COMPACT TOKAMAKS AS CONVENIENT NEUTRON SOURCES FOR FUSION REACTORS MATERIALS TESTING

F. Bombarda[1], B. Coppi[2], Z.S. Hartwig[2], M. Sassi[1], M. Zucchetti[2]
[1] ENEA, CR Frascati, Rome, Italy
[2] Massachusetts Institute of Technology, MIT, Cambridge (MA), USA

Corresponding author: sassi@frascati.enea.it

Environmental acceptability, safety and economic viability will be the keys to the successful diffusion of Fusion Power. This will entail the development of radiation resistant materials. All the first wall materials now under development must be tested from the nuclear properties viewpoint: in particular they must survive exposure to damage from neutrons having an energy spectrum peaked near 14 MeV with annual doses in the range of 20 dpa (displacement per atoms), and total fluences of about 200 dpa.
Testing of candidate materials, therefore, requires a reliable high-flux source of high energy neutrons. Fusion creates more neutrons per energy released than fission or spallation. In the near term, DT fusion may become the most intense neutron source. At neutron production rates higher than 10^{18} n/s, both fission reactors and accelerator spallation sources are close to their upper rate limits, while fusion sources have development perspectives.
A tokamak neutron source could be designed and built in a relatively short time, extrapolating present designs of fusion tokamaks, paying attention to some additional R&D, to emphasize quasi-steady state or at least longer operation, disruption avoidance, component reliability, materials, etc.
Compact high-field tokamaks can be a candidate as a neutron source for material testing devices, essentially due to their design characteristics, compact dimensions, high magnetic field, high neutron production, flexibility of operation, etc.
This study addresses the development of a tokamak neutron source for a material testing facility using an Ignitor-based concept. Ignitor is a proposed compact high magnetic field tokamak, aimed at reaching ignition in DT plasmas and at studying them for periods of a few seconds. Revisions of its operating parameters in order to act as a suitable neutron source in a material testing device are discussed and a new operating scenario is proposed.
The Ignitor-based tokamak source is actually based on the extrapolation of Ignitor parameters carried out for designing the Columbus tokamak. It has a longer plasma discharge length, and does not reach ignition: however, its neutron production is estimated to be fully sufficient for an experimental material testing device.
Features of the tokamak neutron source are illustrated and preliminary results are discussed. At his maximum power, Ignitor will produce more than 3×10^{19} n/s, a quite strong neutron source. Therefore, there is the possibility to study the performance of an Ignitor-like neutron source as material testing device, evaluating the specific damage rate per neutron produced and/or per second of operation, and therefore the required operation times in order to achieve relevant dpa quantities in the tested materials.
Radiation damage evaluations have been performed by means of the ACAB code for some fusion-relevant materials, like pure iron, ASI316L, EUROFER, SiC/SiC, Mo, Graphite, V-15Cr-5Ti. Values ranging from 1.6×10^{-26} to 2.4×10^{-25} dpa per source neutron have been obtained. At full power operation, they are translated into 16 to 250 dpa/y. This shows the potential of this neutron-rich device for fusion materials testing. Some full-power months of operation are sufficient to obtain relevant radiation damage values in terms of dpa: the setup of a duty cycle for the device in order to obtain such operation times is the next required step to proceed with the evaluation.