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Supercritical CO2 Brayton power cycles for DEMO fusion reactor based on Helium Cooled Lithium Lead blanket

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Abstract— Fusion energy is one of the most promising solutions to the world energy supply. This paper presents an exploratory analysis of the suitability of supercritical CO2 Brayton power cycles (S-CO2) for low-temperature divertor fusion reactors cooled by helium (as defined by EFDA). Integration of three thermal sources (i.e., blanket, divertor and vacuum vessel) has been studied through proposing and analyzing a number of alternative layouts, achieving an improvement on power production higher than 5% over the baseline case, which entails to a gross efficiency (before self-consumptions) higher than 42%. In spite of this achievement, the assessment of power consumption for the circulating heat transfer fluids results in a penalty of 20% in the electricity production. Once the most suitable layout has been selected an optimization process has been conducted to adjust the key parameters to balance performance and size, achieving an electrical efficiency (electricity without taking into account auxiliary consumptions due to operation of the fusion reactor) higher than 33% and a reduction in overall size of heat exchangers of 1/3. Some relevant conclusions can be drawn from the present work: the potential of S-CO2 cycles as suitable converters of thermal energy to power in fusion reactors; the significance of a suitable integration of thermal sources to maximize power output; the high penalty of pumping power; and the convenience of identifying the key components of the layout as a way to optimize the whole cycle performance.

Index Terms— Balance of plant; Fusion power; Energy conversion; HCLL; DEMO

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