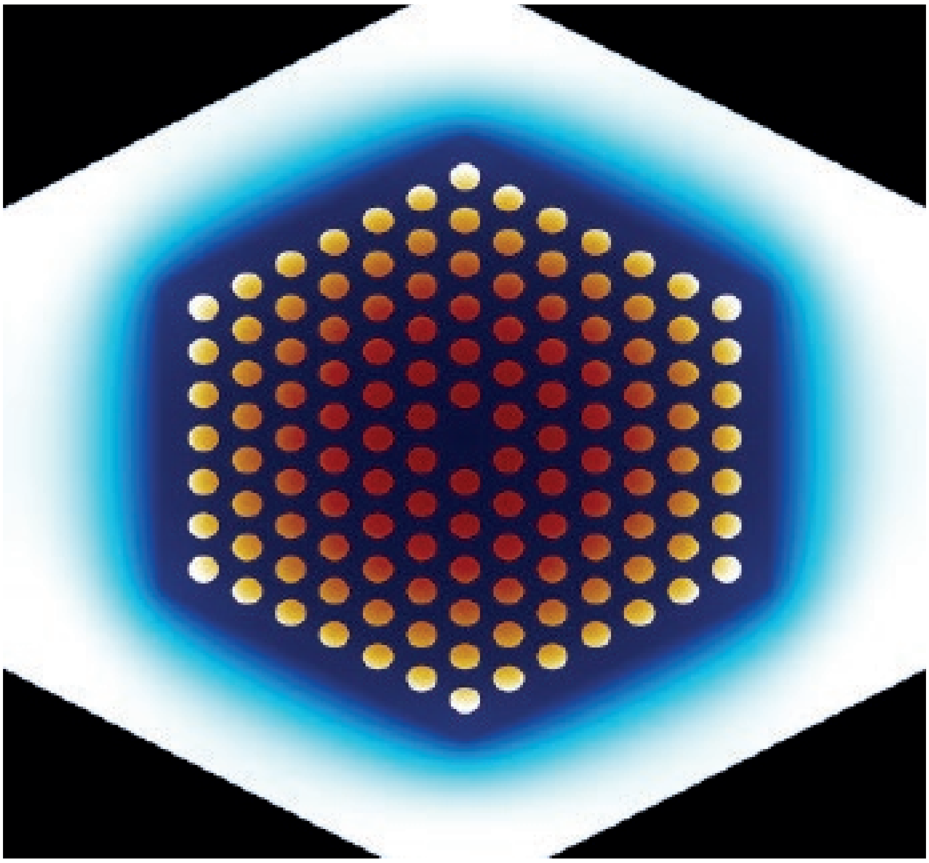
Newsletter #2

OCTOBER 2017

ESSANUF

European Supply of SAfe NUclear Fuel



Graphics from the Serpent criticality safety calculation showing relative fission power (red-yellow colors) and thermal neutron flux (blue colors) in a VVER-440 fuel assembly.

The vision of the ESSANUF project is to create greater security of energy supply and contribute to the security of supply of nuclear fuel for Russian-designed pressurized water reactors operating in the EU and Ukraine by diversification of fuel sources and in full compliance with nuclear safety standards.

VVER-440 Fuel Methods and Methodologies

A key element of the ESSANUF program has been to establish the methods and methodologies to be applied for VVER-440 fuel design and core analyses. The effort has included the selection of the best suited codes and implementation of required adaptions. Couplings between the codes have been created to enable data transfer between the programs, and an extensive validation of the codes has been carried out. A brief description of the software and scope in each area is provided below.

Nuclear design
The code package APA-H (ALPHA-H, PHOENIX-H and ANC-H) is already successfully used for core design work for VVER-1000 type plants. In the ESSANUF project, APA-H has been validated for VVER-440. APA-H calculated parameters were compared to registered data during plant operation from Loviisa unit 1 cycle 25-32. The overall result and conclusion is that the codes can be used also for VVER-440; however, further development of the methods would improve the accuracy.

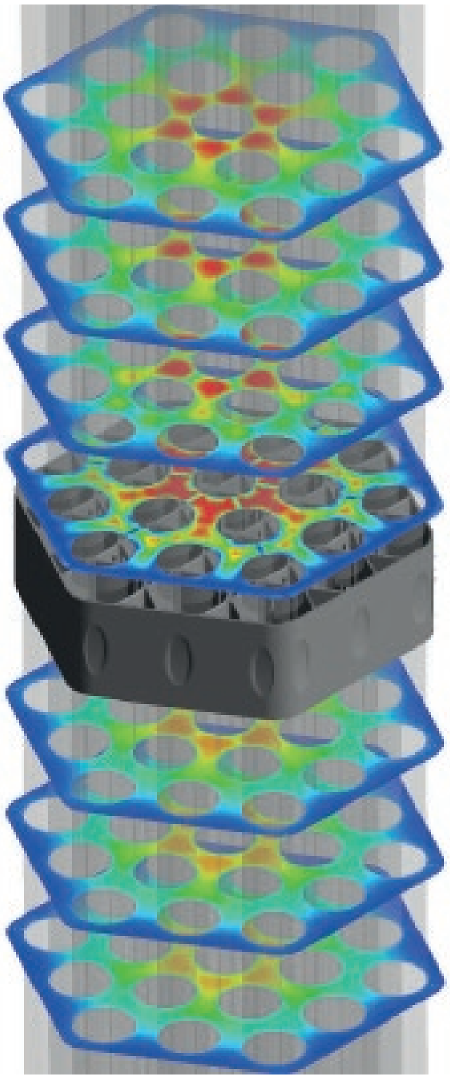
Fuel rod design
As part of the ESSANUF effort, models to support best-estimate and conservative safety analyses have been incorporated into the fuel performance code TRANSURANUS. The implemented models cover the thermo-mechanical behavior, the corrosion and the hydrogen uptake of cladding, as well as the fission gas release and swelling of UO2 fuel. The simulation of the high-temperature cladding oxidation and the computation of the equivalent cladding oxidation were revised.

Additionally, a ready-to-use methodology has been developed with consideration taken for country-specific requirements for fuel-rod design in Finland, Slovakia, Czech Republic, Hungary and Ukraine.

Fault analysis
Tools and a methodology for the assessment of fuel failures under design-basis accident conditions have been developed. To improve the tool box, the following codes have been coupled: TRANSURANUS-DYN3D, DYN3D-ATHLET, TRANSURANUS-ATHLET, TRANSURANUS-RELAP, TRANSURANUS-SERPENT and TRANSURANUS-APROS (outside the project). In addition, ready-to-use methodologies for LOCA and RIA have been developed, with consideration of country-specific requirements in Finland, Slovakia, Czech Republic, Hungary and Ukraine.

Thermal hydraulics
Development of Computational Fluid Dynamics (CFD) models of the previous and the new fuel assembly design, as well as a previously tested bundle, have been made for 1-phase/2-phase simulation to predict the assembly pressure loss and critical heat flux behavior. An appropriate critical heat flux correlation and pressure loss coefficient correlations have been determined for the new assembly design based on CFD results. Additionally, an integrated methodology has been achieved for the thermal-hydraulics calculations required for VVER-440 fuel licensing in each of the target countries.

Nuclear criticality safety analyses
Nuclear criticality safety analysis, including code validation and sensitivity studies, has been performed for the new fuel assembly design for storage and transport operations. Additionally, a nuclear criticality safety methodology has been defined for the European Union (EU) and Ukraine based on International Atomic Energy Agency (IAEA) guidelines and regulations, taking into account national requirements and deviations.



CFD-analysis showing the distribution of steam in cross sections around the upper spacer of a test assembly.

Workshop in Finland
In June 2017, Lappeenranta University of Technology hosted a workshop to discuss the methods and methodologies developed within the ESSANUF program. Consortium members and representatives from VVER-440 operators, including Fortum, MVM Paks NPP, Slovenské Elektrárne, Energoatom and EZ, and representatives from regulatory bodies from Finland, Hungary, Czech Republic and Armenia participated. The workshop was successfully performed with active participation from all 35 participants providing very valuable input to the continued development of methods and methodologies.

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 671546

Additional Information
This is the second newsletter to keep you updated on the status and progress of the ESSANUF project. Additional information is available on our website, please visit: www.essanuf.eu