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Optimization Applied to Heat Loss Through Industrial Furnace Walls

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1 Introduction

Industrial furnaces are equipment intended for heating materials, aiming at various purposes such as cooking, melting, heat treatment, drying and others. Regardless of the work to be performed, it is expected that the furnace will be capable of transferring the heat generated by the combustion to the material with maximum efficiency, uniformity and safety. In this perspective, it is of fundamental relevance a detailed study of the materials that compose the walls of the furnace, guaranteeing, therefore, the maximum energy efficiency of the device through the minimum spent fuel and also ensuring its required structural characteristics.

The optimization may be seen as a strategy used in several sectors of science, seeking, through specific objectives, the choice of the option of greater viability. From this perspective, optimization is the act of obtaining the best results given certain circumstances [1,3]. In this work, we analyze the optimization of industrial furnace walls made up of multiple layers composed of different refractory and structural materials. In such context, we look for interval of parameter values related to the thermal conductivity, the mechanical strength of the structure and the cost of production of the materials that optimize the rate of heat transfer to the external environment.

2 Heat Loss Process and Search Variables

The heat loss process in this type of system can be analyzed as a thermal circuit, in which each region through which the heat flows represents a thermal resistance to the tranfer energy [2]. The Figure 1 shows a representation of the such circuit.

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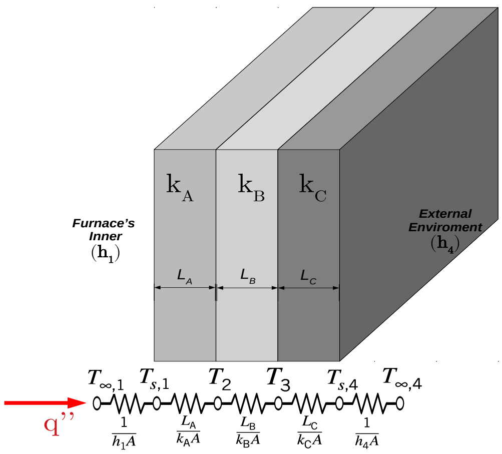

Figura 1: Thermal circuit for the process of heat transfer through the wall of an industrial fornice.

Considering conduction and convetion process, the heat transfer rate per unit area for this system depends on parameters as the thermal conductivity and convetion given by.

$$q'' = \frac{T_{\infty,1} - T_{\infty,4}}{\frac{1}{h_1} + \frac{L_A}{k_A} + \frac{L_B}{k_B} + \frac{L_C}{k_C} + \frac{1}{h_4}} \tag{1}$$

The research carried out here is to find optimal values of thermal conductivity of the composite materials of the kiln wall layers, that promote the minimum rate of heat transfer, taking into account its mechanical strength (Young's modulus E and Poisson's coefficient ν), the cost associated with its production and the required fluid temperatures $T_{\infty,1}$ and $T_{\infty,4}$.

The Pareto Frontiers obtained provide valuable information about which options are most appropriate for each type of furnace structure. The study conducted here also serves as a basis for the optimization of more complex structures and with different geometries and compositions.

Referências

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