Novelty of the LFR-AS-200 project

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Abstract.

The CYCLAD project proposed by CERN is a novelty-ADS because it couples a Single-Stage High Power Cyclotron with a sub-critical system based on the innovative lead-cooled LFR-AS-200.

LFR-AS-200 is under development by Hydromine in cooperation with ENEA. LFR stands for Lead-cooled Fast Reactor, AS stands for Amphora-Shaped, referring to the shape of the inner vessel and 200 is the electrical power in MW. The project has been carried out by a team of engineers, who had participated in the construction of SPX1.

The LFR-AS-200 exploits the peculiar, safety-relevant properties of lead, and has been conceived to enhance safety while dispensing of hitherto critical components typical of the pool-type fast reactors. In addition namely to the absence of intermediate circuits, a feature common to any other LFR project, LFR-AS-200 dispenses of (i) the in-vessel refueling machine, (ii) the above-core structure, (iii) the diagrid, (iv) the strongback, (v) the shielding elements, (vi) in-lead bearings of the pumps, (vii) flywheels to increase the mechanical inertia of the lead pumping system, (viii) the "LIPOSO" or equivalent tubular hydraulic connection between the pumps and the core and (ix) the "Deversoir" or equivalent system aimed at keeping the reactor vessel at the temperature of the cold collector.

The result is a specific volume of the primary system of less than 1 m^3/MWe, i.e. about 4 times less than that of the SPX1 Sodium-cooled Fast Reactor, and also several times less than of other international LFR projects, a key-factor for cost reduction. The simplification of the primary system and the suppression of critical components reduces the required in-service inspection effort and increases the plant's mechanical robustness and availability.

These achievements are the result of the use of innovative components and of a primary system layout differing from current technology.

The steam generator features a short-height, spiral-tube bundle partially raised up to the reactor roof. It is fed from the bottom with outlet port at the lead free level of the cold collector in order to drastically reduce the reactor vessel height and the mass of displaced lead in the design case of steam generator tube rupture.

The primary pumps, with a short shaft full of lead, are installed in the hot collector in the space available inside the steam generator. The fuel assemblies are anchored at the top in gas space by means of a long stem which supports the core instrumentation and is equipped with mechanical expansors to open up the core like a flower and passively shut down the reactor, when the temperature of lead at core outlet exceeds the nominal value.

The removal of the decay heat is also ensured by passive systems in order to guarantee safety even in case of failure of protection logics, failure of operator intervention or cyber-attack.