MSFR (CNRS, France)

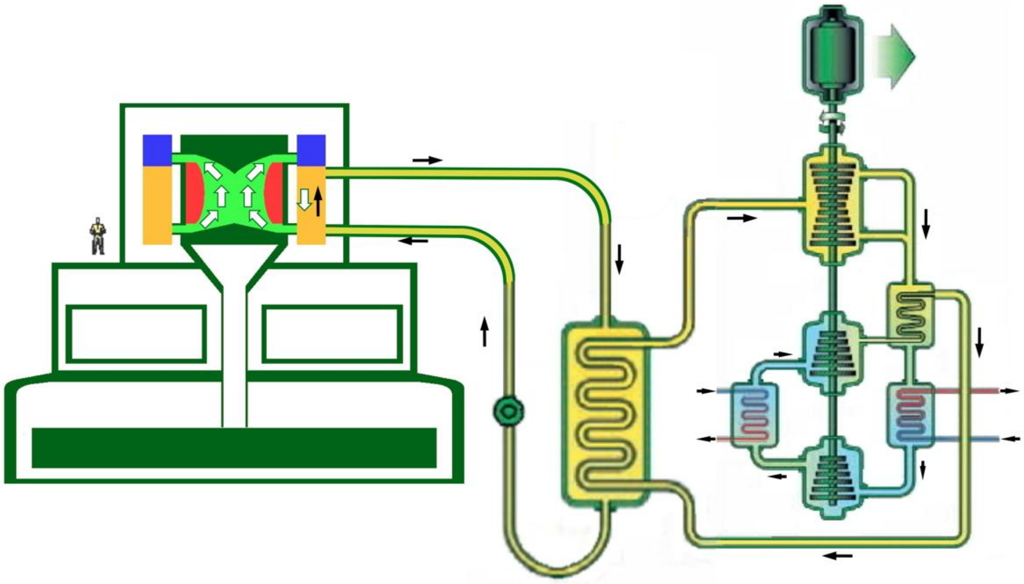

FIG. 30. Depiction of the MSFR system

Full name:	*Molten Salt Fast Reactors (MSFR)*
Designer:	*CNRS (France)*
Reactor type:	*Molten salt reactor*
Electrical capacity:	*1,500 MWe*
Thermal capacity:	*3,000 MWth*
Coolant	LiF-(U,Pu)F_3-ThF_4 (lithium and actinide fluorides)
Primary Circulation	Forced
System Pressure:	*< 10 bar*
System Temperature:	*≅750 °C*
Fuel Material:	*Actinide fluorides containing Th and ^{233}U, ^{235}U and/or Pu*
Fuel Cycle:	*Continuous refueling*
No. of safety trains:	*No defined yet*
Emergency safety systems:	*Hybrid*
Residual heat removal systems:	*Hybrid*
Design Life:	*>60 Years*
Design status:	*Concept*
Planned deployment/1st date of completion:	*After 2050*
New/Distinguishing Features:	*Fast spectrum molten salt reactor with Thorium fuel cycle. The MSFR combines the generic assets of fast neutron reactors (extended resource utilization, waste minimization) with those associated to a liquid-fuelled reactor (online fueling and reprocessing, uniform fuel irradiation, passive salt draining system).*

Introduction

Since 2004, the National Centre for Scientific Research (CNRS, France) has focused R&D efforts on the development of a new MSR concept called the Molten Salt Fast Reactor (MSFR) currently supported by the Euratom's EVOL project. As opposed to thermal molten salt reactors, the MSFR does not employ any solid moderator (no graphite lifespan issues) which results in a fast-spectrum breeder reactor with a large negative power coefficient that can be operated in a Thorium fuel cycle. Other advantages of a MSR include homogeneous fuel irradiation and the possibility of fuel reload and processing on-line or in batch mode, without requiring reactor shut-down and involving the transfer of small volumes of fuel. GIF forum selected the MSFR concept in 2008 as one of the GEN IV reference reactors.

Description of the Nuclear System

The reference MSFR is a 3,000 MWth reactor with a total fuel salt volume in primary circuit of 18 m^3, operated at a max fuel salt temperature of 750°C. The reactor has three different circuits: the fuel circuit, the intermediate circuit and the power conversion system. The main components of the fuel circuit are the fuel salt which serves as fuel and coolant, the core cavity, the inlet and outlet pipes, the gas injection system, the salt-bubble separators, the fuel heat exchangers and the pumps. The fuel salt is a molten binary fluoride salt with 77.5% of lithium fluoride; the other 22.5% are a mix of heavy nuclei fluorides. As shown in the figure below, the fuel salt flows from bottom to the top of the core cavity. After exiting the core, the fuel salt is fed into 16 groups of pumps and heat exchangers located around the core. Three main components of the core are: the upper and lower axial neutron reflectors and the radial fertile blankets (red in the figure). The reactor blanket (whose purpose is to increase the breeding ratio) is filled with a fertile salt of LiF-ThF4 with an initial composition of 22.5% mole $^{232}ThF_4$. Thanks to the MSFR fast spectrum, the fuel reprocessing unit only extracts a small amount of the fuel salt (order of a few litres per day) for fission product removal and then returned the cleaned fuel salt to the reactor.

Description of the Safety Concept

The MSFR fuel circuit includes a passive salt draining system (by gravity) which can be used for a planned reactor shut down or in case of incidents/accidents leading to an excessive increase of the temperature in the core. Thanks to the online fuelling and reprocessing, the MSFR has a low core reactivity inventory. Moreover, control rods or neutron poisons are not necessary due to the large negative feedback coefficients which allow a reactivity control based on the balance between the power generated in the fuel salt and the power extracted in the heat exchangers. Lastly, adequate reactivity margin during cold shutdown is obtained in the MSFR by draining the fuel salt into the dedicated tanks where the fuel can be passively cooled without returning to criticality (thanks to the tanks volume and geometry). The absence of absorbent rods simplifies the reactor operation and eliminates some accident initiators (e.g. a control rod ejection).

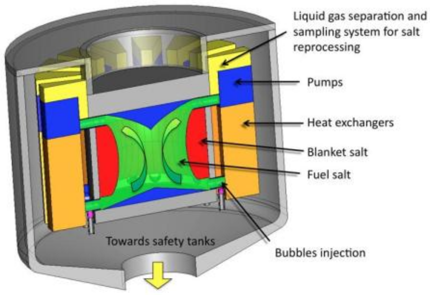

FIG. 31. Schematic MSFR design showing the fluoride-based fuel salt (green) and the fertile blanket salt (red).

Deployment Status and Planned Schedule

The analysis of possible French energetic scenarios show that the deployment of the MSFR after 2050 would allow efficient close of the current fuel cycle (reduce the stockpiles of produced transuranic elements).