ADVANCED-FUEL FUSION REACTORS WITH COMPACT HIGH-MAGNETIC FIELD TOKAMAKS

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Most of the nuclear fusion studies are currently devoted to the Deuterium-Tritium (DT) fuel cycle, the easiest way to reach ignition. The recent stress on safety by the world community has stimulated the research on other fuel cycles, based on advanced reactions, such as Deuterium-Helium-3 (DHe). With DHe, it is not necessary to breed and fuel tritium. The DHe cycle has a very low presence of energetic fusion neutrons, and it has the possibility to obtain electrical power by direct energy conversion of the protons. DHe fusion has its own set of problems, such as the availability of 3He and the attainment of the higher plasma parameters that are required for burning.

To begin to explore the possibilities of DHe plasmas, a burning plasma experiment at high magnetic field and high plasma densities like Ignitor and its evolution (Candor) are particularly attractive.

Candor, a design evolution of Ignitor in the direction of a reactor using a DHe fuel cycle, has been proposed; it is a feasibility study of a high-field DHe experiment of larger dimensions and higher fusion power than Ignitor, still based on the core Ignitor technologies.

The main characteristics of the Candor machine are the following: the major radius Ro is about double than Ignitor, plasma currents up to 25 MA with toroidal magnetic fields BT = 13 T can be produced. Unlike Ignitor, Candor would operate with higher values of poloidal beta around unity and the central part of the plasma column in the Second Stability region to the major plasma instabilities. To produce a similar strong magnetic field in a larger machine, the toroidal field coils are divided into two sets of coils and the central solenoid (air core transformer) is placed between them in the inboard part.

In Candor, the DHe burning regime can be reached by a combination of ICRF heating and alpha particle heating due to DT fusion reactions that take the role of a trigger. Thanks to this fact, and unlike other proposed DHe fusion experiments, Candor is capable of reaching DHe ignition on the basis of existing technologies and knowledge of plasma confinement.

This paper deals with a study of the feasibility of D-He3 plasmas ignition with DT initial trigger, the elaboration of suitable operating regime scenarios for Ignitor to study D-He3 burning, the study of the performance of Candor as a D-He3 burning fusion reactor, the evaluation of environmental and safety performance of Candor and comparison with other D-He3 burning experiments and the evaluation of the He3 supply for Ignitor and Candor and its possible sources.