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Title

Pt/Al_2O_3 catalyst for 98 w% hydrogen peroxide decomposition: influence of spherical catalyst diameter on performance and longevity.

Authors

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Abstract

In the current efforts to make space propulsion greener, High Test Hydrogen Peroxide (HTP) is investigated to replace hydrazine, both in monopropellant and bipropellant thrusters [1]. The ability of hydrogen peroxide to decompose into high temperature gaseous oxygen and water vapor mixture with a catalyst has already proven its efficiency in rocket propulsion [2,3]. However, the use of a catalyst providing balance between durability and high-performance decomposition is crucial to allow efficient thrust in monopropellant mode, and efficient ignition of a hydrocarbon combustion reaction in bipropellant mode.

The combustion facility ACSEL, designed to study the ignition and the combustion of storable propellants such as hydrocarbons or ethanol with hydrogen peroxide, has been improved with a catalytic chamber upstream of the main combustor. This addition enables to characterize HTP decomposition in terms of performance and to ease the ignition of fuel in bipropellant mode, as the hydrogen peroxide is preliminarily decomposed by catalyst beads. In the present study, the ACSEL catalytic chamber, equipped with a heating system, was used in monopropellant mode without fuel injection, and home-made γ- Al_2O_3 spheres impregnated with 5 % in weight of platinum were studied as catalysts.

The diameter of the supporting material sphere and its influence on the reactivity, the performance of decomposition and the longevity of the catalyst are investigated. The diameter of the spheres has in fact an impact on the performance of the decomposition: reducing the diameter of the catalyst beads can increase pressure loss within the chamber while improving the performance of decomposition by increasing the available surface of active phase. for the to-be decomposed hydrogen peroxide. To experimentally assess those change in performance and longevity and to optimize a compromise in the size of the spheres, two batches of home-made Pt/Al_2O_3 catalysts were prepared, one on 2 mm diameter spheres and the other on 1 mm diameter spheres. Both were tested on the ACSEL test bench set in monopropellant mode. Their performances in terms of temperature of decomposed gas and c^* were characterized, at different initial temperatures of the catalyst. The physical and chemical properties of tested catalysts were also analyzed and compared before and after tests, using nitrogen sorptiometry for measurement of specific surface area and transmission electron microscopy (TEM) for inspection of the catalytic active phase). Hydrogen chemisorption was also used to characterize the ageing of the catalysts to calculate the dispersion of the active phase, as well as inductively-coupled plasma-optical emission spectrometry (ICP-OES) to determine the active phase mass fraction.

Experiments showed that for the test series carried out, the 1 mm catalyst did not particularly cause an increase in the pressure loss downstream of the catalytic chamber, but the c^* performance was slightly improved compared to the 2 mm catalyst. It was also noticed that the smaller size catalyst enabled a better decomposition at a catalyst initial temperature closer to the ambient than the 2 mm catalyst.

References

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