Abstract

Solving the problem of plasma and impurity transport is one of the key issues for the success of controlled nuclear fusion. It is connected with the necessity of control of ions and atoms released during the discharge from the walls and the tokamak divertor, the so-called intrinsic impurities and gases deliberately introduced into the plasma (nitrogen, neon, argon, krypton) (exrternal impurities), whose task is to limit the energy fluxes to the tokamak wall. Impurities have a huge impact on the discharge evolution and plasma parameters in the tokamak.

The subject of this dissertation is the analysis of the transport of plasma and impurities in the JET ILW tokamak (Culham, UK), i. e. the current configuration of the JET tokamak with a beryllium wall and tungsten divertor corresponding to the expected operating conditions in the ITER reactor. Understanding the transport of impurity in the JET ILW tokamak and in the future fusion reactors: ITER, DEMO, is one of the most important issues requiring a significant research effort. Obtaining a reliable simulation tool to predict and interpret discharge parameters is one of the main objectives of the work carried out by the Eurofusion Consortium in recent years.

The paper presents physical processes leading to generation of impurities in tokamaks, as well as physical mechanisms responsible for transport of impurity ions in plasma column. Since the above mentioned processes as well as the relations between them are strongly non-linear, one of the ways of obtaining information on their influence on the impurity transport in the tokamak is computer modelling. The main objective of the study was to analyze the transport of plasma impurities, the influence of impurity ions on the main plasma parameters, such as energy confinement time, plasma temperature, plasma radiation and thermal load of the divertor plates. The complexity of problems outlined above is presented on a specific example of plasma modeling in the JET ILW tokamak using COREDIV and ETS (European Transport Solver) codes.

One of the important results of the research described in this thesis is the implementation in the ETS code of the numerical algorithm taken from the the COREDIV code, which solves the impurity transport equations.

In separate chapters, the results of analyses of the impact of different factors such as impurity level, radial transport of particles in the scrape of layer (SOL), basic discharge parameters (such as plasma density, heating power, plasma current) and the different impurity seeding gases (N, Ne, Ar, Kr) are discussesd. The results of calculations carried out for plasma parameters in various working conditions of the tokamak: with good (H -mode) and low energy confinement (L-mode) as well as for the so-called hybrid discharges are presented.

The comparison of the calculation results with the experimental data showed a high correlation between numerical simulations and the experiment. It was found, inter alia, that in the case of tungsten divertor the emergence of a self-regulatory mechanism for tungsten production, which is the main source of radiation in the core plasma of the tokamak, is essential. This thesis presents conclusions that are important for the optimization of discharges in the JET ILW tokamak and for the operation of devices

equipped with tungsten divertor such as the ITER reactor.