RECYCLING OF RARE METALS FROM THE DECOMMISSIONING OF NUCLEAR FACILITIES

Symposium on recycling of metals, April 8-10, 2014, Studsvik, Sweden
Dr. Frank Charlier, Dipl.-Phys. Jan Philipp Dabruck, RWTH Aachen University (Germany)
Phase out and decommissioning in Germany

Project “recycling of rare metals”: idea, project partners, project goals

Sustainability and public acceptance

Work schedule

Material mass flow and metals in focus

Activation calculation and decay of activity

Assessment of recyclability of rare metals from decommissioning
PHASE OUT AND DECOMMISSIONING IN GERMANY

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SITUATION IN GERMANY

- In 2011, 19 NPP`s had been in operation
- Life Time Extension of German NPP`s: 01/2011
- Fukushima accident: 03/2011
- Shut down of 8 NPP`s: 08/2011

Consecutive shut down of the remaining 9 NPP`s by the end of 2022
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PROJECT IDEA

Recycling of rare metals from decommissioning of nuclear facilities:

Investigation, into which strategically important rare metals are present in nuclear facilities and whether they are economically recoverable or not.
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RECYCLING OF RARE METALS - PROJECT GOALS (1)

- Identification and quantification of relevant metals in selected components

- Calculation, as to which of these components are not radioactive and are accessible for a further metallurgical recycling

- Calculation, regarding which of these components are accessible for metallurgical recycling after the decay of activity or after decontamination
RECYCLING OF RARE METALS - PROJECT GOALS (2)

- Process evaluation of the recoverability and recyclability of rare metals of the identified components

- Presentation of the economic importance of a resource-efficient metal recycling programme
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SUSTAINABILITY AND PUBLIC ACCEPTANCE

- Non recycled metals are permanently lost
- Waste reduction
- Reduction of mining activities
- Conservation of resources

Higher public acceptance for decommissioning projects
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GENERAL WORK SCHEDULE

- Creating a data base for identified economic strategically relevant components and metals

- Establishment of a simulation model to determine the activation of the components of the NPP

- Identification and analysis of the recyclability of relevant components and determination of technically possible recoverable amounts

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GENERAL WORK SCHEDULE (2)

- Development of a resource-efficient recovery technique for these rare metals

- Concentration in appropriate recycled products (material-groups and alloy-groups)

- Evaluation of the economic potential of an optimized decommissioning
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MASS FLOW AND METALS IN FOCUS

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# DECOMMISSIONING AMOUNTS

## Example NPP Stade

<table>
<thead>
<tr>
<th>non-nuclear area</th>
<th>nuclear area</th>
</tr>
</thead>
<tbody>
<tr>
<td>198,000 t</td>
<td>132,000 t</td>
</tr>
<tr>
<td>controlled release</td>
<td>controlled reuse and recycling</td>
</tr>
<tr>
<td>128,500 t</td>
<td>500 t</td>
</tr>
<tr>
<td>97.3%</td>
<td>0.4%</td>
</tr>
<tr>
<td>128,500 t</td>
<td>500 t</td>
</tr>
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<td>97.3%</td>
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</tr>
</tbody>
</table>

PWR-NPP Stade [E-ON]

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NON-FERROUS METALS IN FOCUS (E.G.)

- indium (In)
- niobium (Nb)
- vanadium (V)
- tin (Sn)
- nickel (Ni)
- molybdenum (Mo)
- silver (Ag)
- hafnium (Hf)
- ...

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RELEVANT COMPONENTS (E.G.)

- Components of the primary circuit
  - Reactor internals
  - Absorber-facilities
  - Grid structures

- Components of the control technology
  - Pumps
  - Fittings
  - Heat exchangers
  - Steam generator

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ACTIVATION CALCULATION
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“Virtual Reactor” with neutron flux distribution calculated by MCNP
ACTIVATION CALCULATION

Calculated with ORIGEN based on neutron flux distribution and detailed material composition

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DECAY OF ACTIVITY
DECAY OF ACTIVITY

- component-wise determination of the nuclide vector and the activity inventory

- calculation of the activity attenuation over time with respect to decay chains of the nuclides

- calculation of the period after which the specific components can be recycled
ASSESSMENT OF RECYCLABILITY
ASSESSMENT OF RECYCLABILITY

Investigation: Reactor Components & Materials

Evaluation: Content of rare Materials in Components

Remaining Components usable for Recycling

Technological and economical Assessment of Recyclability

Selection of appropriate Process Chains for relevant Materials

Conclusion & Final Report

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ASSESSMENT OF RECYCLABILITY (1)

- Classification of the identified materials by recyclability:
  analysis of the material shape, texture and the composition of the structures, alloys and components

- Selection of suitable process chains for metal recycling
ASSESSMENT OF RECYCLABILITY (2)

- Presentation of the distribution of recoverable and recyclable non-ferrous metals
- Evaluation of the results
- Decision to be taken, if recycling of specific components is feasible and of economical interest

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SUMMARY

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Recycling of rare metals from the decommissioning of nuclear facilities

- Detection of rare metals in relevant components
- Interdisciplinary approach:
  - nuclear simulation
  - activation calculation
  - metallurgical consideration
  - feasibility of recycling
  - economic consideration
SUMMARY (2)

Recycling of rare metals from the decommissioning of nuclear facilities

- Decision, if substitution of raw materials by recycling of rare metals from decommissioning is
  - technically feasible and of
  - economical interest
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