IAF SPACE PROPULSION SYMPOSIUM (C4)
Joint Session on Nuclear Power and Propulsion Systems, and Propellantless Propulsion (10-C3.5)

Author: Dr. Alessandra Barco
University of Leicester, United Kingdom

Dr. Richard Ambrosi
University of Leicester, United Kingdom
Mr. Pierre Coquay
ESA - European Space Agency, The Netherlands
Mr. Christophe Fongarland
ESA - European Space Agency, The Netherlands
Mr. David Le Falc'her
European Space Agency (ESA/ESRIN), Italy

IMPACT MODELLING FOR THE ESA RADIOISOTOPE POWER SYSTEMS

Abstract

Since 2009, the European Space Agency (ESA) has been conducting activities to develop a European capability for the independent design, production and management of radioisotope power systems (RPS) for space applications. The program is focused on the use of americium-241 as an innovative alternative to the plutonium-238 fuel currently used by USA, Russia and China. The University of Leicester is leading the development of a 10 Wel radioisotope thermoelectric generator (RTG) and a 3 Wth radioisotope heater unit (RHU). The 241Am-based RHU is currently baselined for the Exomars Rosalind Franklin mission, to be launched in 2028. An important aspect of the ESA activities is safety, and this involves ensuring that the design of these systems, in particular of the heat source (i.e., fuel and containment layers), meets a set of stringent requirements, in order to minimize an inadvertent release of radioactive material into the environment in the event of an accident. Safety tests, such as impacts on non-deformable surfaces or with fragments, are still an essential part for the qualification of the RPS heat sources, in order to study and verify their ability to survive accident scenarios. However, software modelling is also indispensable for the design process, since it allows studying a wide range of scenarios with different boundary conditions and assumptions, without relying solely on expensive experimental activities. The software used for the impact simulations performed by the University of Leicester is the hydrocode LS-Dyna®. The first impact models for the 241Am-based heat sources were created as part of a wider collaboration between the University of Leicester and ArianeGroup (May 2018 – October 2020), supported by ESA. Since then, two different, and yet complementary, approaches have been identified to model the behaviour of the clad (the inner containment for the fuel) during and after a high-speed impact, when the material reaches the non-linear plastic region: the hydrodynamic model and the Johnson-Cook model. The next step is the implementation of more realistic models for the nuclear fuel in ceramic form; collaboration with fuel experts would be highly beneficial to improve the fuel modelling. Future software simulations will also include the outer containment layers (aeroshell and insulation); appropriate models for the carbon-based materials will be chosen in accordance to the material supplier's inputs and suggestions. Impact tests that are currently being planned as part of the ESA program will inform the LS-Dyna® models.