Power Handling of the Bulk Tungsten Divertor Row at JET: First measurements and comparison to the GTM thermal model

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*See the Appendix of F. Romanelli et al., Proceedings of the 24th IAEA Fusion Energy Conference 2012, San Diego, USA

1 Introduction

The divertor of the new JET ITER-like Wall (ILW) currently includes a solid tungsten row for the outer strike point – indicated in red colour below.

The design of the tile assemblies of the bulk tungsten divertor row in JET was improved in the course of several experiments with respect to the power and energy performance: high heat fluxes (HHF) tests in several e- & ion beam facilities (JUDITH, TEXTOR, MARION).

These experiments were carried out in parallel with extensive modelling of the complete tungsten tile assembly in the so-called Global Thermal Model (GTM) [2].

HHF nominal values: 7-9 MW/m², \( E_{\text{dep}} \leq 60 \text{ MJ/m}^2 \)

Goal: understand the heat flow from the plasma-facing surface through the supporting structure down to the base plate of the JET MkII divertor sufficiently to be able to later interpret operational data from the torus.

2 GTM Model

- 3D Finite Element (FE) model, no simplifications, T-dependence
- Radiation significant in the cooling process: \( \varepsilon > 0.34 \) around 2000°C
- Special attention to contact layers: \( \dot{\lambda} \text{ in } (2.1-36 \text{ W/(m.K)}) \text{ at } 2000°C \)
- Detailed modelling of clamping arrangements: \( \dot{\lambda}_{\text{shims}} \text{ in } \dot{\lambda}_{\text{Makor-11mm}} \)

3 Experimental

Infrared camera(s) – esp. KLD9 (Octant 8)

- Provide the temperature of the plasma-facing surface of the tile (check boundary condition)

4 Results

- Temperature of the clamping springs (vulnerable component) close to model temperature: systematic correction to measurement +30°C
- Characteristic time in very good agreement too: better than 10%
- Wedge carrier wings: +10/+65° in the range 150-300°C but different time constant!
- Surface of the tungsten tile: deviations in the order of 100°C
- Cooling of all parts under the same temperature curve (envelope) from ~500°C down to ~200°C

5 Conclusions

- Excellent to fair agreement on the temperature of different components. The time constants to reach a common temperature show deviations from the model.
- The experimental behaviour of the row of bulk tungsten tiles during plasma operation is close to design values in a wide range of operational parameters with deposited energy densities around and slightly above 30 MJ/m².
- The tile is designed for a maximum local temperature of the plasma-facing tungsten of 2200°C and a maximal energy deposition of 60 MJ/m² (+0/-10%).