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PYROLYSIS STABILITY OF DIFFERENT METHANE FUEL QUALITIES FOR REGENERATIVE COOLING ROCKET ENGINES USAGE

Abstract

Several organisations around the world are researching and developing rocket engines using liquid methane and oxygen as propellants. This propellant combination, sometimes called “methalox”, has gained interest over the last years due to its favourable specific gravity, storage temperature, and thermal stability, which allows for the design of efficient and compact launch vehicles. Methane can be obtained from various sources, including biogas and natural gas. However, this is linked to the additional cost and resources needed for the methane purification process. Therefore, the possibility of using a wider range of methane fuel qualities could allow for further cost reduction of space flights in the near and distant future. In this study, we tried to explore the possibility of using various natural gas and LNG qualities as potential rocket propellant with a specific focus on pyrolysis stability of those fuels. As part of the European effort to develop methane-based rocket engines, KTH’s division of Heat and Power Technology (HPT) and industrial partner GKN Aerospace formed the MERiT project. In this research project, we are investigating the characteristics of methane when used as a coolant in additively manufactured cooling channels for rocket nozzles. One of the main aspects under investigation is the thermo-catalytic decomposition of methane fuels in such channels. This pyrolysis process results in the deposition of solid carbon on the cooling channel walls, which act as a thermal insulator. This deposition therefore leads to higher wall temperatures and reduced engine lifetime. The pyrolysis of methane fuel depends, amongst others, on the flow properties, temperature, pressure and residence time, but also on the catalytic properties of the channel wall material and the composition of the fuel. Several representative gas mixture compositions corresponding to typical natural gas, LNG and biogas were studied for catalytic pyrolysis stability on MERiT Pyrolysis Setup (MPS) at various temperatures representative of the potential operating condition of the rocket engine. As the test sample representing the rocket engine cooling channel, we have used the widespread Inconel 600 and pure nickel for reference study. Pyrolysis intensity was evaluated by an array of real-time sensors for revealing time domain perspective of pyrolysis onset. Total pyrolysis product was compared by quantification of the carbon soot deposition on the sample surface after each experiment. The study resulted in a comparative analysis of pyrosis stability of various methane dominant fuels and could serve as a basis for further studies.