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Performance improvement of a transcritical CO_2 refrigeration cycle using two-stage thermoelectric modules in sub-cooler and gas cooler

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ABSTRACT

A novel integration of a trans-critical CO_2 refrigeration cycle with thermoelectric modules in the gas cooler and sub-cooler is presented, wherein a two-stage thermoelectric generator (TEG) produces power from the waste heat of gas cooler, which is a considerable amount of required power in two-stage thermoelectric cooler (TEC) to sub-cool the refrigerant before expansion device. Mathematical simulation of TEG and TEC as well as energy and exergy based thermodynamic analysis of the proposed system is performed, and the effects of some important parameters on the system performance are investigated. A comparison is carried out between the proposed system and the simple CO_2 refrigeration cycle, indicating that the proposed configuration improves the coefficient of performance (COP) about 19%. Also, it is observed that the TEC and TEG have better performance in a two-stage configuration. The parametric study reveals that the new configuration decreases the cycle operation pressure at maximum COP and exergetic efficiency.

Amélioration de performance d'un cycle frigorifique transcritique au CO_2 utilisant des modules thermoélectriques biétagés dans un sous refroidisseur et un refroidisseur de gaz

Mots clés : CO_2 transcritique ; Générateur thermoélectrique (TEG) ; Refroidisseur thermoélectrique (TEC) ; Sous-refroidissement thermoélectrique ; Optimisation

1. Introduction

Carbon dioxide as a refrigerant has attracted the interest of researchers because of its unique thermal characteristics, such as low viscosity, good heat transfer coefficients, no toxicity, environmental benefits in comparison to HFCs, and no inflammability. CO_2 has a great potential for development of energy- and cost-effective refrigeration systems due to zero ODP (ozone depletion potential), negligible GWP (global warming potential), and very low cost (Yari and Mahmoudi, 2011). The major challenge in CO_2 refrigeration is the relatively high working

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