# New Kind of Resistojet with Power System Based on Supercapacitors.

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***Abstract***

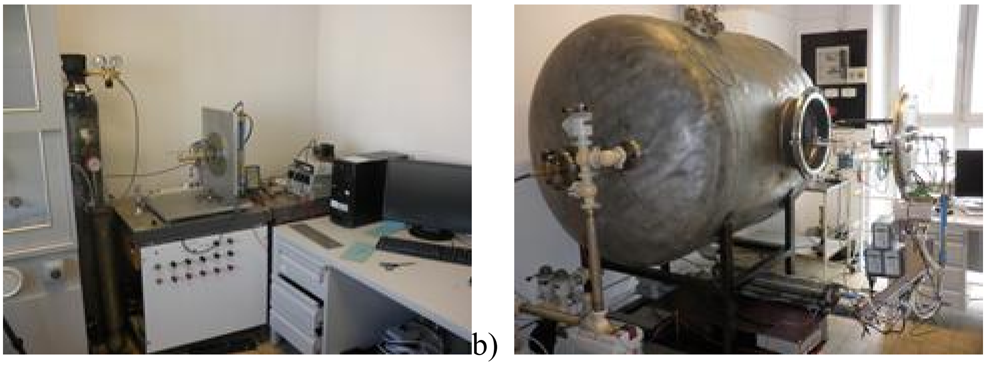
While the range of application of small and medium satellites still growing, appropriate propulsion systems should be developed as well. In many missions, mass and volume of propulsion system make up more than half of satellite probe, what makes mass reduction one of the most important issue during the system development. First solution to reduce the mass is using devices of high specific impulse and high density of storable propellants. Ion engines obtained very high specific impulse, but they produce very small thrust. High density of propellants is offered by chemical engines, but usually they are also very toxic substances.

Therefore, if mission needs a thrust in range of 0.1÷1N and high specific impulse at level of 200s, electro-thermal propulsion can be considered as an effective and cheap solution. This kind of propulsion is much safer and easy to handle, but high demand for electric power becomes a real problem, especially when pulses of large total impulse are necessary.

To overcome this problem, new kind of resistojet is proposed. The most characteristic feature of the resistojet is that it's not directly powered from satellite power system, but from its own, dedicated system based on supercapacitors.

This paper presents a research on model of resistojet which can be powered by supercapacitors in satellite propulsion. Basic performances of such system, calculated including preliminary study of mass and power budget, shows that this solution can be good for some range of space mission.

First phase of the project was building a research stand. Preliminary study was conducted in small vacuum chamber and for final research, more sophisticated stand was design and build.



a) b)

**Figure 1. Research stands: A – small research stand, B – large research stand.**

The main problem in the design of pulsed resistojet is compromise between the thermal capacity of the resistojet and heat transfer efficiency of the device. When the heater is used in pulsed mode it should have low mass and thermal capacity in order to reduce the energy necessary for heating up the devices. On the other hand the main technological limit in the resistojet thrusters is heat transfer due to laminar regime of the flow in the heater. The heat transfer area should be as large as possible. On the other hand the increase of the area is limited by the mass of the device. In order to find the optimal solution several design options have been considered. The first was use of oscillating element. Numerical study showed that this solution tremendously increased the heat transfer. However the experiments showed that the driving system could be too complicated. Another investigated option were porous heating elements. The numerical simulations showed that they ensure high heat transfer as well. Unfortunately the limiting factor here is the problem of introduction of power into the system. The other problem was difficult construction of a heater in laboratory conditions. Because of all that difficulties, idea has been dropped. Two concepts of heater based on porous element is shown on figure 2.

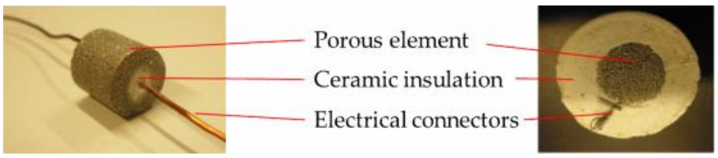



**Figure 2. Concepts of heater based on porous element.**

The other idea was based on capillary tubes directly heated by electric current. Few option of that design was checked. The main idea was a heater build by small capillary tubes connected with each other – in a row from electrical point of view, and in parallel from gas-flow point of view. To limit the heat loses, thruster with three-way gas recirculation was proposed. Final version of a heater and exemplary results are shown in figure 3 and 4.

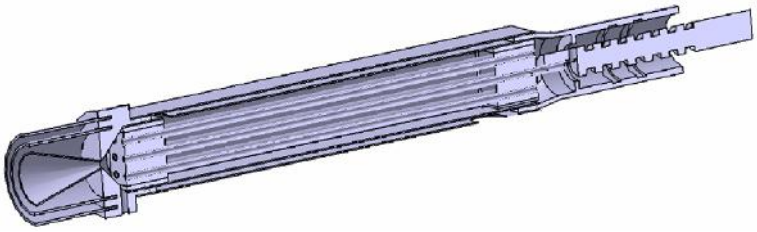


**Figure 3. Final conception of resistojet thruster.**

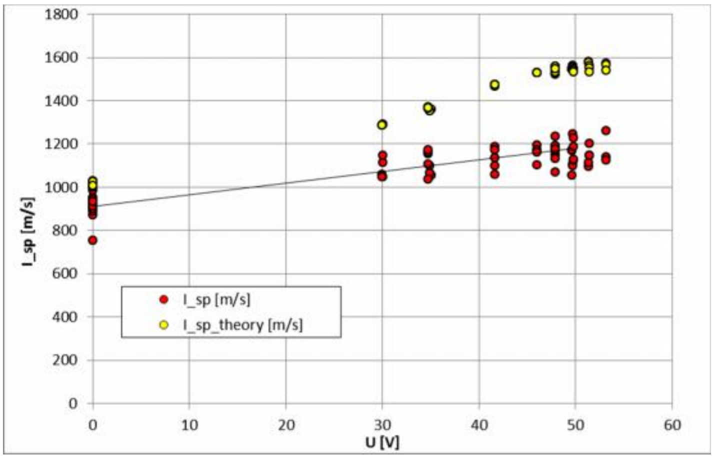



**Figure 4. Exemplary results of a research.**

This solution ensures simple design with reasonable heat transfer performances and potentially low mass of the resistojet. This solution has been chosen in the first phase of the feasibility study of the new type of a thruster. Final version of the resistojet is powered by power supply based on supercapacitors. 30 supercapacitors of 300 F each are connected to deliver 70 V of voltage, 10 F of total capacitance and maximum peak power on level of 5 kW.

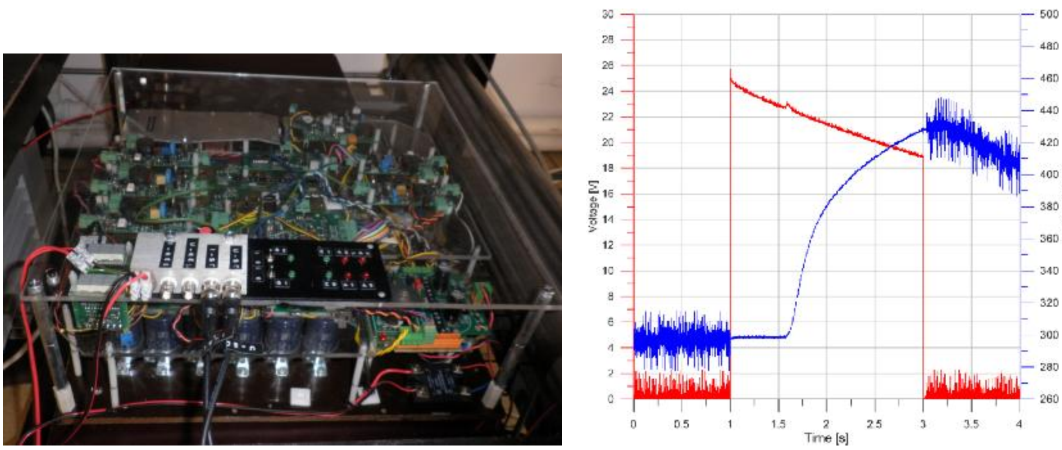



**Figure 5. Power supply and exemplary chart of voltage and gas temperaturę versus time.**

The presented research will be followed by conceptual and detailed design of the resistojet and its tests.