A hydrogen powered aircraft

The solution that will make the world a better place

www.hdt.com.ua

www.h2dt.com

Hydrogen Dynamics Technology – February 2022

Content

Item 1.1: STORAGE OF HYDROGEN IN HYDRIDE INTERMETALLIC COMPOUNDS

Metalhydrides for autonomous systems, introduction

Metalhydrides are known as a potentially efficient way to store hydrogen with high density and low risk.

With the development and completion of the first submarine U212 A series by HDW (now Thyssen Krupp Marine Systems) in 2003 and its export model U214 in 2004, the use of metalhydrides for hydrogen storage in mobile platforms has become feasible and practical in new applications.

In recent decades, a huge number of new intermetallic and partially covalent compounds that absorb hydrogen have been identified and characterized to a greater or lesser extent.
In addition, this class of materials is based on the thermodynamic properties of metalhydrides, making it possible to develop a new technology for compressing hydrogen. This technology allows the direct use of thermal energy to compress hydrogen gas without the need for any moving parts. Such compressors for pressures up to 200 bar have already been developed and are now commercially available. Metalhydride compressors for higher pressures are under development. Moreover, systems consisting of a combination of metalhydrides and pressure vessels have been proposed as a practical solution for on-board hydrogen storage in fuel cell of means of transport.

Under the programmes "Hydrogen Storage Systems for Mobile and Stationary Applications" and the International Energy Agency (IEA) Hydrogen Target 32 "Hydrogen-based Energy Storage" various compounds for use in hydrogen storage systems ranging from 500 g to several hundred kilograms have been developed and will be introduced and tested in the near future.

One of the goals of energy storage with hydrogen is to demonstrate the feasibility of using hydrogen to support the integration of renewable energy sources into energy systems.
The storage, transport and distribution of hydrogen must be optimized so that hydrogen is available for storage and distribution centers in enterprises and conveniently delivered to consumers.

Item 1.2: STORAGE OF HYDROGEN IN HYDRIDE INTERMETALLIC COMPOUNDS

Solution for storing hydrogen in metalhydride cylinders by the H2DT team

The H2DT team studied all the existing methods of hydrogen storage for its use on board aircraft and opted for metalhydrides.

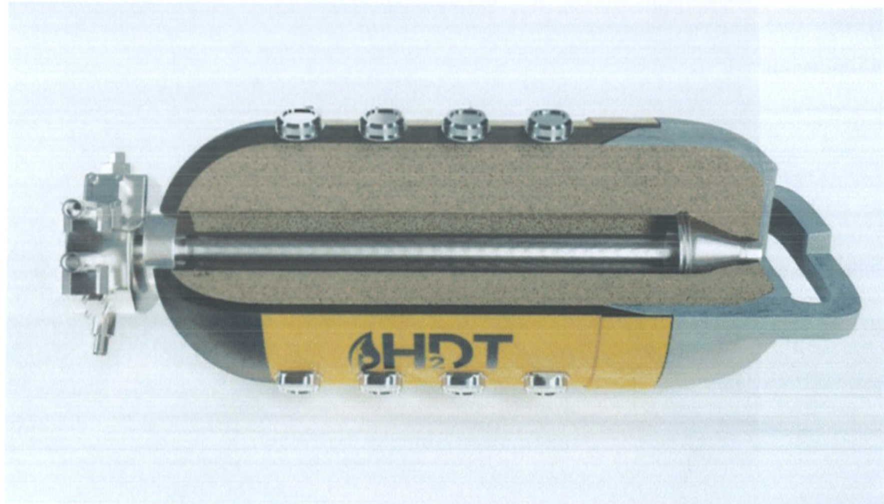
After analysis metalhydride technology, the team first chose a titanium-magnesium alloy-based metalhydride for application. But its sorption characteristics were not satisfactory to us, while its weight is 8% of the total mass.

We decided to conduct research in the direction of hydrogen storage in titanium, magnesium and zirconium nanoparticles. But we did not achieve the desired result.

When we learned how to produce fullerenes, we started experimenting with combining titanium and zirconium nanoparticles with fullerenes.

We have obtained the desired result of storing hydrogen in a bound state up to 38% of mass. This technology has been thoroughly tested at our enterprise and has shown high efficiency.

We have learned how to activate this type of metalhydrides without using temperature. In the case of classical metalhydrides, it was necessary to use temperature effects on the cylinder itself to activate the processes of hydrogen sorption and desorption.

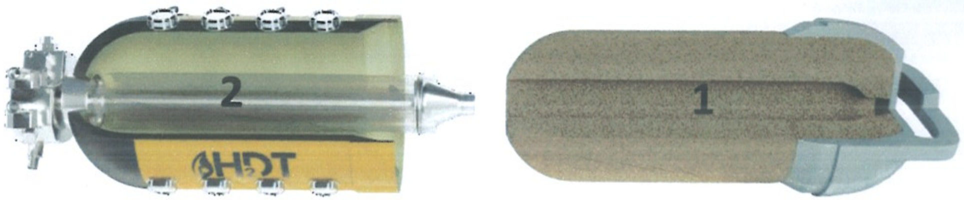


Metalhydride cylinder model developed by H2DT

The process of hydrogen sorption and desorption is achieved by applying ultrasound to nanoparticles of a specific frequency and range.

Item 1.3: STORAGE OF HYDROGEN IN HYDRIDE INTERMETALLIC COMPOUNDS

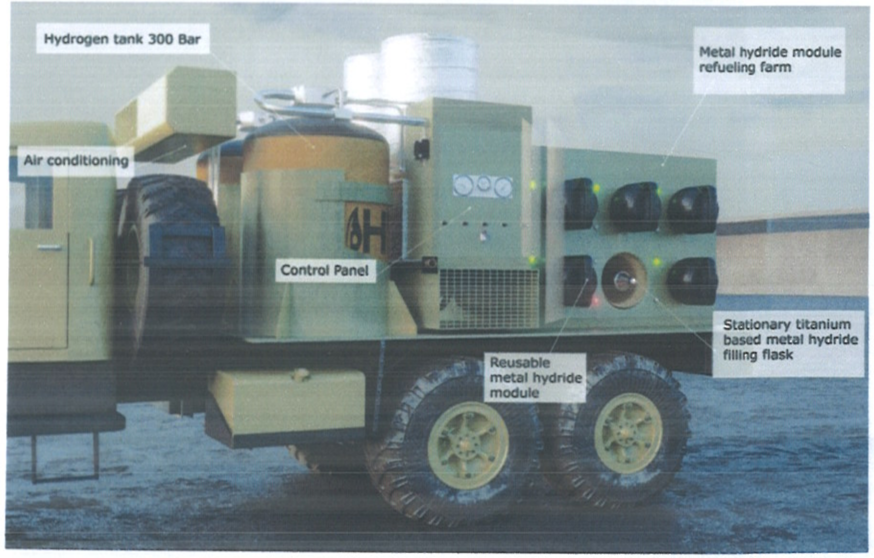
Decision on refueling of metalhydrides at airports



To ensure the integrity of the fuel system and to avoid depressurization of the lines at the junction of the stop valves with the line, a cylinder was designed with a separate core (1) from the shell (2).

This arrangement provides a solution to quickly prepare the aircraft for take-off. Refueling is carried out within 15 minutes from a mobile tanker. This method guarantees the safety of personnel working directly with hydrogen fuel.

The mobile tanker is capable of independently producing hydrogen in an amount of up to 10 kg within 24 hours. To do this, it is necessary to connect the mobile tanker to a 380volt power supply network with a permitted load of 66 kWh, and supply water to the electrolyzers from the water supply network. The amount of water required to produce 10 kg of hydrogen is up to 5000 liters.



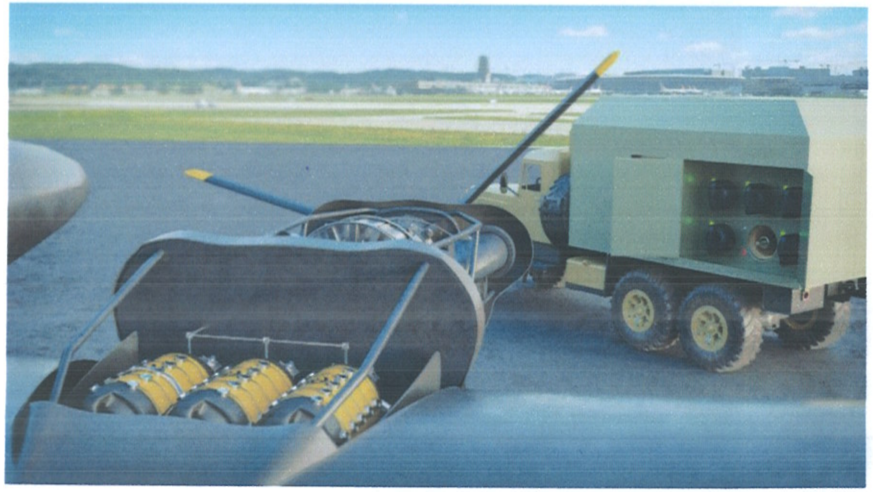
General view and composition of the mobile tanker.

Item 1.4: STORAGE OF HYDROGEN IN HYDRIDE INTERMETALLIC COMPOUNDS

Decision on refueling of metalhydrides at airports

The replacement of the cylinder core occurs in the following order:

1. The tanker drives up to the aircraft which use this technology.
2. The flight engineer disconnects the metalhydride core from the base of the cylinder, after making sure that all valves are closed and air does not enter the network.
3. The cores are transported to the tanker, and they are installed in the places provided for them.
4. Following the instructions, the flight engineer refills the metalhydride core with hydrogen fuel. After refueling, the core is moved to a designated place in the aircraft.



Item 2.1: HIGH TEMPERATURE HYDROGEN POWER GENERATOR

The principle of operation of the fuel cell

A fuel element/cell is a device that efficiently generates direct current and heat from hydrogen-rich fuel by electrochemical reaction.

A high-temperature fuel cell is similar to a battery in that it generates direct current by chemical reaction.

However, unlike batteries, fuel elements/cells cannot store electrical energy, do not discharge and do not require electricity for re-charging, while they can continuously generate electricity as long as they have fuel and air reserves.

Item 2.2: HIGH-TEMPERATURE HYDROGEN POWER GENERATOR

Generator design

The high temperature hydrogen generator consists of:

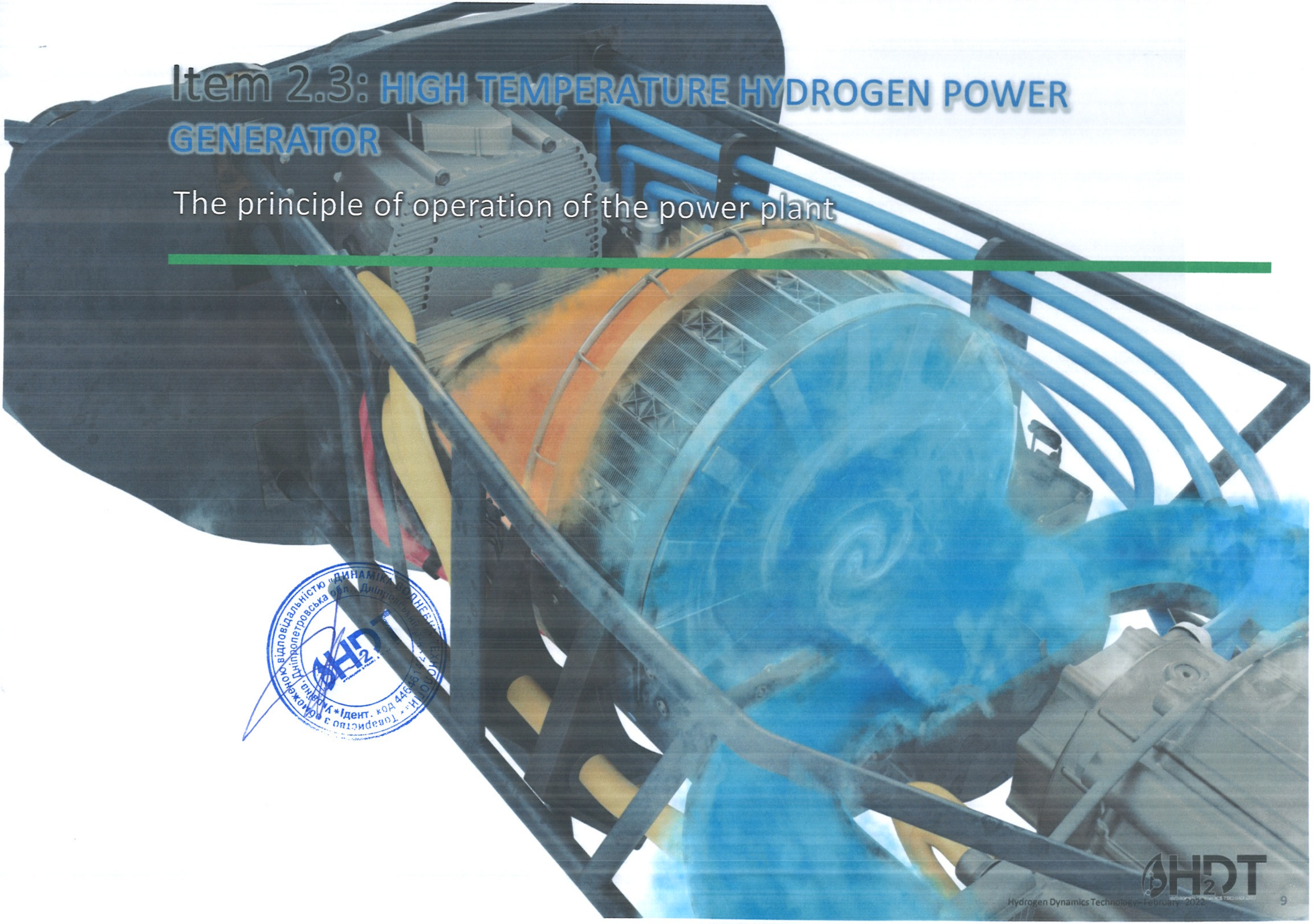
A) Fuel cell (3) – 17 pieces. The power of each fuel cell is reached up to 9 kW in a short-term peak load.

With the aircraft fully charged, the power-to-weight ratio reaches 1.8 kW/kg.

B) Forced air cooling systems.
The principle of operation of the cooling system:
the turbine forcibly supplies cooled air up to 25˚C to the heat exchangers (2), thus the heat is removed from the fuel cells (3).

Item 2.3: HIGH TEMPERATURE HYDROGEN POWER GENERATOR

The principle of operation of the power plant



Item 2.3: HIGH TEMPERATURE HYDROGEN POWER GENERATOR

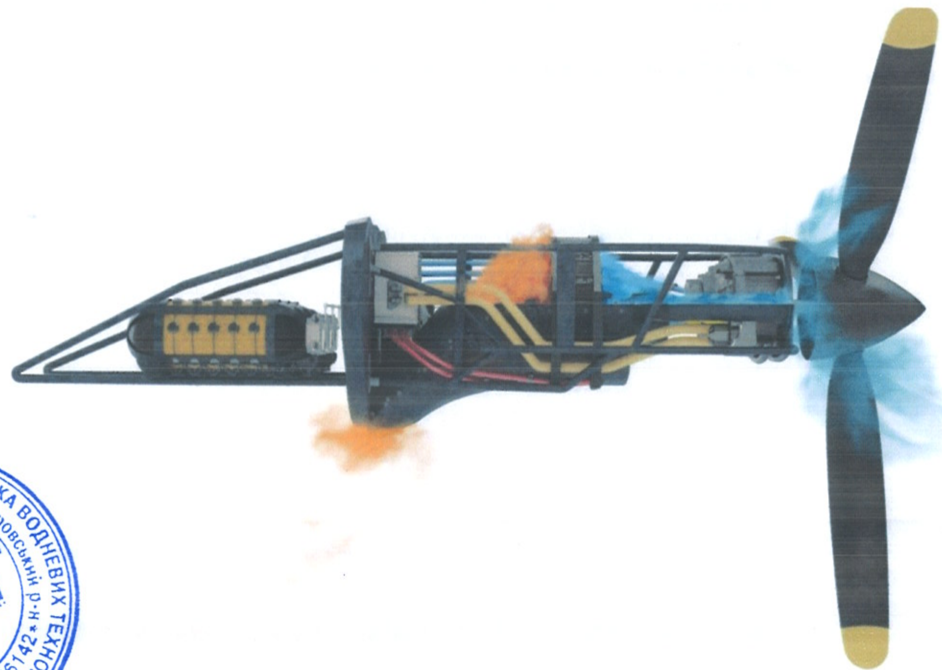
The principle of operation of the power plant

Before starting the power plant, the system of forced air supply to the fuel cell is turned on, the system is blown out to remove condensation from the internal surfaces. The cooling system turns on automatically.

After hydrogen is supplied to the generator cells, electricity is generated. The electricity generated on board the aircraft is first fed to the batteries in the wings to recharge them. Batteries are used as an emergency power source in case of an emergency on board an aircraft, e.g. failure of hydrogen fuel cells, and are also connected to the electric motor when the power consumption increases.

Battery capacity 2 x 34 kWh.

The cooling system operates independently of the discharge propeller.



Товариство з обмеженою відповідальністю «ДИНАМІКА ВОДНЕВИХ ТЕХНОЛОГІЇ» * м. Дніпро, Дніпропетровська обл., Дніпровський р-н * Ідент. код 44646142 * H2DT

Item 3: Characteristics of the Piper PA - 34 aircraft after upgrading to hydrogen fuel

Crew: 1 person;

Passenger capacity: 6 people (Depending on the configuration);

Aircraft length: 8.72m; **Wingspan**: 11.86 m.;

Aircraft height: 3.02 m.;

The weight of the empty aircraft: (it was – 1457 kg), **it became - 1275 kg**. (Depending on the modification);

Payload: (it was - 698 kg), **it became - 980 kg**. (Depending on the modification);

Maximum take-off weight: (was – 2155 kg), **became - 2255 kg** (Depending on the modification);

Cruising speed: 348 km/h. (Depending on the modification);

Maximum flight speed: 378 km/h. (Depending on the modification);

Maximum flight range: (it was – 1611) km, **it became - 3132 km**. (Depending on the modification);

Maximum flight altitude: 7620 m.;

Type of aircraft engine: (it was – reciprocating engine**), it became - electric engine**;

Power plant: 2 × H2DT400W1 (Depending on modification);

Power: (it was - 2 × 220 hp), **it became - 543.8 hp**. (Depending on the modification).

Development program

Today, for aircraft, the system for the safe storage and movement of hydrogen has been solved and is ready for expansion.
In our opinion, this is the most difficult thing that had to be solved for the use of hydrogen in the aviation industry.

Our next step concerns the modernization of the fuel cell.
It is necessary to conduct a number of experiments to test the operability of the membrane at peak loads.
We already have experience in designing and manufacturing fuel cells with a capacity of up to 4 kW.
We plan to launch the production of a fuel cell with a capacity of up to 9 kW in 2024.

With respect,

Petro Pallanytsia
+38 (068) 977 01 80
palyanytsia@hdt.com.ua

www.hdt.com.ua
www.h2dt.com