ENERGETICS

MUR DM 117/Newcleo - Development of a subchannel code for full-core thermal-hydraulic analysis of lead-cooled fast reactors

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Context of the research activity	Code development in support of core design Progetto finanziato nell'ambito del PNRR - DM 117/2023 - CUP E14D23001950004
Objectives	The design of Lead-cooled Fast Reactors (LFRs) currently under development at newcleo is a multidisciplinary task, dealing with many deeply interconnected physical and engineering parameters, thus resulting in a multiphysics coupled problem. This coupled problem can be logically subdivided into separate physical problems, with Thermo-Mechanics (TM), Thermal-Hydraulics (TH) and NEutronics (NE) as the three most relevant physics involved. Each physical problem is supported by purposely developed Design-Oriented Codes (DOCs) where a compromise between runtime performance and physical and numerical accuracy is necessary for routine engineering applications. In particular, the engineers require the most accurate results from the fastest core calculations possible to assess reactor design and safety, and this becomes possible only developing specialized models with a clearly delimited application domain. The TH design is initially conducted at the fuel element level by means of DOCs based on the Sub-Channel (SC) method, such as ANTEO+ for undeformed bundles and EFIALTE for deformed bundles (the latter is currently under development within the H2020 PASCAL project). Moving to the full core analysis, a first approximation can be obtained by running different standalone ANTEO+ calculations for the assemblies composing the core. A more accurate calculation should account for the inter-SA heat transfer by self-consistently solving the TH problem within each SA and within the InterWrapper (IW) region. A literature review pointed out that available codes for the full core TH

	analysis of LFRs are either too complex to be useful in the design phase (COBRA-WC and NETFLOW) or too simplified (SE2-ANL). This motivates the development of a new DOC solving the whole-core TH problem. A first step towards the development of a full core SC code was represented by TIFONE, a code for the IW flow and heat transfer, which has been recently developed and preliminary validated at ENEA Bologna within a contract with Politecnico di Torino. The proposed work consists in the design, development and preliminary validation of a TH code based on the SC method for the full core analysis of an LFR. The code design shall comply with specific requirements to be set at the beginning of the activity, and follow rigorous software quality assurance guidelines. The design shall be thoroughly described in a Software Design and Implementation Document (SDID) describing the governing equations, solution methods, data flow diagrams and pseudocode. The code development shall be carried out using the most recent Fortran 2018 standard, and take advantage of modern programming practices, aiming at maximizing the code execution speed and overall performance.

Skills and competencies for the development of the activity	Fundamentals in Numerical Analysis, Computational Fluid Dynamics and Thermal-hydraulics. Computer skills (already present or willing to learn): LATEX, Fortran, Python.