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Reference Scenario for an Advanced Deuterium Power Plant System

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Abstract

The proposal is to make large deuterium (D-D) magnetic fusion power plants in which some (most) of the tritium produced by fusion is removed and stored. This tritium will ultimately decay to helium-3 that will be recycled to supplement the helium-3 produced by fusion. Thus the dominant fusion becomes that of deuterium and helium-3. The tritium would be removed using ion cyclotron waves in a similar manner to that proposed by Chang et al, and tested on TEXTOR, for removing alpha particles from a D-T plasma.

Interestingly, with this scheme it only takes about 25 years before the rate of helium-3 production is sufficient to support a doubling of such plants every decade, with very low tritium content. The importance of this is that the production of 14.1 MeV neutrons is substantially reduced over a standard catalyzed D-D plant and even more so over a D-T plant.

To be specific, if 90% of the tritium can be removed, the first power plant will average only 5.8% 14.1 MeV neutron power, when averaged over 30 years of operation. (5.8% of total plasma fusion power, any blanket neutron gain is extra). Later generations will get down to less than 4% of 14.1 MeV neutrons by using surplus helium-3 from earlier power plant operation. Ultimately, in steady state, the 14.1 MeV fraction will be 3% of total plasma fusion power.

Large tokamak power plants are used to illustrate the approach, because it is possible to use “ITER rules” to develop a consistent system. In reality, at large scale – 5000 to 6000 MW thermal – other systems may turn out to be superior.

C.S.Chang, “Control of Energetic Ion Confinement by Ion Cyclotron Range of Frequency Waves”, Phys. Fluids B 3 (1), 259, 1991.

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