Design Goals and Interrelationship among Core Design Parameters

Course 22.39, Lecture 2
9/11/06
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### Major Design Choices

<table>
<thead>
<tr>
<th></th>
<th>PWR</th>
<th>GFR</th>
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<tbody>
<tr>
<td>Coolant</td>
<td>Water</td>
<td>He or SCO₂</td>
</tr>
<tr>
<td>Neutron Spectrum Fuel</td>
<td>Thermal</td>
<td>Fast</td>
</tr>
<tr>
<td>Fuel</td>
<td>UO₂</td>
<td>Dispersion in Matrix CERCER (U-TRU) C/SiC</td>
</tr>
<tr>
<td>Decay Heat Removal System</td>
<td>• Active (Gen II) • Passive (AP1000 and ESBWR)</td>
<td>Active or Passive</td>
</tr>
<tr>
<td>Power Conversion Cycle</td>
<td>Rankine</td>
<td>Brayton with Supercritical CO₂ Or Helium</td>
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</tbody>
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Principle PWR Design Challenges

#1 Reduction of Capital Cost

Design Approaches:

• Constructability
  ➢ Modularity, Informatics, Construction Techniques

• Design Approach
  ➢ Safety by Natural Phenomena
  ➢ Unique Approaches
    ◆ Filtered, Vented Containment
    ◆ Containment in Cooling Tower
    ◆ Steam Generators outside Containment
    ◆ Rapid Refueling Technology
#2 Reduction in O&M Cost

Design and Management Objectives:
- Reduce Operator Burden
- Reduce Plant Operating Staff
#3 Reduce Spent Fuel Inventory (holding fuel cycle cost level)

Design Approaches

- Increase Fuel Burnup
- Increase Plant Thermal Efficiency
- Separation of Actinides
- Reprocessing of Actinides
Typical Nuclear Plant Operating History
## Time Periods in an Operating Cycle

<table>
<thead>
<tr>
<th>Operation</th>
<th>Outages within Operator Control</th>
<th>Outages outside Operator Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Power</td>
<td>Planned Outages (PO) $T_{PO}$</td>
<td>Idle Outages (I) $T_I$</td>
</tr>
<tr>
<td>Effective Full Power Period, EFPP</td>
<td>Unplanned Outages (UO) $T_{UO}$</td>
<td></td>
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<tr>
<td></td>
<td>Outage Extension (EO) $T_{EO}$</td>
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<tr>
<td></td>
<td>Forced Outage (FO) $T_{FO}$</td>
<td></td>
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<tr>
<td></td>
<td>Refueling Outage (RO) $T_{RO}$</td>
<td></td>
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<tr>
<td></td>
<td>Maintenance Outage (MO) $T_{MO}$</td>
<td></td>
</tr>
</tbody>
</table>

### Definitions
- **Unplanned Outages (UO)** ($T_{UO}$)
- **Planned Outages (PO)** ($T_{PO}$)
- **Forced Outage (FO)** ($T_{FO}$)
- **Outage Extension (EO)** ($T_{EO}$)
- **Refueling Outage (RO)** ($T_{RO}$)
- **Maintenance Outage (MO)** ($T_{MO}$)
- **Idle Outages (I)** ($T_I$)
Plant Operating Characteristics

Source: 22.39 “Class Note 1”
Effect of Cycle Length on Plant Operating Factors (assuming a 30 day refueling outage length, $T_{RO}$) and 30 Day Idle Time Period, $T_I$, outside the Plant Operator’s Control

Source: 22.39 “Class Note I”
Equivalent Annulus Representation of the pin cell geometry and the inverted or matrix cell geometry

Source: 22.39 “Class Note 1”