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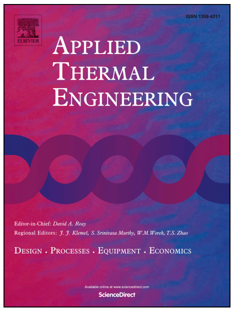

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Thermodynamic Analysis and Optimization of a Closed Regenerative Brayton Cycle for Nuclear Space Power Systems

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Abstract

Nuclear power systems turned to space electric propulsion differ strongly from usual ground-based power systems regarding the importance of overall size and mass. For propulsion power systems, size and mass are essential drivers that should be minimized during conception processes. Considering this aspect, this paper aims the development of a design-based model of a Closed Regenerative Brayton Cycle that applies the thermal conductance of the main components in order to predict the energy conversion performance, allowing its use as a preliminary tool for heat exchanger and radiator panel sizing. The centrifugal-flow turbine and compressor characterizations were achieved using algebraic equations from literature data. A binary mixture of Helium-Xenon with molecular weight of 40 g/mole is applied and the impact of the components sizing in the energy efficiency is evaluated in this paper, including the radiator panel area. Moreover, an optimization analysis based on the final mass of heat the exchangers is performed.

Highlights

- A design-based model of a Closed Brayton Cycle is proposed for nuclear space needs.
- Turbomachinery efficiency presented a strong influence on the system efficiency.
- Radiator area presented the highest potential to increase the system efficiency.
- There is maximum system efficiency for each total mass of heat exchangers.
- Size or efficiency optimization was performed by changing heat exchanger proportion.

Introduction

When compared to ground-based power systems, space power systems present a set of novel aspects, such as low power level, lightweight and a radiant heat rejection from the energy conversion scheme. For propulsion purposes, lighter power systems for the same power output promote more available mass for the payload. Furthermore, the high cost involved in