UNIVERSITY OF CHEMISTRY AND TECHNOLOGY PRAGUE

Spent fuel characterization with the emphasis on Russian type of reactors

(Project theses)

J. Miksova, L. Nachmilner, J. Macak (CR), B. Dalis (Lithuania), V. Krasnorutskii, A. Nosovskii , G. Lysychenko, S. Sayenko, T. Dudar (Ukraine)

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Areas of interest

1. SNF composition

2. Cladding degradation

SNF generation

Czech Republic	Duration of operation (y)	End of operation (y)	No of assemblies
NPP Dukovany (4x 440 WWER)	50	2035	17494
NPP Temelín (2x 1000 WWER)	50	2052	4174
New NPP‘s (2 units >1000 MWe)	60	2095	min. 3770 max. 5328
Total (some 7 500 t)			**min. 25438** **max. 26996**

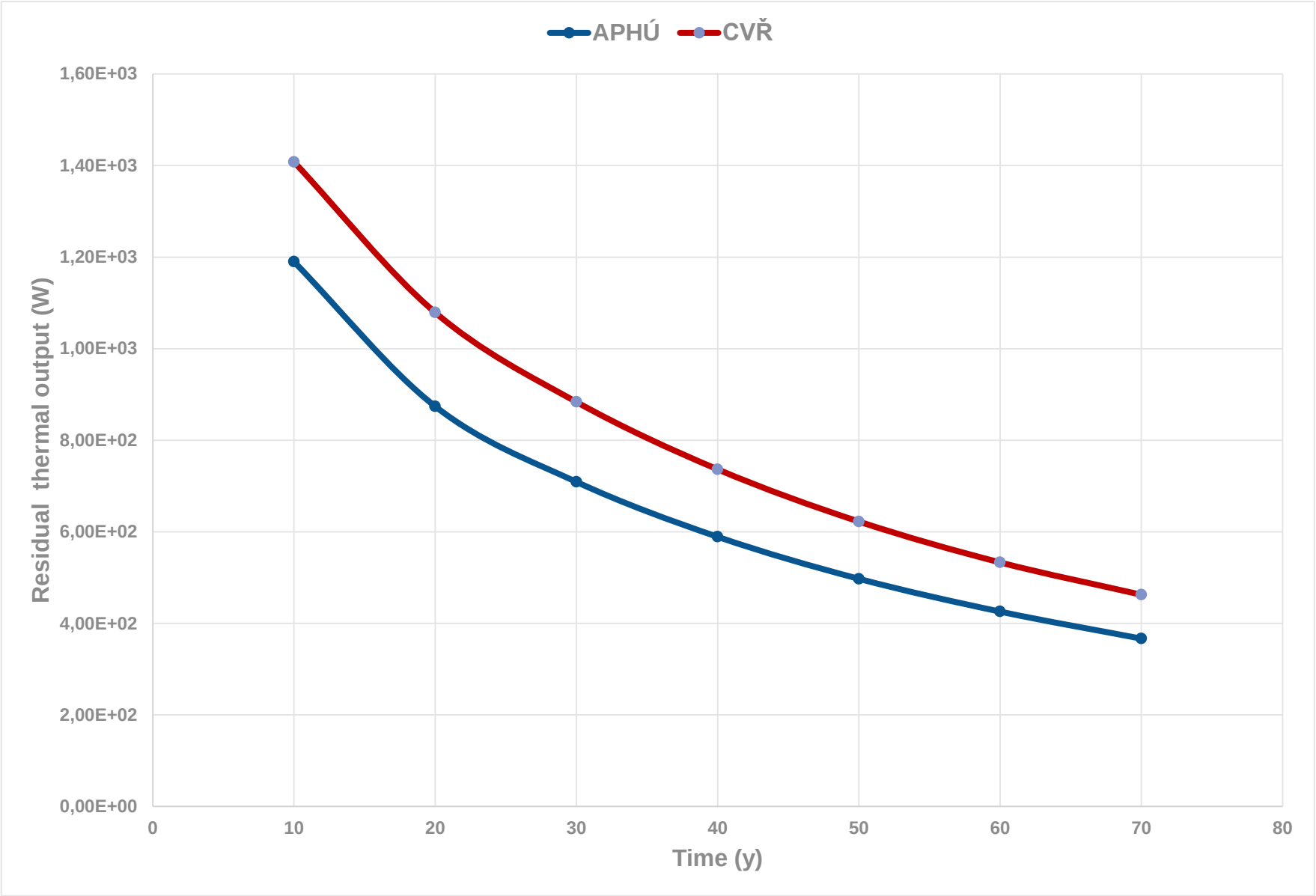
Ukraine:

- **13 VVER-1000 reactors**
- **2 VVER- 440 reactors**
- **3 RBMK-1500 reactors + 1 damaged**

Lithuania:

- **2 RBMK-1500 reactors**

Comparison of two inventory calculations in the CR – heat output



Goals

- Benchmarking calculations using different codes
- Verification of calculated values by sample measurements
- Establishment of joint methodology for SNF inventory determination

Cladding issues: Challenges

NPP operator:

Increasing fuel burn-up –> more intensive degradation during campaign

Nuclear regulator:

To what extent can fuel cladding be considered as an engineered barrier?

Project goal:

Based on operational performance of Zr-alloy cladding to assess its residual barrier and containment functions under simulated deep geological repository conditions

Cladding degradation mechanisms

Hydriding of Zircaloy

- During operation – being studied
- In repository conditions – need to define scenarios and propose a testing programme for characterisation of the Zr-hydride layer

Corrosion of Zircaloy and SS cladding

- During operation – being studied (demineralised water)
- In long term – a testing programme to be proposed using granitic water

Objectives

- Description of Zr-hydride layer and its anticipated evolution during disposal
- Experimental assessment of barrier functions of Zr-alloy cladding in contact with simulated deep repository aqueous environment under a range of conditions
- Identification of principal types of corrosion interaction between Zr-alloy and simulated aqueous environment
- SS cladding degradation studies

Potential processes to be investigated

- Growth of Zr-hydride layer during operation and geological disposal
- Zr alloy performance during anaerobic x aerobic periods of disposal
- Corrosion effects of ground water species
- Corrosion effects of water radiolysis products
- Evaluation of mechanical damages due to higher burn-up, temperature, pressure, and irradiation and their impact on corrosion processes

Work to be performed

- Mapping of hydride layers created during operation and in simulated disposal environment
- Assessment of dry oxidation period influence on residual barrier functions of cladding
- Experimental tests of cladding interaction with simulated deep repository environment under a range of conditions (temperature, pressure, different concentrations of aggressive components as Cl, O_2, γ) using in-situ applied electrochemical methods
- Comparative experimental tests of irradiated Zr-alloy and SS samples
- Analysis of generated corrosion products

Anticipated team

- Research Centre Rez, Czech Republic
- University of Chemical Technology, Prague, Czech Republic
- Department of Nuclear Physics and Energy of National Academy of Sciences of Ukraine (National Scientific Centre «Kharkov physical – technical institute»)
- Institute of Environmental Geochemistry, Kiev, Ukraine
- Institute for Safety Problems of Nuclear Power Plants, Chernobyl, Ukraine
- Centre for Physical Sciences and Technology, Lithuania

Capabilities CV Rez

- Modelling codes for SNF inventory
- Hot cells
- Research reactor irradiation capacities
- Emission electron microscopy (hot/cold)
- Anaerobic boxes (cold)
- Optical microscopy (hot/cold)
- Metallographic measurements (hot/cold)
- Experience in metallographic measurement of irradiated materials (reactor surveillance samples)
- Experience in evaluation of irradiated Zr alloy cladding (WWER 440 reactor conditions)

Capabilities of UChT

- Corrosion and material protection in energy production systems
- Corrosion problems in steam generators of nuclear power plants
- Moessbauer spectroscopy of corrosion products and metal-inhibitor interaction products
- Acoustic emission of stress corrosion cracking
- Electrochemical studies of corrosion processes (impedance spectroscopy, polarization techniques)
- Autoclaves
- Experience in evaluating operational corrosion of Zr-alloy cladding (cold)

Capabilities of Ukrainian institutions

- Codes for SNF inventory calculation
- Radiation Monitoring System
- Emission electron microscopy
- Spectrometric measuring systems for α, β, γ
- Neutron analysis
- Sampling of RBMK SNF
- Sampling of irradiated Zircaloy

Summary

- An international team has been put together to manage the issue of SNF inventory and long term performance of fuel cladding focusing on Russian type of reactors
- The team has theoretical capabilities (codes) and practical experience in dealing with those issues
- The team has facilities and equipment allowing to reach the project goals