Hypervapotron Fatigue Study

B. Chuilon
EURATOM / UKAEA Fusion Association, Culham Science Centre, OX14 3DB Oxon, United Kingdom
bchuil@jet.uk

Hypervapotron elements are extensively used in JET and MAST Neutral Beam systems and have withstood many 10s of thousands of cycles at high heat flux loading (up to 18 MW/m$^2$). Traditional elastic methods for determining the fatigue lives of hypervapotrons greatly underestimate lifetimes; sometimes predicting failures after only one cycle, whereas no failures have been observed even after more than 100,000 cycles. As a result their validity is questioned when strains are dominated by thermal loadings. To study this fact several types of fatigue analysis were performed using a hypervapotron finite element model. These ranged from conventional S-N methods of analysis to modelling crack growth using fracture mechanics. The full results of this study will be presented with conclusions as to the suitability of each method.

The fracture mechanics approach revealed how crack growth at the most highly stressed point is slow, while crack growth in other key areas does not take place. The results show a strong dependence on initial crack size. More precisely, if the largest non-detectable manufacturing defect of 2 mm is present in the most highly stressed region of the hypervapotron, then the fatigue lifetime is estimated to be 155,000 cycles at an incident heat flux density of 10 MW/m$^2$. This result falls in line with experimental observations and the typical fatigue lifetime requirements needed for operations on ITER.

This work was funded jointly by the United Kingdom Engineering and Physical Sciences Research Council and by the European Communities under the contract of Association between EURATOM and UKAEA. The views and opinions expressed herein do not necessarily reflect those of the European Commission. This work was carried out within the framework of the European Fusion Development Agreement.