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Complex and efficient waste heat recovery system in aluminum foundry

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Abstract

The study presents the evaluation of a heat recovery system in a Romanian aluminum foundry. The study was based on a thermal power balance that revealed on one side that the components of the balance is in good agreement with similar results presented in the literature and revealed on the other side the heat recovery potential from the available waste represented by exhaust gases. The proposed heat recovery from waste is capable to recover more than 25% of the total thermal power of the burners, equivalent with more than 60% of the available waste.

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Keywords: phase change material; sphere; air conditioning

1. Introduction

The aluminium foundry industry is a high energy consuming sector. By examining the overall footprint, the monetary and environmental costs can be determined and minimized through different value engineering techniques [1].

An important task of this industry is to determine the heat losses and the recovery potential over the complete process line of liquid metal handling [2].

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Engineering in traditional foundry is usually regarding the quality of casting component as the most important issue and leave the energy saving or energy efficiency as the subsidiary one [3, 4].

Aluminum melting furnaces operate at energy efficiencies of (10…38) % with a strong potential to achieve over 40% efficiency improvement [5, 6].

Close to half of the total energy input to aluminum furnaces leaves it as waste heat, which may be harnessed for useful purposes [7]. Fundamentals of heat transfer processes that may be used for the heat recovery are presented in [8].

Exhausted gas from the aluminum furnaces is the most important waste than can be recovered because of the very high energy content, being reported as (40…60) % [5, 6, 9].

It is also reported that somewhere between (20…50) % of industrial energy input is lost as waste heat in the form of hot exhaust gases, cooling water, and heat lost from hot equipment surfaces and heated products [10].

The goal of this study is to analyse several heat recovery solutions and to present a very efficient one, capable to convert waste into heat, cold and electricity.

2. Material and method

The study refers to the aluminum foundry Schulte & Schmidt from Braşov, Romania.

The foundry is equipped with three types of furnaces manufactured by Hindenlang KLV: KLVE-1200 (1200 kg), KLVE-600a (700 kg) and KLVE-600b (500 kg). The total number of furnaces is 8 and all are equipped with natural gas burners.

The melted aluminum is used in 10 under pressure moulding machines. In the warm periods of summer time, between (4…6) machines can't be operated, because of the insufficient cooling capacity of the existing hybrid cooling system, based on one electric chiller and one water cooling tower.

The cooling capacity of the existing chiller (160 kW) was not increased during the time, when new furnaces and moulding machines were mounted into the foundry. The cooling capacity of the existing cooling tower is unknown but insufficient. The maximum cooling demand was calculated at (400…420) kW based on technical data of the moulding machines and the maximum deficit of cooling power, during summer, was calculated at (240…260) kW.

The analysis of chemical composition of exhausted gas was performed in order to evaluate the thermal potential of the waste to be recovered.

From technological point of view, pairs of furnaces are linked to single chimney flue, thus existing 4 chimneys serving the 8 furnaces.

One important characteristic of the gas exhausting system is the presence of gaps between the furnaces and the chimneys. Due to these gaps, false air enters into the exhausted gas flow channels and high excess air was revealed in all the chimneys.

On each chimney, were performed several measurements and the average measured parameters of the exhausted gas are presented in table 1.

Table 1. Average parameters of exhausted gas

Parameter	Value	u.m.
Exhaust temperature	700	°C
Excess air (λ)	2.6	-
CO_2	5	%
NO	40	ppm
NO_x	40	ppm

Based on these parameters it was calculated the burning process.

The evaluation of the thermal powers balance was the first step of the analysis.

The main components of the thermal powers balance are calculated as follows for each of the 3 types of furnaces:

- The thermal powers of burners (btp) was estimated at 75% of the maximum capacity of the gas burners from each furnace based on the produced flue gas rate;

- The useful thermal power (utp) was calculated as:

$$utp = \frac{m \cdot c_s (t_m - t_s) + m \cdot l + m \cdot c_l (t_l - t_m)}{\tau} \; [kW] \quad (1)$$