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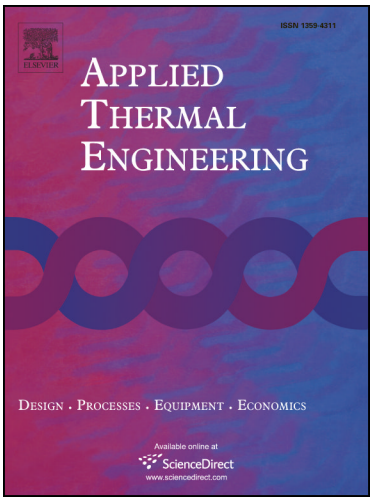

Research Paper

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A WATER-AMMONIA HEAT TRANSFORMER TO UPGRADE LOW-TEMPERATURE WASTE HEAT

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Abstract
A prototype water-ammonia absorption heat transformer has been built and thoroughly tested. Compared to water-salts mixtures, water-ammonia allows operating the machine in a lower temperature range, fostering recover of low-grade heat. Driving temperatures between 60 °C and 64 °C were tested, with condenser temperatures of 8 °C to 16 °C. The unit proved able to operate in a stable, reliable and repeatable way in this working range, achieving gross temperature lifts up to 25 °C and thermal COPs in the range 0.400-0.475. Useful effect up to 4.5 kW was achieved, with electric consumption always below 100 W.

Keywords
Heat transformer; water-ammonia; absorption; low-grade heat; prototype, heat recovery.

1. Introduction

1.1 Application of a low-temperature heat transformer

In industries, an average of 50% of the energy input is rejected into ambient [1], often with energy-consuming processes; one of the main hurdles to recovery being its low temperature. Connolly et al. [2] estimate that waste heat from industries in the European Union alone sums up to approximately 2700 PJ/year, about 4% of the total primary energy supply [3]. In a growing energy demand scenario, the exploitation of a fraction of such low temperature heat has relevant potential to improve the overall efficiency and reduce energy needs, emissions and costs.

The direct use of waste heat with passive technologies (heat exchangers and storages) to pre-heat other processes at lower temperature is the simplest option. Nevertheless, a significant share of waste heat is discharged at very low temperatures (<65 °C) [4]. Such waste heat can power very few processes [5]. Even ORC cycles are generally designed to work in a higher temperature range [6], and their efficiency becomes extremely low with such driving temperatures [7].

The alternative to the direct use of waste heat is its upgrade to higher temperature levels.

Vapour compression heat pumps can achieve quite large temperature lifts, with significant consumption of electrical energy. Absorption heat pumps, instead, replace the electrical requirements with a high temperature heat source to achieve their effect. In absorption heat transformers, the temperature increase is achieved by degrading a fraction of the low grade heat itself, thus without the need of a high exergy input, except for an almost negligible electrical consumption.

Besides the upgrading of waste heat from industry for internal reuse, a possible application of a low-temperature absorption heat transformer is in district heating networks, where it could ease waste heat or solar thermal energy recovery. This could be obtained with two possible configurations. In the first, the heat transformer could upgrade the temperature of these sources, allowing their integration in conventional district heating networks: those have an average supply temperature of 86°C in Sweden [8] and between 70 and 120°C in Denmark [9], the countries representing the state of art of the technology. Alternatively, in future 4th generation low-temperature networks, a heat transformer could locally increase the temperature for those end users that need it.

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