Expected performance of a $^{235}\text{UO}_2$ fuel rod in an open pool research reactor

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**UO₂ Fuel Rod for Research Reactors**

- Proven performance in many reactors for many years under various conditions
- Well established suppliers
- Good database on in-reactor performance for fuel design
- Good negative feedback effect of UO₂ fueled core especially in low power density core

Adopt PWR Fuel Design
To a open pool research reactor

- Much different reactor condition of most research reactors from power reactors
  - temperature
  - pressure
Open pool reactor with UO$_2$ fuel

- Core Power: 70 KW
- Fuel active height: 0.32 m
- Power peaking: 1.84
- Coolant inlet temp.: 35 °C
- Natural circulation
- Rod-to-Rod Pitch: 1.8 cm
Open pool reactor with UO$_2$ fuel

Adopt PLUS 7 fuel rod design
Open pool reactor with UO$_2$ fuel

Comparison of operating conditions between typical PWR and UO$_2$-RR.

<table>
<thead>
<tr>
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<th>PWR*</th>
<th>UO$_2$-RR</th>
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</thead>
<tbody>
<tr>
<td>System pressure (bar)</td>
<td>155.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Coolant temperature (°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Inlet</td>
<td>291</td>
<td>35</td>
</tr>
<tr>
<td>- Outlet</td>
<td>324</td>
<td>38</td>
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</tbody>
</table>
II. Performance Calculation & Results

• Fuel Rod Design
  – Pellet, cladding, gap dimensions: from KSNP fuel design
  – EP design, EP welding method: from KSNP fuel design
  – Other design parameters are decided based on reference design
II. Performance Calculation & Results

FRAPCON-uni code was used:

- FRAPCON: well accepted oxide fuel performance analysis computer code approved by NRC
- Natural circulation not considered in the original code
- Necessary modifications are applied to FRAPCON for the analysis of UO$_2$ fuel performance in open pool type reactor.
- For conservatism, hot channel power and peaking factors are increased
II. Performance Calculation & Results

Power History: Average LHGR = 0.682 KW/m
II. Performance Calculation & Results

1. Change of fuel BU

- **EOL**
  - Rod average BU: 3.4 GWD/MTU
  - Max. BU: 6.8 GWD/MTU

- Much less than PWR fuel rod ~ 60~70 GWD/MTU
II. Performance Calculation & Results

2. Change of fuel temperature

- Max. centerline T: 126°C
- Almost no change

Much less than fuel melting
T > 2800°C
II. Performance Calculation & Results

3. Fuel temperature distribution at max. P. position

- Centerline T: 126 °C
- Fuel surface T: 106 °C

Very low fuel T → no significant FGR expected
II. Performance Calculation & Results

4. Fission gas release

- FGR at EOL < 0.04%
- Very low FGR compared with PWR fuel
- Low fuel T & low BU
II. Performance Calculation & Results

5. Rod internal pressure

- RIP decreases as BU increase
- RIP maybe close to external coolant pressure
- RIP decreases because fuel volume decreases while there was no FGR
- Need more analysis for RIP and related design criterion
II. Performance Calculation & Results

- The difference between RIP and system pressure seems relatively small compared to other performance parameters.

- RIP seems to sensitively dependent on He backfill pressure and the free volume in the fuel rod.

- Detailed analysis seems to be necessary on the effect of major parameters on the RIP.
III Conclusions

- In order to utilize the well proven performance with good supply potential of the UO$_2$ fuel in small reactor, a small open pool type research reactor was proposed.

- Preliminary evaluation of the UO$_2$ fuel performance in open pool reactor showed its good performance and large safety margins compared to relevant fuel design criteria.

- Rod internal pressure showed high dependence on initial He backfill pressure and more design studies are seemed to be necessary to optimize the performance.
Thank you for your kind attention!