Abstract: A feasibility study has been performed on a natural circulation cooled small nuclear reactor with a molten salt or tin as a coolant. This reactor is called the U-Battery. The study included neutronics calculations to obtain the minimum dimensions required for a critical system during burnup, the calculation of coolant temperature and core temperature reactivity coefficients, and an investigation of the thermal hydraulics to assess the possibilities for natural circulation cooling. For every coolant, core designs are feasible within the dimensions imposed and with natural circulation of the coolant.

1 Introduction

To be economically competitive, industrial energy consumers are in need of affordable power generation with a stable price setting. Since a significant part of the energy price is caused by the usage of the electricity grid, on-site power generation is an economically attractive option. Because of the stable price of nuclear energy, there is a large potential for small nuclear reactors placed on-site.

The U-Battery is a very small inherently safe, self regulating nuclear reactor (20MWth) for electricity generation or process heat applications. It can be operated for fuel cycles of 5-10 years without refuelling and is proliferation resistant. Natural circulation is the preferred cooling mechanism. Auxiliary safety or decay heat removal systems should be minimised. To be competitive with conventional on-site power generators, it should also be operated without intensive monitoring and with no on-site maintenance.

To minimise the impact on the surroundings, the U-Battery must be removable after shutdown. The primary circuit is incorporated into a transportable 'sealed' container. The size of the core is constrained by the fact that the core and primary heat exchanger must be incorporated into this container. The maximum height, width and length of the primary system should remain within 3.5 m, 3.5 m and 20 m, respectively, to make road transport possible.

This article presents the results of a parameter study that was performed to assess the feasibility of the U-Battery. Its dimension restrictions and fuel requirements were analysed for different fuel cycle lengths and coolant candidates, with natural circulation of the coolant as primary choice.

2 Neutronic Feasibility

The U-Battery is graphite moderated and uses TRISO coated UO₂ fuel particles with enrichment up to 20%. TRISO particles retain the fission products up to a fuel temperature of 1600°C for limited periods of time. To reduce neutron leakage, the dimensions of the reactor core without reflector where