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Molten Salt Reactors for Nuclear Electric Propulsion

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Abstract. Molten Salts Reactors (MSRs) have key aspects that made them an interesting reactor concept for Nuclear Electric Propulsion (NEP). In particular, the use of a liquid fuel allows for a greater design flexibility thus opening the possibility for designing a relatively simple reactor concept. In addition, high power core densities with relatively low fuel temperature gradients are possible in MSRs. Moreover, a nuclear fuel based on a molten salt can operate at high temperatures with relatively low pressure and little fuel thermo-mechanics issues. Liquid fuel also provides significant neutronics feedbacks that can be used to decrease the requirements on the reactor control systems. A MSR can be designed to have thermal, epithermal or fast neutron spectrums. Finally, it is interesting to note that some of the technological challenges found in MSRs designs for terrestrial applications are less an issue for space applications. CNRS is currently carrying-out preliminary design studies for a Nuclear Electric Propulsion (NEP) engine based on a Molten Salt Reactor concept. These studies take advantage of the CNRS knowledge gained over years on numerical modeling and experiments for the MSRs. In the first stage of the project (two years), the main goal is to define two potential MSR concepts for NEP, one with a relative low power output (10-50 kWe) and the other design for a high power application (more than 100 kWe). The first stage should also contribute to identify the key technology bottlenecks. During the second stage (four years starting by the end of 2019), these two concepts will be investigated in high detail with the help of the advance multi-physics model developed for MSRs. This numerical model allows performing detailed neutronics, thermal-hydraulics and thermomechanics coupled calculations. Simple experiments to validate critical design aspects are also expected to be carried-out in the laboratory molten salts experimental platform. The main outcomes of the second stage are the completion of the key reactor components design and the definition of a set of experiments that would be required to accomplish the "proof-of-concept" thus enabling to move the technology beyond TRL 3.

Keywords: nuclear electric propulsion, molten salt reactor, conceptual design.