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8TH INTERNATIONAL CONFERENCE on THERMAL ENGINEERING and THERMOGRAMMETRY with Exhibition and Hungarian pre-session on Thermal Energy

VIII. Nemzetközi Hőtechnikai és Termogrammetriai
Konferencia
kiállítással és hazai hőenergetikai előszekcióval

2-4 June, 1993
(pre-session: 1 June)
House of Technology, Budapest, Hungary
MTESZ Székház

ABSTRACTS

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COMPUTER AIDED DESIGN OF REFRACTORIES

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.

The greatest base of the decreasing of mechanical and metallurgical energy are the industrial furnaces and the heating power engineering machines. The energy, used for the heating industrial furnaces, reaches the 20% of the energy consumption of the country.

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 these equipment can be optimized. *An important part of the constructional changing is the modernization of the wall structure of these 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've installed the well known structural optimization techniques to solve these 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 aim of our work is to develop a *decision support system on personal computer* [1,2].

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, contains the material and realization costs; the cost of the energy lost through the wall of furnace to surrounding and the cost of the stored energy in the wall.

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At the optimization one should build an objective (merit) function, which extreme 'es the optimum. Regarding a continuously working furnace the objective ıction is as follows:

$$K = \sum_{i=1}^{n} \frac{x_i.(P_i + L_i)}{t_a} + \varphi.t_{year}.P_{fuel}\frac{3600.}{F_{fe}};\left[\frac{Ft}{year}\right]$$

where

K: is the specific cost of the unit surface of the furnace for a year,
n: is the number of layers at walling,
x_i: is the thickness of a layer [m],
P_i: is the cost of a layer [Ft/m^3],
L_i: is the assembly cost of a layer [Ft/m],
t_{year}: is the working time in a year [hour],
t_a: the amortization of the furnace [year];
P_{fuel}: is the cost of the fluel [Ft/m^3],
F_{fe}: the heating value of the fluel, [J/m^3],

$$\varphi = \frac{T_{fb} - T_k}{\sum_{i=1}^{n} \frac{x_i}{\lambda_i} + \frac{1}{\alpha_k}};\left[\frac{W}{m^2}\right],$$

T_{fb} : is the inside room temperature of the furnace [° C],
T_k : is the outside temperature [° C],
α_k : is the heat transfer coefficients between the outside surfaces of the furnace d the surrounding area,
λ_i: is the heat-conveying coefficient of a layer material, which depends on the erage temperature of the layer [W/m^2.° C].

We are looking for an optimum of the above described objective function due the following constraints:

- n = 3 number of layers,
- the minimum sizes of the layers are $x_{1min} = 0.065$ [m]; for the other layers $x_{imin} = 0.$; (i = 2,3);
- the minimal steps at discrete values are 0.005 [m]
- the maximum sizes of the layers are $x_{imax} = 0.5$ [m]; (i=1,2,3),

- the total thickness should be $\sum x_i \le 0.5$ [m],
- the values of the temperatures
  $T_{fb} = 1300$ [° C],
  $T_k = 10$ [° C],
  $T_{fk} <= 70$ *[° C]; the outside surface temperature of the furnace.*
- the heat transfer coefficient $\alpha_k = 11.1$ [W/m^2 ° C],
- the amortization time is 3 years practically,
- the working time in a year is 6500 hours,
- we've taken natural gas as fluel, which price is 12 [Ft/m^3];
- the heating value of the fluel is [35 MJ/m^3];

Material code	Temp ° C	Dens. kg/m^3	Prices Mater.	Ft/m^3 Manuf	Heat a_0	convey. a_1	coeffic. a_2	a_3
Chamotte								
T4	1400	1850	23998	20000	0.8705	4.41e-4	1.49e-8	0.
Foamed chamotte								
DVM3	1380	550	52480	7400	0.2556	-6.62e-5	3.17e-7	-8.7e-11
DVM5	1400	800	47732	7150	0.3276	-8.2e-5	4.73e-7	-1.8e-12
Concrete								
L18	1380	2000	99200	20000	0.961	-8.47e-4	9.93e-7	-2.3e-10
L12	1240	1950	74256	20000	0.822	-8.07e-4	1.09e-7	-3.5e-10
FL10	1300	1400	92700	17000	0.867	-1.75e-4	2.61e-6	-1.06e-9
L04	1000	510	34800	7500	0.1605	-3.4e-11	7.5e-8	0.
Fibrous materials	700	120	4480	4500	3.92e-2	2.67e-4	0.	0.
Isolyth	1100	130	34650	10000	6.67e-4	2.18e-4	-1.54e-8	1.2e-11
Sibral								
RATH KMOD 1650/80	650	160	36000	13500	-5.0e-3	2.1e-4	-1.95e-7	1.9e-10
RATH KMOD 1260	1260	130	30000	11000	4.29e-2	-2.05e-5	2.79e-7	-5.2e-11

Table 1.
List of used fireproof and heat insulator materials.

- the heat-conveying coefficients of the different fire-proof materials are approximated by a polynom, where parameters are depend on the average temperatures of the layers in the following way:

$$\lambda = a_0 + a_1.\overline{T}_1 + a_2.\overline{T}_2 + a_3.\overline{T}_3$$

We've used the modified Rosentrock's Hillclimb procedure to find the optimum. *The direct search technique is able to determine discrete optimum, using commercially available sizes* [2]. The program runs on IBM PC 486 compatible computer under Borland C++. The flow chart of the computer program can be seen in Fig.1.

where

S_i: is the step length,

x_i: is the wall thicknesses as variables,

N: is the number of variables,

α and β are parameters to accelerate if the direct search direction is good, or brake if the direction is bad.

We've made computer runs with the most frequently used materials. We've checked several wall structures with three layers. The codes and the main parameters of the chosen materials can be seen on Table 1.

Code number	1st layer	2nd layer	3rd layer
1	T4	DVM3	ISOLYTH
2	T4	DVM5	SIBRAL
3	DVM5	L04	ISOLYTH
4	L18	L04	SIBRAL
5	FL10	L04	SIBRAL
6	DVM5	SIBRAL	ISOLYTH
7	L12	SIBRAL	ISOLYTH
8	L04	SIBRAL	ISOLYTH
9	KMOD 1650	ISOLYTH	ISOLYTH
10	L04	KMOD 1650	ISOLYTH
11	L18	KMOD 1650	ISOLYTH

Table 2.
The variation of the different materials in three layers.

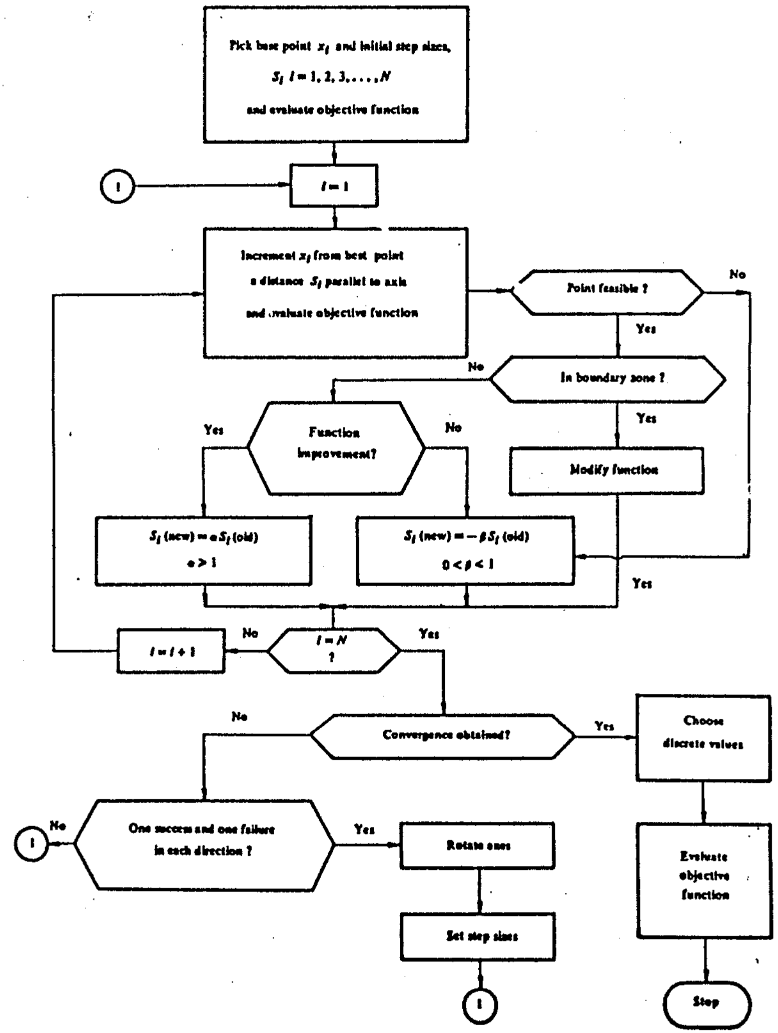

Fig. 1.
Flow chart of the Hillclimb procedure

At the optimization to take into account the different material grades is very ifficult. The combination of the chosen materials is great, a number of different wall-tructures can be built, so *we've chosen only a limited number of variation* according to able 2.

We have no results checked from all aspects. **The first runs show the following onclusions:**

- the size constraints, the minimal and maximal sizes, have a great effect on the otimum. These constraints are usually active.

- at the optimization one of the wall thicknesses became zero. In this case there e only two layers in the wall structure.

- among the constraints there was no any constraints on average temperature in e layers. We think, this is a new way to develop the next model.

- at the cost function the material-assembly and the cost of the heat loss have pposite effect: if the first part is greater, than the wall thicknesses are decreasing, herwise if the heat lost price is greater, than the thicknesses are increasing to the nit.

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Acknowledgement: the research was supported by the Hungarian Fund fc ientific Research under grant No. OTKA 4407/1992-96.

INTERACTIVE VISUALIZATION SYSTEM FOR 3D GRAPHICS POST-PROCESSING

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The problem of graphics treatment of model and experimental results in Thermo-CAD has received increasing attention of scientists who work in this branch of science.The traditional approach to analysis data is a very time consuming and expensive process. The computer graphics post-processing is the way to increased productivity of scientist and engineers. The objective of this work is the software for graphics control of data in investigations : the LEONARDO graphics system.

The LEONARDO is interactive visualization system with integrated windowing environment. This is written for the MS Windows IBM PC user. LEONARDO is a system for treatment of 1D, 2D fields and 3D fields of numerical data of different nature: scalar and vector fields, section of structured data in 2-3 D space, for example for heat-mass transfer fields distribution, emperature or electromagnetic fields and another users data. The LEONARDO is powerful and portable visualization system for 3D fields data treatment,includes cartesian and special bodyfitted coordinate systems.

The basis of ideology of functioning of our graphic system is the possibility of draw designing in free style with matching of different graphic modes by presentation of information.The LEONARDO graphics is operating on WINDOWs user environment. The programming in this environment requests the more distinctly xpressed specialization of windows according functioning indication.

The user before graphics treatment must write the special text or binary file hat presents the result data in arrays form. The number and type of field uantities, coming from experiments or model computations,is defined by user. This ile contains the information about solvers grid, names of data arrays and symbolic ata about geometry and boundary of the model with blocked zones too. The LEONARDO has a context-sensitive, mouse operated graphical user interface GUI). It consists of a set of pulldown menus,that allow the selection and ombination of various representations, such as contours fields and shaded contours naps), arbitrary cutting planes, vectors fields, sections and profile, iagrams,drawings and text. The GUI consists of main toolbox iconographic menu nd different dialogue boxes.Viewing operations and interactive interrogation of the ata fields are ensured through the use of cursor and windows buttons. The system upports a multiwindow concept in which graphics can be displayed independently in pened windows with different additional facilities, such as undoing ommands,interactive picking for selection and removal of graphics objects.

The multiwindow environment allows the user to analyze quickly different ata loading during sitting and repeat operations for comparative analysis. The data presentations are subdivided into scalar and vectors. For graphical treatment of alar values the contours,isosurfaces with color shade are used on 2D, 3D zones. ocal profiles and value distribution are available as one-dimensional graphics or ction line but set of vectors can be shown with different colored attributes: gments, footers and arrows. All previously mentioned probes are available for 3D tting planes. Other special features such as hidden-line removal, block fill and undary plot enhance the visualizations of complex model. If the user wants to