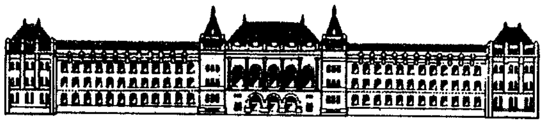

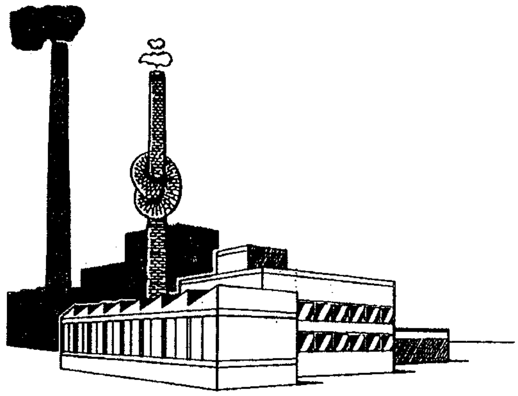

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OPTIMUM DESIGN OF WALL STRUCTURES OF EQUIPMENT WORKING ON HIGH TEMPERATURE

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Introduction

There are more than ten thousand equipment working on high temperature in Hungary (furnaces, boilers, drying ovens, reactors). Most of them became obsolete, working with high waste ratio and with short lifetime. The maintenance and modernisation of this equipment claim a great amount of fire-proof materials and labour work, high level of knowledge and great cost.

The greatest bases of the decreasing of mechanical and metallurgical energy are the high temperature equipment, the industrial furnaces and the heating power engineering machines. It is possible to decrease the energy consumption of the equipment, working on high temperature, by making some developments on the combustion technology, on the construction. The costs of this equipment can be optimised. An important part of the constructional changing is the modernisation of the wall structure of this equipment.

At the furnaces a great part of the total cost of the structure represented by the cost of the wall. This is the reason, why we have installed the well-known structural optimization techniques to solve this type of problems, to build a computation technique, which is able to determine optimal walling from the point of view of costs, taking into account the technological requirements.

The level of structural design has an important role in the efficiency of the economy. The aim of the modern structural design is the material, cost and energy savings, to increase design reliability and reduce time to do it and these have a great effect on the economy of products as well [1].

Optimum design of the wall structure

The aim of our work is to develop a decision support system runs personal computer. The optimization of the walling means finding the minimum of the costs.

There are two general costs at the walling: cost of establishing the wall:
- the realisation cost depends on the cost of used materials, the assembly costs and the lifetime of the materials,
- the cost of the energy lost through the wall of furnace to surrounding and the cost of the stored energy in the wall.

At the optimization one should build an objective (merit) function, which extreme gives the optimum. Regarding a continuously working furnace the objective function (K, HUF/year)) contains the material cost for a year (K_1), the assembly cost of the wall (K_2) and the energy cost due to energy, lost through the wall (K_3).

The specific costs are determined by the material grade of the wall (P_i), the assembly costs (L_i) are determined by behaviours of the different layers a,b,c (ρ, λ,c) the thicknesses (S_i) and the surface of the wall (A). (beside the surface, the amount of heat treated materials (T), the number of working hours per year (t), the intensity of the production and the used energy (P_w) have great effect on the costs).

$$K = \frac{a.(P_a + L_a)}{T} + \frac{b.(P_b + L_b}{T} + \frac{c.(P_c + L_c)}{T} + \varphi.t.P_w.A$$

where φ is the specific energy loss factor of the wall [W/m^2].

We were looking for an optimum of the above described objective function using the modified Rosentrock's Hillclimb procedure. The direct search technique is able to determine the optimum due to non-linear and multivariable objective function and inequality design constraints. The optimum usually means minimal mass, or cost, or maximal reliability.

The program can find the discrete optimum, using commercially available sizes. The program runs on IBM PC 486 compatible computer in Borland C++ language.

There is a data base developed for the computation, contains the material behaviours, such as the maximum working temperature of the material, density, specific thermal capacity, the heat transfer coefficient, the material and assembly costs.

Conclusions

We have made several computations with different materials and structural layout:

- the size constraints are usually active, so the upper and lower sizes have a great effect on the results,

- the layer thicknesses can be zero at the optimization, so this layer is unnecessary, can't reduce the cost.

The developed computer program is able to determine the optimum wall structure using different materials, taking into account the necessary costs and energy.

[1] Dr.Mikó,J., Dr.Szemmelveisz Tné, Dr.Jármai, K.: Design of economic fire-proof walling (in Hungarian). Combustion Techniques 92. XXVIII. Industrial Seminar, Miskolc, House of Science and Techniques, Aug.26-28. 1992. Proceedings p.178-189.