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Abstract

Pro-Ecological Use of Waste Energy from the Cooling System of an Industrial Furnace †

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1. Introduction

The increase in energy prices is causing a renewed interest in methods of using existing energy sources. The association of technological processes seems particularly attractive. Another way of utilizing waste energy is to use it for social and living purposes or in another useful way. This approach to the process guarantees the possibility of reducing the consumption of primary fuels, reducing CO_2 emissions, and reducing the operating costs of a given technological installation.

2. Industrial Measurements

The simplest way to utilize part of the waste energy from electric metallurgical furnaces is to use the enthalpy of water to cool electrode fittings and other infrastructure elements exposed to high temperatures. Such systems are characterized by the simplicity of solutions based on standard liquid–liquid heat exchangers, which is why they are often used and described [1,2].

The low temperature of the liquid in the cooling circuit, approximately 60–70 °C, predisposes this enthalpy stream to be used in heating systems of buildings, dryers, or greenhouses. An additional convenience is the use of clean refrigerants in the circuits, which significantly extends the period of failure-free operation. However, a significant limitation is the seasonal variability of demand for this type of energy and the limited amount that can be used in relation to the total waste energy generated in the process.

The presented calculations and the proposed solution are based on measurement data obtained during the operation of an electric resistance-arc furnace. The results are presented for a selected, representative day of operation of the facility. Due to the specific nature of the technological process, the sequence of changes, and the recording of measurement data, a day is counted from 10 p.m. to 10 p.m. the next day. The energy flow supplied to the furnace is shown in Figure 1.

The cooling system and the elements of the connection infrastructure to the collectors are shown in Figure 2. Some of the connections were made with flexible hoses due to the movement of the elements. The temperature distribution in the collective collectors of the furnace cooling system is shown in Figure 3. The highest temperatures of the glycol solution were recorded in the collective collector and are approximately 70 °C.

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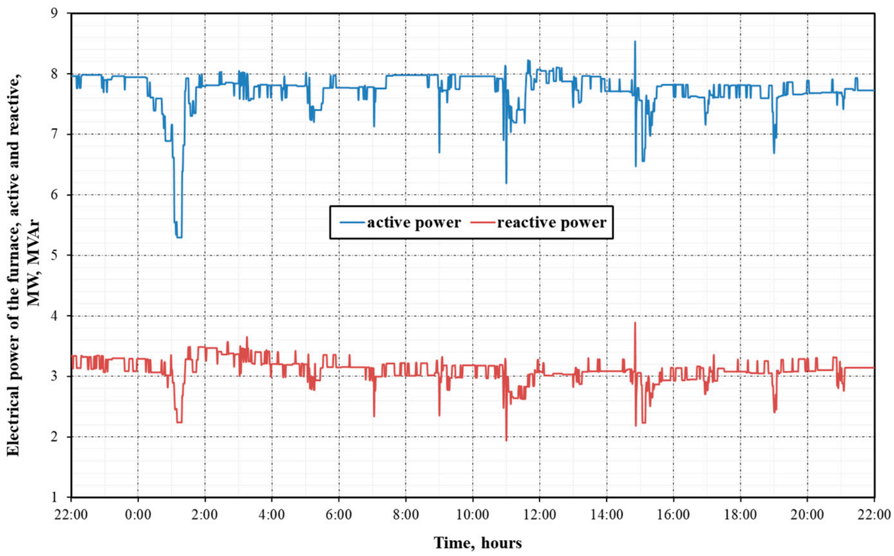

Figure 1. Stream of electric energy supplied to furnace.

Figure 2. Collective collectors together with elastic pipes of cooling system.

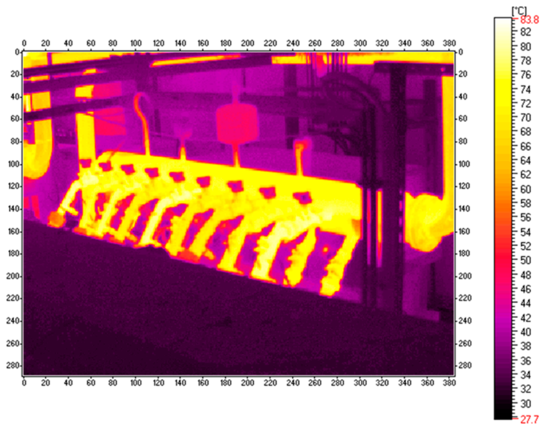

Figure 3. Temperature distribution in the collective collectors of the furnace cooling system.

3. Results and Discussion

The daily temperature change in the secondary circuit of the furnace cooling system exchanger is shown in Figure 4. The increase in the water energy flow in the cooling circuit is shown in Figure 5.

Due to the variability and seasonality of the demand for thermal energy in the system, there is a fan cooling tower shown in Figure 6, which enables smooth control of the temperature of the circulating medium in the cooling system. It also provides additional protection of the system when heat is not collected for social purposes [3–7].

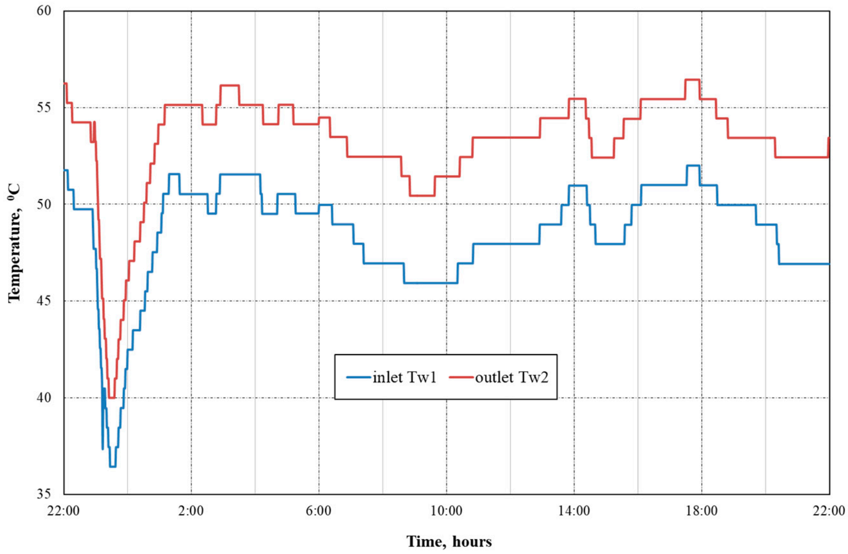

Figure 4. Water temperature in the furnace cooling system.

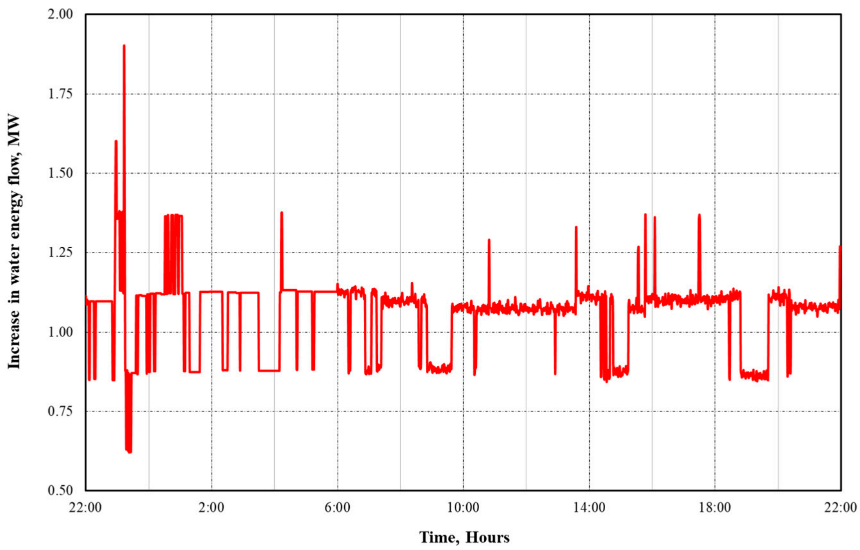

Figure 5. Increase in water stream energy in furnace cooling system.

Figure 6. Fan cooling bed of furnace cooling system.

The presented waste energy management solution is characterized by a simple implementation system. The liquid–liquid exchanger used is characterized by small dimensions with significant power. The average power that can be used in the energy recovery system during the normal operation of a metallurgical furnace is 1 MW. Assuming a price of EUR 15 per 1 GJ of thermal energy, this translates into savings of approximately EUR 1300 per day in the winter season.

The use of waste energy from the considered technological installation reduces fuel consumption, carbon dioxide emissions, and operating costs [8].

4. Conclusions

The analyzed system for using waste energy from the cooling system of a metallurgical resistance-arc furnace has many significant advantages as follows:

➢ simplicity of design and small dimensions,
➢ smooth power regulation in the recovery system in accordance with the current demand thanks to the use of a fan cooling tower as a substitute receiver,
➢ measurements and calculations show that the average power that is used in the energy recovery system during the normal operation of a metallurgical furnace is 1 MW.

Assuming a price of EUR 15 per 1 GJ of thermal energy, this gives savings of approximately EUR 1300 per day in the winter season. Thanks to the use of a fan cooling tower, the flexibility of the proposed system has increased, regardless of the current heat demand. Implementing this solution can contribute to significant savings and economic profits.

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