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Influence of thickness and notch on impact bending properties of pure tungsten plate material

J. Reiser[1], M. Rieth[1], and A. Hoffmann[2]

[1]*Karlsruhe Institute of Technology, IAM-AWP, P.O. Box 3640, 76021 Karlsruhe, Germany*
[2]*PLANSEE Metall GmbH, Reutte, Austria*

Tungsten and tungsten alloys are currently considered as candidate materials for various divertor applications in future fusion reactors. This is mainly due to their high temperature strength, good thermal conductivity, and comparably low activation under neutron irradiation. The drawback of tungsten materials is their inherent brittleness, low fracture toughness, and a ductile-to-brittle transition (dbt) that occurs at high temperatures.

Especially refractory alloys show a strong correlation between microstructure and their manufacturing history. Since mechanical properties are defined by the underlying microstructure, refractory alloys can behave quite different, even if their chemical composition is the same. It was shown in previous work that plate materials have to be preferred to rod material for parts for a future fusion application and that pure tungsten has the best fracture behavior compared to doped tungsten e.g. tungsten with potassium or strengthened by e.g. lanthanum oxide.

Therefore, the fracture behavior of tungsten samples made from a plate with a thickness of 1mm, 3mm, and 4mm were investigated. The tested samples have dimensions of 1*3*27mm without notch, 3*3*27mm without notch, and 3*4*27mm with notch. Those samples were characterized by Charpy tests which were performed up to 1000°C in vacuum. Results show that 1mm plate material is anisotropic and that the dbtt occurs at 200°C on a sample orientated in rolling direction and at 350°C on a sample orientated perpendicular to the rolling direction. Even 3mm plate material shows a dependence of the dbtt on the rolling direction and the dbtt occurs at 450°C and 600°C respectively.

The influence of the notch as well as the influence of the thickness of the sample was investigated and the dbtt as well as the Charpy impact energy were identified with respect to the sample orientation. All results are discussed and assessed in regard to the optimization of future component fabrication for high temperature nuclear fusion application.

Corresponding Author:

Jens Reiser
jens.reiser@kit.edu
Karlsruhe Institute of Technology, IAM-AWP
P.O. Box 3640, 76021 Karlsruhe, Germany
Tel: +49 721 6082 3894, Fax: +49 7247 82 4567