In Space Propulsion 1

Sprawozdania

Informacje na temat projektu

ISP-1

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Strona internetowa projektu

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Periodic Report Summary 2 - ISP-1 (In Space Propulsion 1)

Project context and objectives:

The main objective of the project is to improve the knowledge and techniques necessary for future space missions cryogenic propulsion, with emphasis on low thrust cryogenic propulsion (LTCP), with liquid oxygen (LOX) and hydrogen or liquid methane as propellants.

Achieving this goal requires to:

- improve knowledge on LOX / methane combustion through research on injection, ignition, combustion, soot formation and engine cooling;
- improve the embrittlement characterisation of different materials in presence of hydrogen by designing

and operating a fatigue testing set up for characterisation of materials performance in high-cycle fatigue regime, under different environments and for positive strain ratios, as well as by theoretical analysis and modelling of embrittlement behaviour;
- investigate the tribological behaviour of materials in oxygen for demanding thermodynamic cycles and develop an oxidation model. Design a tribometer for methane conditions;
- improve the knowledge of the performance and constraints for the design of LTCP with heat accumulators: modelling of phase change accumulators and thermal cyclic testing of a water / ice heat accumulator;
- design and test a high speed - lightweight cryogenic propellant electric pump, demonstrate the feasibility of a high performance small centrifugal pump.

Project results:

During the second year, the technical progress is summarised as follows:

1. On LOX / methane combustion, the second period of the project was devoted to acquiring and consolidating data from experimental work, as well as to building models, in order to validate these models by computational fluid dynamics (CFD) computation during the present period and the remaining period.

A soot model was derived from Worley's one, but the activity showed the necessity to develop a dedicated model for combustion in pure oxygen. The low pressure kinetics was also derived involving 24 species and 103 reactions.

Concerning the experimental work, the coherent anti-Stokes Raman spectroscopy (CARS) campaign was achieved and ignition campaigns at ambient pressure and low pressure as well. They gave very well defined conditions which are very important for CFD computation.

Concerning CFD computation, RANS (Reynolds-averaged Navier-Stokes) computations were carried out at nominal working point for comparison with CARS database. The flame length and final combustion temperature were obtained with reasonable agreement but some discrepancies arose between results and CARS measurements in the flame. Nevertheless, these computations show several ways to enhance our methodology for CH4 oxycombustion modelling and computations.

Preliminary CFD computations were also carried out for ambient pressure ignition with Large eddy simulation (LES) model.

2. For Hydrogen embrittlement research, modelling and experimental study, the materials for the test campaign in the last year of the project have been selected and test conditions have been defined. In total three materials will be tested with regard to hydrogen embrittlement in the HCF regime: Inconel 718 and A 286 which are of immediate interest for the industrial partners and Inconel X750 which is relevant for the more fundamental studies on the material law. The experimental setup definition was achieved.

3. For compatibility and tribology in LOX and methane in cryogenic environment

Experimental work was performed along two approaches: Scientific research on the tribological behaviour of materials in LOX, for which tests in different environments were performed in order to better understand the contribution of the different potential mechanisms to the observed behaviour. A more applied approach was used in order to assess the different materials to be used for the propellant electric pump, in terms of compatibility and wear. The study of a tribometer for tests in liquid methane was achieved.

4. For heat accumulators study and modelling

The numerical model for computing the behaviour of two phase flow phenomena in the heat accumulators was improved. The last version is based on a two-fluid model inside tubes and three-dimensional (3D) laminar and turbulent resolution (with LES models) of the heat transfer by convection in phase-change material with unstructured meshes. The experimental setup especially designed for the validation of the numerical models was designed and built, with very complete and high accuracy instrumentation.

5. For propellant electric pump design and test

The complete definition file of the electric pump was presented at the detailed design review, and the manufacturing is on-going, as well as the test bench preparation.

Potential impact:

For the third and last period of the project, the same approach applies to the whole project: Perform or finish the tests, and use the experimental results in order to validate the theoretical or numerical study performed previously or in parallel.

Project website: http://www.isp1-fp7.eu

Powiązane dokumenty

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