Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #
Preferred Topics: PROPHY
Corresponding author: SCHOLL Julian
e-mail of corresponding author: julian.scholl@dlr.de
Type: Oral
Status of corresponding author: Student

Title

Activation Energy Determination of the Exothermic Decomposition Reaction of High-Test Peroxide in Inconel 718 Crucibles by Differential Scanning Calorimetry

Authors

Julian SCHOLL [1], Lukas Werling [2], Dominic Freudenmann [3], Stefan Schlechtriem [4]*

* *Corresponding author*
[1] *German Aerospace Center (DLR), Institute of Space Propulsion, Langer Grund, 74239 Hardthausen, Germany, julian.scholl@dlr.de*
[2] *German Aerospace Center (DLR), Institute of Space Propulsion, Langer Grund, 74239 Hardthausen, Germany, lukas.werling@dlr.de*
[3] *German Aerospace Center (DLR), Institute of Space Propulsion, Langer Grund, 74239 Hardthausen, Germany, dominic.freudenmann@dlr.de*
[4] *German Aerospace Center (DLR), Institute of Space Propulsion, Langer Grund, 74239 Hardthausen, Germany, stefan.schlechtriem@dlr.de*

Abstract

The use of "green propellants" in space propulsion will enable more environmentally friendly, safer and cost-reduced space transportation in the future. High-test peroxide (HTP) is discussed as such a green propellant due to reduced toxicity and lower vapor pressure compared to conventional storable liquid propellants such as hydrazine or dinitrogen tetroxide (NTO). The high specific heat capacity of HTP makes an application of it as a cooling fluid in regeneratively cooled space propulsion very interesting. The key challenge here is to control the thermally and catalytically affected exothermic decomposition of HTP inside the cooling channels. It is therefore fundamental to know the catalytic effect of the material used for the cooling channels on this exothermic decomposition of HTP.

Due to its high strength, corrosion resistance and good weldability, the nickel-based alloy Inconel 718 is a common material for combustion chambers and thus also for cooling channels of space propulsion. But currently, the catalytic effect of this material on the exothermic decomposition of HTP is largely unknown. Therefore, in this work, the activation energy of the exothermic decomposition reaction of HTP (97.2 wt%) was determined in passivated high-pressure crucibles made of Inconel 718 by differential scanning calorimetry (DSC). For this, the high-pressure crucibles and 7.0 µl of HTP inside were heated to a temperature of 250 °C in a differential scanning calorimeter (NETZSCH STA 449 F3 Jupiter) using five different heating rates (2, 4, 6, 8, 10 K/min). For each heating rate, five DSC measurements were carried out. Prior to these measurements, the differential scanning calorimeter was calibrated with four calibration substances (indium, tin, bismuth, lead) for each of these heating rates. Based on the "Kissinger method" [1,2] – one of the most popular approaches for determining kinetic parameters by thermal analysis – the DSC measurements were analyzed and an activation energy of 77.97 kJ/mol was determined for the exothermic decomposition reaction of HTP. This activation energy corresponds to literature values for HTP without a catalytic effect. It can therefore be assumed that passivated Inconel 718 has no significant catalytic impact on the exothermic decomposition of HTP.

References

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