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ATOMISATION AND COMBUSTION OF THE ONERA / CNES HIGH PERFORMANCE GREEN MONOPROPELLANT

Abstract

Hydrazine is a compound widely used in the attitude and orbit control system of spacecraft. However, while it has been known for over a century and used as a propellant since the Second World War, its hazardous nature cast an evergrowing shadow on its hegemony in satellite propulsion. Indeed, in 2011, the European Union regulation of Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) has designated hydrazine as a substance of very high concern therefore endangering its production, importation and use on the European soil. Consequently, in 2016, the CNES and the ONERA signed a research collaboration agreement to develop a green monopropellant that would replace hydrazine whilst showing low toxicity, high versatility and improved performances. Amongst the numerous monopropellants that were imagined in the early stages of this project, and after selection, only a single candidate remains, namely the CNES05.

As shown by the previous studies on spray ignition, it appears that the combustion of a CNES05 spray is unstable even in favorable temperature and pressure conditions. In this article, we therefore decide to explore further the ignition mechanisms of this green monopropellant by studying the impact of a single droplet of CNES05 on a hot surface. The aim of this ignition study is to identify the zones of reaction, measure the ignition delay and understand the process through which a monopropellant droplet passes that leads it to ignite. In order to attain these objectives, the impact and ignition is recorded by a high-speed camera that films either in the visible, UV or IR spectrum. This allows us to explore the flame, identify the species that populate it (OH*, CH*, etc.) and therefore reach an understanding of the reaction zone and reaction process. While the first tests are conducted in atmospheric conditions (presence of O2), we then promptly shift to a reactor where the atmosphere is neutral (nitrogen) and the pressure is controlled (from fractions of a bar to 10 bars). These parameters let us check whether the oxygen contained in the air plays a decisive role in the ignition and explore the effects of pressure on this phenomenon.

Lastly, we review the different elements learned from this ignition study and propose improvements upon which we will base our thruster prototype design.

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