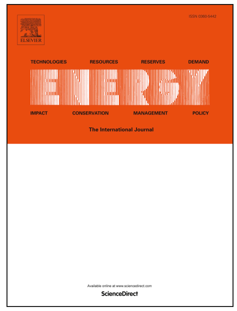

Thermodynamic analysis on theoretical models of cycle combined heat exchange process: The reversible heat exchange process

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Thermodynamic Analysis on Theoretical Models of Cycle Combined Heat Exchange Process: The Reversible Heat Exchange Process

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Abstract: Concept of reversible heat exchange process as the theoretical model of the cycle combined heat exchanger could be useful to determine thermodynamics characteristics and the limitation values in the isolated heat exchange system. In this study, the classification of the reversible heat exchange processes is presented, and with the numerical method, medium temperature variation tendency and the useful work production and usage in the whole process are investigated by the construction and solution of the mathematical descriptions. Various values of medium inlet temperatures and heat capacity ratio are considered to analyze the effects of process parameters on the outlet temperature lift/drop. The maximum process work transferred from the Carnot cycle region to the reverse cycle region is also researched. Moreover, influence of the separating point between different sub-processes on temperature variation profile and the process work production are analyzed. In addition, the heat-exchange-enhancement-factor is defined to study the enhancement effect of the application of the idealized process in the isolated heat exchange system, and the variation degree of this factor with process parameters change is obtained. The research results of this paper can be a theoretical guidance to construct the cycle combined heat exchange process in the practical system.

***keywords*:** Cycle combined heat exchange process; Reversible heat exchange process; Numerical solution; Process temperature analysis; Process work analysis

1. Introduction

For energy conservation and environmental protection, the waste heat emitted from power plants is important heat sources for the heating network [1]. However, for the purpose to control the contaminant emission and ensure environmental safety, the thermal power plants or the nuclear plants are usually set far away from the crowed urban areas and the scale of heating system should be larger. Therefore, the long distance heating supply technology is applied, but some problems are still need to be solved. One of the issues is the ineffectiveness due to the high thermal losses during the heat transportation [2], [3], [4]. Up to present, many solutions are proposed by the researchers to solve this problem. Among them, the large-temperature-difference heat supply technology with a large drop between the supply and return temperatures of the primary water in the heating networks is a meaningful to reduce the pump energy consumption and heat leak in the transmission process[5]. In the application of this technology, the temperature range of primary water is usually 110℃-25℃. However, the range of secondary water temperature for the heat demand side in the heating condition is 45℃-60℃. Comparing these two ranges, $T_{pri,in} > T_{sec,out}$ and $T_{pri,out} > T_{sec,in}$, it can be easily found that using the normal heat exchanger in the heat substation, the temperature variation curves of the two mediums will intersect, which is counterfactual according to the second law of thermodynamics.

In order to solve this issue, attempts are conducted to extend the heat exchange ability of the heat substation in the heating networks. In research works [5], [6], [7], the concepts of absorption heat exchanger and heat adaptor are presented, in their work, the absorption heat pumps and heat exchangers are combined as an AHE (Absorption Heat Exchanger), which is installed in the heating substations to exchange the heat form primary water to the secondary water. In the machines of AHE and the heat adaptor, the primary water is cooled by flowing into generator and the evaporator sequentially and the secondary water flows through the absorber and condenser to be heated. By the absorption cycles, the heat is extracted effectively and the temperature profile curves of the two mediums are intersected.

According to the former research[8], any types of heat-driven refrigeration cycles (such as absorption refrigeration cycle, adsorption refrigeration cycle and the steam jet refrigeration cycle) can be simplified as multi-heat-reservoirs refrigeration cycles with three or four heat sources, which can be shown in Fig. 1. In these cycles, two of the sources construct the heat engine cycle and the rest form a heat pump cycle, which is driven by the work from the former one.