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MHD calculations, microwave heating scenarios simulations and diagnostics updates on SCR-1 stellarator

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Stellarator of Costa Rica 1 (SCR-1) is the first (and so far, the only) stellarator device in Latin American region and has been operational since June 29, 2016. SCR-1 has a microwave heating system composed of two magnetrons of 2 kW and 3 kW and each generates microwaves at 2.45 GHz 1 with a mean magnetic field <B> = 41.99 mT. This work presents the latest MHD calculations and simulations of microwave heating scenarios as well as the updates in the diagnostics systems with the design and implementation of a bolometer, Mirnov coils, Rogowski coils and diamagnetic loops. MHD equilibrium calculations were performed using the VMEC code in free boundary mode including the poloidal cross-section of the magnetic flux surfaces at different toroidal positions, profiles of the rotational transform, magnetic well, magnetic shear and total magnetic field norm. The rotational transform (iota) for 0°, magnetic well and magnetic shear profiles are shown in Figure 1.

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Outer magnetic flux surfaces bend more sharply than inner magnetic flux surfaces indicated by a decrease of the rotational transform with an effective radius. There are significant plasma edge fluctuations that tend to increase with negative and low values for the negative and low magnetic well similar to TJ-II, reported from 2.

Additionally, simulations of microwave heating scenarios were performed by the IPF-FDMC [3] full wave-code. These simulations calculate the conversion of the ordinary waves to extraordinary waves and the location of the region where the conversion was carried out. Moreover, the microwave heating scenarios for the toroidal position 330° are presented. The microwave heating scenarios showed the O-X-B mode conversion around 12%-14%.

Regarding the diagnostics, the mechanical and electronic design of the bolometer is presented (Figure 2), as well as magnetic diagnostics that have been developed.

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The case of the bolometer was designed based on the cylindrical geometry of the ports of SCR-1. The dimensions of the ports are 83.13mm and 72.9mm (depth and diameter respectively). The case itself has three cylindrical pieces made of stainless steel, with a pinhole of 0.8mm diameter to let the radiation hit the photodiode to measure the radiation energy emitted by the plasma. An electromechanical system was developed to auto-calibrate the position of the photodiode to get the maximum resolution to measure the radiation coming out from the stellarator. Concerning the magnetic diagnostics, Rogowski coils are going to be located close to the bolometer port, both inside and outside the vessel. The Rogowski diagnostic is essentially a toroidal solenoid placed around the plasma volume aiming to register the magnetic flux passing through the solenoid interior. Our Rogowski is designed to measure signals coming from currents of 0.1 A and up to 1.0 A. Meanwhile, diamagnetic loops are located at 0° and 90° on the toroidal axis angles, outside and inside the vacuum vessel, while Mirnov coils are at 0°, 45°, and 90° on the toroidal axis angles, with a total of 10 turns each one. The exact poloidal distribution of each set of the Mirnov diagnostics is not relevant in this first experimental stage, for which our only objective is to obtain reliable magnetic measurements and more pertinently. In conclusion, new diagnostics are implemented in SCR-1. A stainless steel bolometer was designed with an adjustable auto-calibration system that allows its use in different conditions. In total, 7 different sets of magnetic diagnostics are implemented. Meanwhile, the electron Bernstein waves could be damped by ion-electron collisions therefore it is necessary to know the ion density profile for the plasma of SCR-1 to calculate the ion-electron collision frequency.

References

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Country or International Organization

Costa Rica

Affiliation

Instituto Tecnologico de Costa Rica

Authors: Dr VARGAS, V.I. (Instiutto Tecnologico de Costa Rica); Prof. SOLANO-PIEDRA, R. (Instituto Tecnologico de Costa Rica); Prof. RAMÍREZ, A.A. (Instituto Tecnologico de Costa Rica); Prof. HERNÁNDEZ-CISNEROS, M. (Instituto Tecnologico de Costa Rica); Mr COTO-VÍLCHEZ, F. (Instituto Tecnologico de Costa Rica); Mr ROJAS-QUESADA, M.A. (Instituto Tecnologico de Costa Rica); Mr ARAYA-SOLANO, L.A. (Instituto Tecnologico de Costa Rica); PEREZ-HIDALGO, J.E. (Instituto Tecnologico de Costa Rica); Mr VÍLCHEZ-COTO, F. (Instituto Tecnologico de Costa Rica); Dr KÖHN, A. (IGVP, University of Stuttgart); Mr JIMÉNEZ, D. (Advanced Computing Laboratory, Costa Rica National High Technology Center, CeNAT); Mr CAMPOS-DUARTE, L. (Advanced Computing Laboratory, Costa Rica National High Technology Center, CeNAT,); Dr MENESES, E. (Advanced Computing Laboratory, Costa Rica National High Technology Center, CeNAT,); Mr CERDAS, F. (Instituto Tecnologico de Costa Rica); Mr GONZÁLEZ-VEGA, M. (Instituto Tecnologico de Costa Rica); Mr ARIAS, S. (Instituto Tecnologico de Costa Rica)

Presenter: Dr VARGAS, V.I. (Instiutto Tecnologico de Costa Rica)

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