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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
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INVESTIGATION OF THE THERMO-MECHANICAL AND ABLATIVE BEHAVIOUR OF SILICON CARBIDE BASED CONCRETES EXPOSED TO HYBRID PROPULSION ENVIRONMENTS.

Abstract

This research is part of the PERSEUS project, a space program concerning hybrid propulsion and supported by CNES. The main goal of this study is to characterize silicon carbide based concretes in a hybrid propulsion environment. The nozzle throat has to resist to a highly oxidizing paraffin/LOX hybrid environment, under temperatures ranging up to 3000C. The study is divided in two main parts: the first one deals with the thermo-mechanical characterization of the materials up to 1400C and the second one with an investigation on the ablation behaviour under a standard or a highly oxidizing atmosphere, up to 3000C. The combustion time is of 15s. Four concrete grades are considered: the maximum aggregate sizes is of 3mm, 2mm, 1.6mm and of 0.8mm for a micro-concrete. Young's modulus was determined by a resonant frequency method and four-point bending creep tests were conducted up to 1200C. First results show an increase of the Young's modulus with the stabilisation temperature and a higher value for the concrete with a 3mm aggregate size, compared to the micro-concrete. Creep begins close to the stabilisation temperature. Modelling will be used to choose the better stabilisation temperature and to describe the thermo-mechanical behaviour. High-temperature ablation tests were made at PROMES-CNRS laboratory, on a 2kW solar furnace, with a concentration factor of 12,000. A 7 to 15 MW/m2 incident solar flux and a 7 to 90 seconds exposure time have been chosen. Optical microscopy, ESEM, EDS and 2D/3D roughness analyses were used to determinate the microstructure evolutions and the degradation kinetics. During tests, silicon carbide undergoes active oxidation, with production of SiO/CO smokes and ablation. A linear relation between mass loss and time is found, accordingly to the Wagner theory (Wagner, 1958), extended to SiC by Hinze and Graham (Hinze Graham, 1976). Tests at a 15 MW/m2 solar flux value have shown a mass loss of 20 mg/cm2 after 15 seconds for the micro-concrete and for the 3mm aggregate size one. After 90 seconds, mass loss attains 80 mg/cm2 for the micro-concrete and 50 mg/cm2 for 3mm aggregate size concrete. Micro-concrete is more interesting for the realisation of the nozzle, thanks to its workability. But its thermo-mechanical properties are less favourable than the 3mm aggregate size concrete. After 15 seconds, both concretes undergo the same ablation. Our goal is to improve thermo-mechanical properties and to study micro-concrete under hybrid propulsion environment and to develop a phenomenological model.