Critical Design Factor for Sector Transport Maintenance in DEMO

H. Utoh, Y. Someya, K. Tobita, N. Asakura, K. Hoshino, M. Nakamura
Japan Atomic Energy Agency

Background
Maintenance is a critical issue for fusion DEMO reactor because the design conditions and requirements for DEMO maintenance schemes are different from ITER.

Difference between ITER and DEMO remote maintenance
- Replacement components (ITER: remote reach; DEMO: overreach)
  - Dose rate (ITER 0.648 Gy/hr; DEMO: Shutdown ~3000 Gy/hr)
  - Field dose rate (1 month rate: 36 Gy/hr)
- DEMO (SimCS): P: 25 MWFF

Focus of this research
Considering plant availability, to transport to the hot cell facility considering three different maintenance schemes

Critical design factors
- High plant availability
  - Time required to minimum number of cutting/sealing points, short transport maintenance time

Common critical issue
Feasible maintenance scenario considering decay heat
- How to transport to hot cell
  - Dose rate (ITER: 0.648 Gy/hr; DEMO: Shutdown ~3000 Gy/hr)
- Irradiation of the TF coils can be supported.

Summary
- Critical design factors
  - High plant availability: Considering plant availability, to transport to the hot cell facility considering three different maintenance schemes based on sector transport maintenance
  - A feasible maintenance scenario considering handling of decay heat in sector transport maintenance

Critical issue 1
How to support enormous turnover forces of the TF coils

1. How to support enormous turnover forces of the TF coils
   - By limiting the number of maintenance ports, sufficient inter-coil structure supporting T-O forces can be installed.

2. Structural analysis by FE analysis
   - Analysis code: AEN513.0

3. Key design factor: Suitability of the sector transferring mechanism considering the radiation resistance

4. Critical issue 2: Sector transport in reactor
   - The limited number of maintenance ports maintenance schemes require the two direction transferring mechanism of sector in the vacuum vessel.
   - The sector is transferred with the sector transport using limited number of vertical maintenance ports.
   - Key design factor: Suitability of the sector transferring mechanism considering the radiation resistance

5. Critical issue 3: Sector transport in reactor
   - The sector transport using limited number of vertical maintenance ports.
   - Sector transport using limited number of horizontal maintenance ports.

6. FE Analysis
   - EM force distribution on TF coil

7. Critical issue 4: Sector transport in reactor
   - The limited number of maintenance ports maintenance schemes require the two direction transferring mechanism of sector in the vacuum vessel.
   - The sector is transferred with the sector transport using limited number of horizontal maintenance ports.

Sector transport using Limited number of Vertical maintenance ports
- Sector transport using Limited number of Horizontal maintenance ports

Advantages of sector transport maintenance scheme
- Low risk of development of RH devices
  - No need for complex handling system in ITER
- High plant availability
  - Time required to minimum number of cutting/sealing points, short transport maintenance time

Transport maintenance
- SAH
  - Shim
  - Imaging fiber
  - Location sensor

Inter-coil structure

- Splash
  - Magnet
  - Shim
  - Location sensor

- All port
  - Pull/insert direction

- Pull/insert direction
  - Horizontal

- Pull/insert direction
  - Vertical

- Maintenance port
  - Horizontal

- Pull/insert direction
  - Vertical

- Pull/insert direction
  - Horizontal

Discussion
In the case of TROUBLE
The severest trouble case in remote maintenance:
- Sector step in the reactor after cutting of coolant pipes

- Cooling system: only natural convection air cooling
- The max. temp. of OB BLK surface increases to ~1100°C at ~40 days after maintenance start.
- Sector should be transferred to hot cell within 48 hours in the case the cold down time is one month.

Trade-off with plant availability
- Review of core configuration including additional cooling system in cryostat would be required for severe trouble case on RM