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The dynamic ergodic divertor in TEXTOR—A novel tool for studying magnetic perturbation field effects

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Abstract

Recently TEXTOR has been upgraded by the installation of the dynamic ergodic divertor (DED). The purpose of the DED is to influence transport parameters in plasma edge and core and to study the resulting effects on heat exhaust, edge cooling, impurity screening, plasma confinement and stability. Alternatively, the DED creates static or rotating multipolar helical magnetic perturbation fields of different mode patterns. A set of 16 helical coils has been installed on the inboard high-field side of the vacuum vessel. Rotating fields of up to 10 kHz can be generated. A novel coil design has been developed which fulfills the various mechanical, electrical, high frequency, thermal, and vacuum requirements. In addition to the various technical aspects of the DED design, implementation and commissioning, highlights of recent experiments will be presented. In particular the impact of the perturbation field on MHD stability and plasma rotation will be addressed.

Keywords: Plasma–wall interaction; Dynamic ergodic divertor; Rotating field; Medium frequency; Coil design

1. Introduction

TEXTOR is a Tokamak Experiment for Technology Oriented Research in the field of plasma–wall interaction. The scope includes a detailed analysis of particle and energy exchange between the plasma and the surrounding chamber as well as active methods to optimize the first wall and the plasma boundary region (Neubauer et al. [1]).

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The DED creates alternatively static or rotating multipolar helical magnetic perturbation fields of different

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mode patterns. Rotating fields of up to 10 kHz can be generated (Giesen et al. [2]).

2. Technical concept

2.1. General layout

The DED consists of a set of 16 helical coils (Fig. 1) on the inboard high-field side of the vacuum vessel covering about 30% of the inboard vessel surface. The coils are aligned in parallel to the magnetic field lines at the nearby $q = 3$ surface. The coils are covered by graphite tiles, which act both as divertor target plates and bumper limiter.

Coaxial vacuum feedthroughs include connections for coil currents and cooling media. All the terminals of the coils are accessible from the outside of the vessel allowing coil connections to be changed for the different modes without breaking the vacuum.

The coil sets are energized by dc or four-phase current at selected frequencies (50 Hz and between 1 and 10 kHz). The peak current in the individual coils is 15 kA for pulse duration of up to 10 s. A set of nine identical frequency converter units is used at a total power of 8.1 MVA.

2.2. Coil design

A novel coil has been developed which fulfills the various mechanical, electrical, high frequency, thermal and vacuum requirements (Fig. 2). It consists of 294 insulated and twisted copper wires. The wires are protected against mechanical damage by glass-fiber bundles, glass-fiber taping and a glass-fiber tube. All is enclosed in a double wall corrugated stainless steel tube.

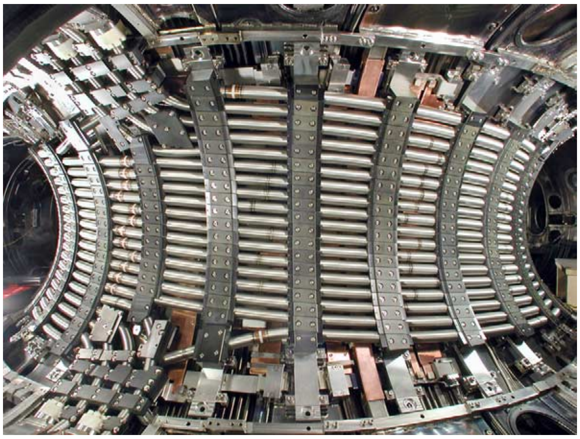

Fig. 1. Arrangement of the DED coils inside the TEXTOR vacuum vessel.

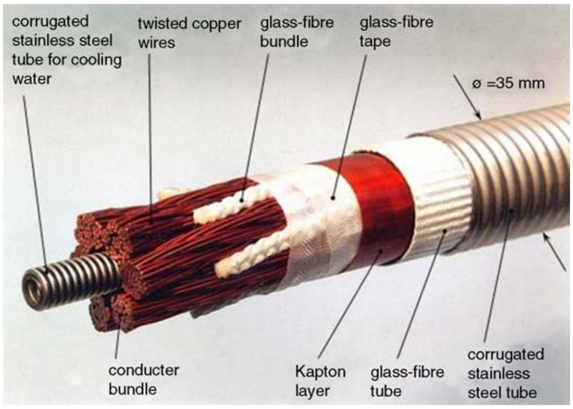

Fig. 2. DED conductor with 6 × 7 × 7 twisted and insulated copper wires.

Cooling of the coils is realized by a combination of water and helium. The remaining voids inside the conductor are filled with slowly streaming helium gas, which ensures an efficient heat transfer from the conductor to a water-cooled corrugated stainless steel tube in the centre of the conductor. The cooling water inside the central tube transports the energy effectively along the coil to the outside cooling circuit.

2.3. In-vessel components and feedthroughs

In order to accommodate the coils without reducing the present minor radius of the plasma, the coils are recessed into the liner (Fig. 3). This required a cut-out of parts of the liner. The original vertical stiffness of the liner is guaranteed by new edge reinforcements and supports.

The ergodization coils are positioned by clamps on C-shape belts welded onto the inboard side of the vessel. C-shaped divertor support structures are bolted onto the vessel above and below the DED coils. Additional ceramic tiles behind the divertor target plates act as a thermal insulation between the divertor tiles and coils also enabling baking of the divertor tiles and the liner.