OperaHPC: OPEn HPC theRmomechanical tools for the development of eAtf fuels: status at mid-project

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The licensing of advanced fuel materials and designs for Gen-II/III reactors requires an extension of the qualification of industrial fuel performance codes to meet the requirements of nuclear safety authorities with the verification, validation, and uncertainties quantification process. To address these requirements, the OperaHPC project works on advanced simulation tools enabling 3D representation of fuel rods. More specifically, the project aims at contributing to the fuel performance code qualification using advanced simulation tools with physically based modelling and high-performance computing capabilities. The project activities range from fundamental research, with experimental characterization of fuel creep behaviour coupled with small-scale simulations, to representative engineering fuel safety studies, using improved industrial fuel performance codes and high-performance computing (HPC) 3D simulations. The latter is also improved in the OperaHPC project with the development of open-source codes, such as OFFBEAT at the fuel rod scale and MMM at the fuel microstructure scale. Moreover, machine learning techniques are developed to enhance the transfer between 3D simulations and industrial models. One strength of the approach is to capitalize all the developments and results obtained in the project in open source codes available for the partners and beyond for fuel performance codes and material communities.
In the first two years of this project, a creep test device for installation in hot cells was designed and transmission electron microscopy was used to characterize the microstructure of an irradiated fuel at the nanoscale. In parallel, atomic scale simulations and physics-based fuel mechanical modelling were initiated to study dislocation mobility. State-of-the-art fuel and cladding mechanical laws were employed in preparation of the advanced mechanical modelling. HPC fuel performance codes are being developed with their verification and validation study cases. The application of the advanced models on industrial issues was initiated through exchanges on machine-learning methods, as well as the computation of input data for fuel safety analysis.
At mid-project, 8 public deliverables and 32 publications were produced, and beta versions of the OFFBEAT and MMM codes are available on open source repositories. Finally, the education and training activities include an exchange programme for young students, the organization of training events and the development of online training focused on the needs of the fuel research community.

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