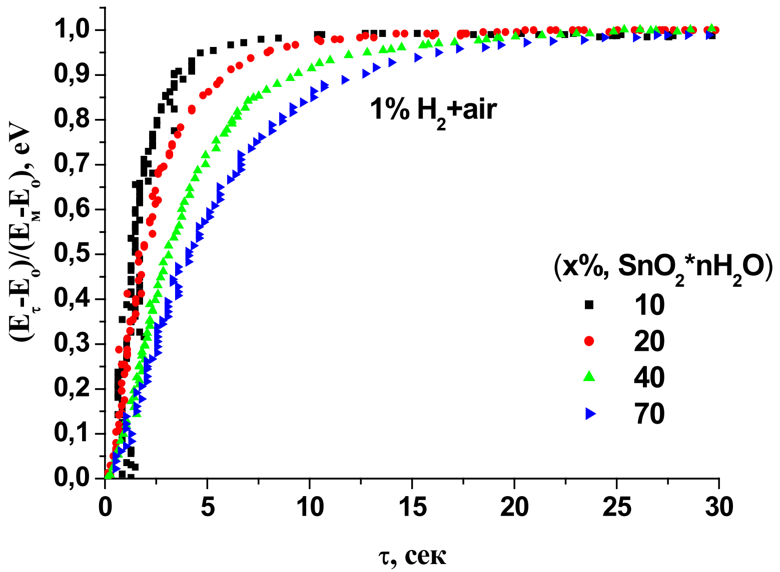
MAIN CHARACTERICTICS

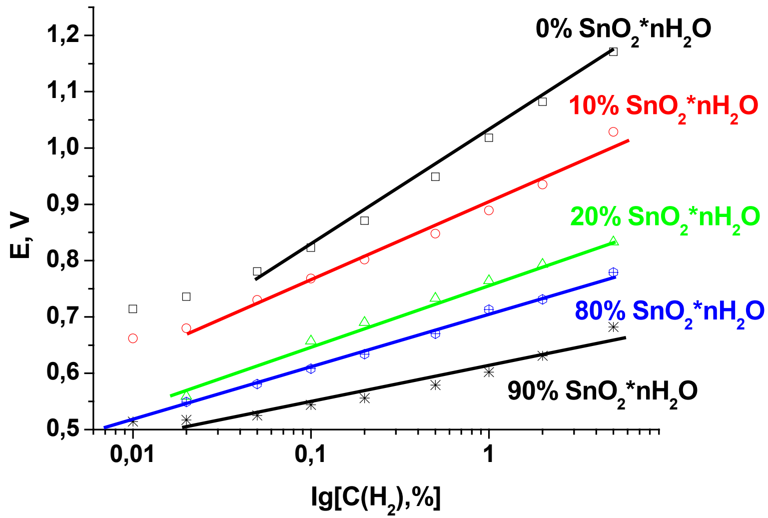
	«ANTEL-1»	«ANTEL-2»
FUEL	HYDROGEN+ OXYGEN	HYDROGEN+ AIR
MECHANICAL POWER, kW	15	18
MAXIMUM POWER, kW	25	40
VOLTAGE, V	115-150	180-200
HYDROGEN PRESSURE, ATM	300	400
RANGE, KM	220	300

SAFETY AND STANDARDS

Electrochemical hydrogen sensors

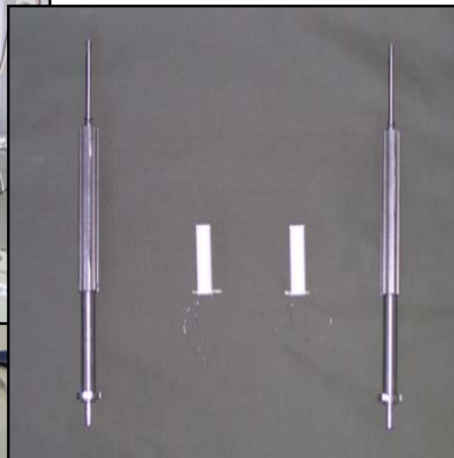
Institute for Problems of Chemical Physics RAS

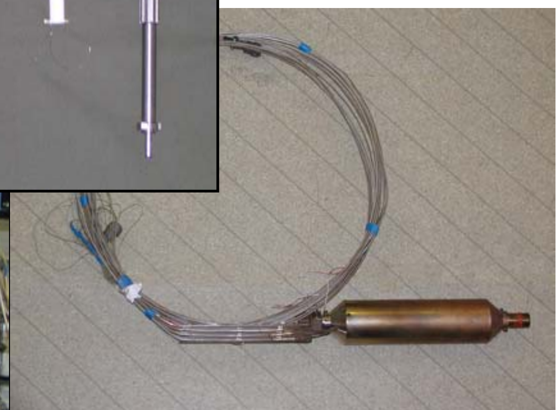




Hydrogen and Oxygen Gas Sensors

SSC “Institute for Physics & Power Engineering”



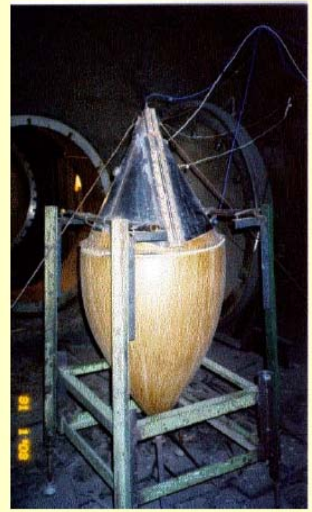


249033, Bondarenko sq. 1, Obninsk, Kaluga reg., Russia

Combustion, detonation and explosion of hydrogen

Institute for High Energy Densities,
Associated Institute for High Temperatures RAS
125412, Moscow, Russia, Izhorskaya 13/19

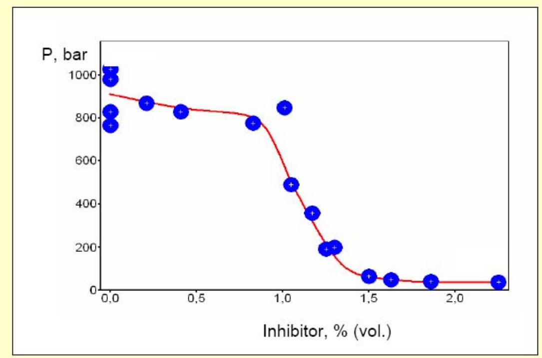
Experimental installations "Cone" and "Pyramid"



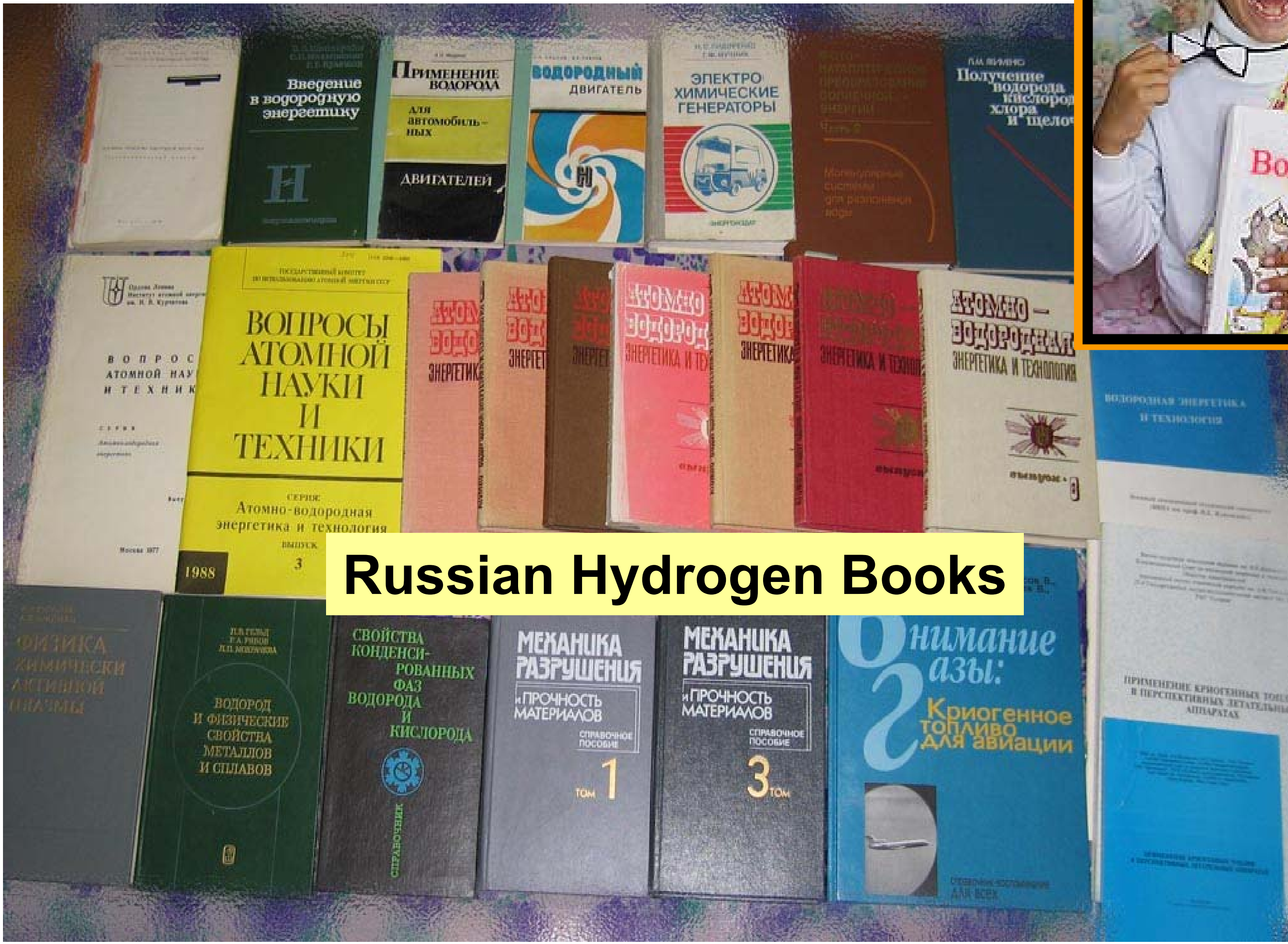
Explosive chamber

Inside diameter – 12 m; Wall thickness – 100 mm; Weight – 470 t.
Chamber is designed for explosion up to 1000 kg TNT.

Suppression of explosion by Inhibitor



Education



Russian Hydrogen Books

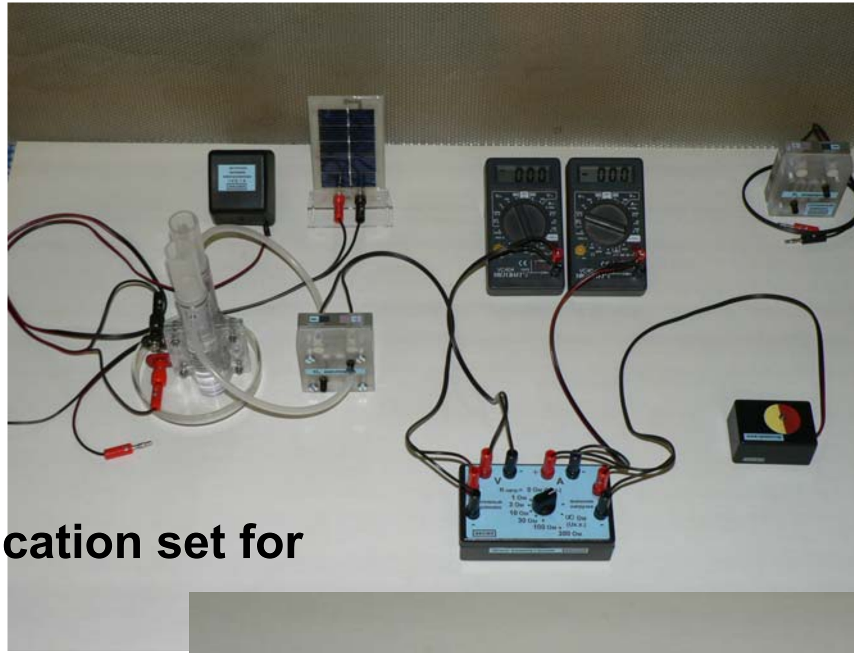
Hydrogen education in high school

FASI Project “Education”

Lectures
Hydrogen Labs
Young Scientists Conferences
Students Hydrogen Clubs

Moscow Power Engineering Institute
Moscow Institute of Physics and Technology
Moscow State University
Saint-Petersburg State University
Novosibirsk State University
Ural Technical University (Ekaterinburg)
Tomsk Technical University
Moscow State Technical University "MAMI"
Moscow Radiotechnics Electronics and Automatics Institute
and many others…

Hydrogen education in elementary school



Hydrogen experimental and education set for elementary schools

Electrolyzer
Photovoltaic cell
Fuel Cell
Diagnostics

Results of Russian R&D in 2005-2006 and new 2007-2012 Federal Program are the good basis for EU-Russia cooperation in Hydrogen Energy

Thanks for your attention!