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Experimental Evaluation of a High Test Peroxide Catalyst Chamber for a Hybrid Rocket Engine

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Hybrid rocket propulsion technology gained in importance recently. A new innovative VENUS-HRE (VEGA New Upper Stage – Hybrid Rocket Engine) concept is developed at the German Aerospace Center (DLR) within the program "AHRES". This rocket engine is based on hydroxyl-terminated polybutadiene with metallic additives as solid fuel and high concentrated hydrogen peroxide (HTP) as liquid oxidiser. Instead of a conventional ignition system, a catalyst chamber with a silver mesh catalyst is designed, to decompose the HTP to steam and oxygen at very high temperature. The catalyst chamber is able to decompose up to 0.4 kg/s of 87,5% HTP. Used as a monopropellant thruster, this equals an average thrust of 700 N.

The chamber consists of the catalyst itself, a mount for the catalyst material, a retainer, an injector manifold, a cooling channel and a casing. Furthermore, a pressure sensor, a mass flow sensor and a thermocouple can be attached to measure the properties of the decomposition products. With the described catalyst chamber tests are carried out using 87.5%wt hydrogen peroxide and different amounts of catalyst material. The chamber is mounted on a test-bed, which comprises attachment, peroxide storage, feed system, valves, data acquisition and control. By determination of the decomposition temperature the integrity of decomposition is verified and compared to theoretical prediction. From the results parameters is derived and described kinetic low which determine catalytic decomposition of HTP within catalytic chamber.
The catalyst chamber is developed based on the results of the design tool SHAKIRA. Several calculations are carried out to determine the appropriate geometry for complete decomposition with a minimum of catalyst material. The experimental results show good agreement to the results generated by the design tool.

The developed catalyst chamber provides a simple, reliable ignition system for hybrid rocket propulsion systems based on hydrogen peroxide as oxidiser. The system is capable of igniting repeatedly without the need to meet an optimal ignition point. Such a system behaves like a hypergolic engine in terms of ignition, no hazardous substances are required.

The developed hardware and software can be used to design monopropellant thrusters based on HTP which are planned to be developed within DLR.

Figure 1: Test facility for hybrid rocket engines at DLR – Trauen, Germany

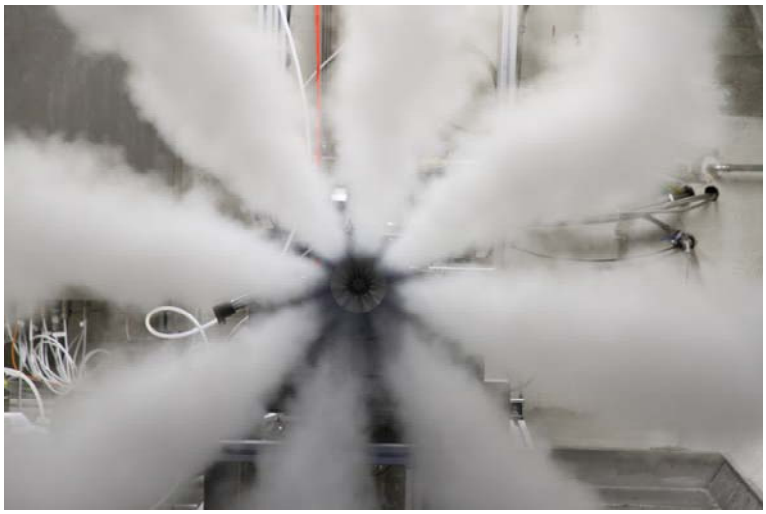

Figure 2: Test with HTP catalyst chamber carried on 17.12.2012

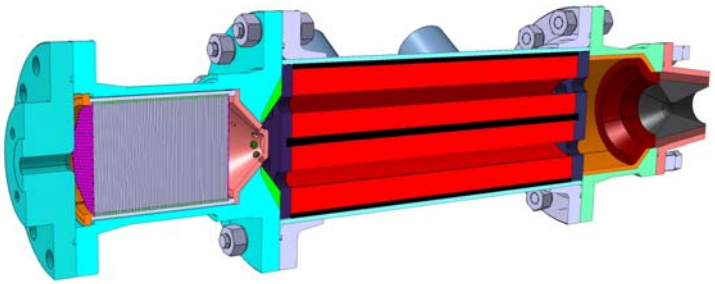

Figure 3: Cross-section of HTP supplied hybrid rocket engine demonstrator