Fatigue and fracture analysis on divertor monoblock heat sink at H-mode operation with Type I ELMs

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1. Introduction
The most advanced and mature plasma facing unit (PFU) technology is the ITER W/Cu PFU, which is a monoblock structure composed of tungsten, copper and CuCrZr as plasma facing material, interlayer and heat sink, respectively. EAST divertor PFU was introduced for thermal-mechanical analysis with simplified Type I ELMs. EAST H-mode heat flux in H-mode (High confinement mode) operating condition. Fatigue failure in CuCrZr heat sink tube including fracture was presented.

2. Monoblock model for analysis
Geometry and material parameters
The monoblock of EAST W/Cu divertor without twisted tape is consist of W, Cu and CuCrZr as armour, interlayer and heat sink, respectively. The temperature-dependent physical properties are taken from ITER-SDC. Assume W as elastic material, Cu and CuCrZr as elasto-plastic material use Chaboche model.

3. H-mode operation with Type I ELMs
Equivalent heat flux
Assumption and simplification made to describe time evolution of heat flux of ELMy H-mode on divertor PFU. Here, we count the equivalent heat flux as the input heat load.

4. Fatigue analysis
Thermal- mechanical analysis
The temperature response of heat sink tube to ELMy is shown in Section 3 which indicates that the transient wave of ELMs have little impact on the tube temperature. We study the equivalent heat flux as the input heat load. Fatigue analysis:

- Thermal- mechanical analysis
- Fatigue damage:
- Fatigue life
- Cumulative damage

5. Fracture analysis
(I) The maximum total strain and stress all appeared in the upper inner wall region of tube in FE model.

- Fatigue damage:
- Fatigue life
- Cumulative damage

6. Conclusions and discussions
The ELMs make a significant influence on the temperature peak of equilibrium and equivalent heat flux is obtained for steady-state analysis. Fatigue analysis:

- Upper inner wall region of tube takes risk to fatigue failure. The elasto-plastic CuCrZr material model was used for ETA, total strain range combined with strain-life curve was presented to estimate the fatigue life which illustrate the cycle number.

- Palmgren-Miner theory is a linear fatigue damage cumulative rule: $D = \sum \frac{N_i}{N_j}$ where $N_j$ is given cyclic strain range.

- The threshold value of fatigue damage set as $D=1$.