Prasada DANDU

Thesis summary

Polarization-sensitive reflectometry based optical fibre sensor for plasma diagnostics in ITER

By Prasadaraju DANDU

Supervisor: Prof. Marc WUILPART

Co-supervisor: Prof. Patrice MEGRET

The understanding that stars derive their energy from the nuclear fusion process has ignited a long-standing interest in harnessing fusion power as a clean and virtually limitless energy source. ITER, as the largest fusion device (to date) under construction, is a major milestone in the pursuit of achieving net power output. The success of ITER, as a large-scale nuclear fusion project, depends on the ability to accurately measure and analyse the behaviour of the plasma—an ionized gas formed by heating the fusion fuel to about 200 million °C.

Plasma current and poloidal magnetic field distribution are two of the major parameters in plasma diagnostic. Conventionally, these parameters are measured using inductive sensors. However, these sensors are expected to fail in ITER environment due to strong radiation and quasi steady state operation. In this thesis, we have investigated the feasibility of using a polarization-sensitive reflectometry (PSR)-based optical fibre sensor for plasma current measurement in ITER. The proposed method offers the unique ability to measure both plasma current and poloidal magnetic field distribution with a single measurement, which is not achievable by any other conventional sensing technique.

Since ITER is not yet operational and there is no other practical way of imitating the ITER conditions, we have developed a simulation tool that represents the sensor's behaviour in the ITER environment. The simulation tool is used to study the feasibility of the proposed sensor for plasma current measurement in ITER. The simulator includes various perturbing effects, such as sensing fibre bending resulting from the geometry of the ITER vacuum vessel (VV) section, twisting that may result from the fibre blowing technique used for installation and the influence of the ambient temperature of the outer VV wall where the sensing fibre will be installed. Furthermore, the effect of the reflectometer's dynamic range is also studied and included in the simulation tool. The obtained results suggest that the proposed sensing technique can be used for plasma current measurement in ITER by utilizing a commercially available spun sensing fibre and an optical reflectometer with dynamic range greater than 11 dB in the sensing zone.

The ability of the PSR-based optical fibre sensor to measure the poloidal magnetic field distribution was then studied theoretically and experimentally. Experimental results from Tore Supra and JET have shown the feasibility of the approach for poloidal magnetic field measurement in tokamaks, indicating its potential applicability to ITER. In Tore Supra and JET, spatially resolved poloidal magnetic field measurements in deci-centimeter range were obtained. The feasibility of extending the approach to achieve centimeter or sub-centimeter range resolution is also verified through an experiment carried out in an MRI scanner.

Overall, this thesis has laid a foundation for a new plasma diagnostic technique for ITER and future tokamaks like DEMO.