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Ecological coefficient of performance analysis and optimization of an irreversible regenerative-Brayton heat engine

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Abstract

In this paper, a performance optimization based on the ecological coefficient of performance (ECOP) criterion has been carried out for an irreversible regenerative Brayton heat-engine. The results obtained were compared with those using the power-output criterion and alternative ecological performance objective-function defined in the literature. The design parameters, under the optimal conditions, have been derived analytically and their effects on the engine's performance have been discussed. It is shown that, for the regenerative Brayton-engine, a design based on the maximum ECOP conditions is more advantageous from the point-of-view of entropy generation rate, thermal efficiency and investment cost.

Keywords: Brayton heat engine; Regenerative; Irreversible; Ecological optimization

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Nomenclature

A	heat-transfer area (m^2)
$\dot{C}$	heat capacity ($kW/m^2 K$)
$\dot{E}$	ecological objective-function (kW)
ECOP	ecological coefficient of performance
N	number of transfer units
$\dot{Q}$	heat-flow rate (kW)
S	entropy (kJ/K)
$\dot{S}_g$	Entropy-generation rate (kW/K)
T	temperature (K)
U	overall heat-transfer coefficient ($kW/(m^2 K)$)
$\dot{W}$	power output (kW)

Greek letters

ε	heat-exchanger effectiveness
ϕ	isentropic temperature ratio
η	thermal efficiency
τ	ratio of heat source to heat-sink temperature

Subscripts

0	environment conditions
C	compressor
H	high-temperature heat source
L	low-temperature heat source
max	maximum
mef	maximum ecological-function conditions
mp	maximum power-output conditions
R	regenerator
T	turbine
W	working fluid

Superscripts

—	dimensionless
*	maximum ECOP conditions

1. Introduction

Many optimization studies for heat engines have been carried out in recent years [1–3]. Usually, the power and power density or the thermal efficiency were chosen as an objective function and thus the design parameters at maximum power and power density or at maximum thermal efficiency were deduced. Some of these