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The analysis of influence of various parameters on heat conduction of a number of heat-insulating materials

Annotation. *The results of the analysis of influence of some main process factors on heat conduction of heat-insulating materials are given in this article. As major factors were considered: density, temperature, humidity. Researchers are conducted on the basis of the theory of planning of experiment. The got dependences of heat conductivity on a closeness and temperature of material show approximately equal influence of these factors on the exit of experiment.*
Key words: *heat conduction, experiment planning, heat-insulating material, temperature, density.*

Before the experiment it is necessary to work out the independent the input parameters and output parameter. As the output parameter, the heat conduction of the material is used. As the input parameters, the temperature, density, humidity and structure are used. In order to obtain the dependence it is planned to use the regression equation such as [1]:

$$y(b,x) = b_0 + \sum_{i=1}^{n} b_i x_i + \sum_{i=1}^{n} \sum_{k=i+1}^{n} b_{ik} x_i x_k + \sum_{i=1}^{n} \sum_{k=i+1}^{n} \sum_{l=k+1}^{n} b_{ikl} x_i x_k x_l + \ldots + b_{12\ldots n} x_1 x_2 \cdot x_n , \quad (1)$$

where b_0 – the free term, is equal to the output at x=0;

bi – the coefficient of regression, indicating the influence of a factor on the process

bij – the coefficients of regression, defining the impact degreeon the process of the interaction of the factors .

Having defined the regression coefficients of this equation, we will have an idea of the influence of the studied factors on the heat conduction amount, about the interaction of the factors and about the direction of the movement to the optimum area.

Thus, the task algorithm of the factorial experiment comes to the following operations:

1) choosing of the equation of regression;
2) planning the multiple-factor experiment;
3) calculation of regression coefficients, assessment of the importance of these coefficients;
4) analysis of the regression equation.

The equation of regression is written depending on the number of the studied factorswhich definethe process.

During a matrix making of planning, it is necessary to consider that in this experiment all possible combinations of meaning of the factors have to be worked out. During the determination of the model parameters estimations, it is often possible to choose freely the conditions of the experiences in limits of some borders. The choice of a number and conditions of the experiments, providing the getting of the best number in the definite sense of the research result, makes the experiment planning purpose.

For each definite type of material, according to the analysis of an influence assessment of the various factors on heat conduction, presented in the chapters 1 and 2, as factors of the experiment we choose:

x_1 - density, kg/m^3;

x_2 - temperature, °C;

x_3 - humidity, %.

Humidity of an insulating material at operation of the high-temperature aggregates will not be so relevant. So, this factor can be omitted.

For physical reasons it is possible to consider that the interrelation (1) has the following aspect:

$$y(b,x) = b_0 + b_1 x_1 + b_2 x_2 + b_{12} x_1 x_2 -- . \quad (2)$$

The necessary number of experiments: N= 2^n, where n – the quantity of the studied factors.

As it has been already mentioned above, the number of some main factors, influencing on the amount of heat conduction, is equal 2. Therefore, the number of interactions N = 2^n = 2^2 = 4.

The following formulae are used to calculate the regression coefficients:

$$b_i = \frac{1}{N}\sum_{j=1}^{N}\overline{y}_j x_i^j, i = 0,..,n$$
$$b_{ij} = \frac{1}{N}\sum_{j=1}^{N}\overline{y}_j x_i^j .. x_\mu^j, i, \mu = 1,2,..,n, \qquad (3)$$

where $\overline{y}_j$ - thevalue of an average output of the process in j-variant;

x_i^j - thevalue of a factor in j-variant.

The intervals of a variation of the experiment factors for mineral cotton are presented in the table 1.

Table 1 – The intervals of a variation of the experiment factors for mineral cotton

Factors	The main level ($x_i = 0$)	The intervals of a variation	The high level ($x_i = +1$)	The low level ($x_i = -1$)
x_1	113,05	13,65	126,7	99,4
x_2	220	180	400	40

The high and low levels are limit values of the varied variables. The area of the experiment planning: $-1 \le x_i \le 1$. It was received by the transition to dimensionless variables or to so-called coding of the factors:

$$x_i = \frac{a_i - \overline{a}_i}{|\Delta a_i|}, \qquad (4)$$

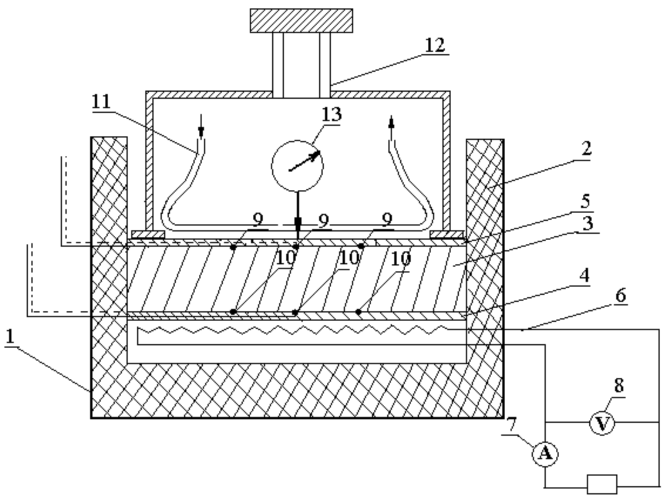
Where a_i - a factor (value of i- variable in the natural scale of measurement);

$\overline{a}_i$ - average level;

$\Delta\alpha_i$ - variation step.

For acquisition of data about the influence of the various factors on heat conduction of an insulating material, the stand (figure 1) consisting of the metal case 1, filled with thermal isolation 2 for decrease of the thermal losses in the environment [2] was used.

The investigated material 3 is located between the warmed and cooled plates 4 and 5 respectively. Heating is made by means of the electric heater in the form of a flat tile 6; the power of the electric heater is determined by ammeter 7 and voltmeter 8 indications. The temperature of a heated surface of the studied material is taken by three thermocouples 9, the temperature of a cooled surface - thermocouples 10. The cooling of a material is run at the expense of the refrigerator 11 in which the cooling water circulates. The mechanical loading is created by means of the mechanism of a subpress 12; the thickness of a layer of the material is measured by the caliper 13. The base of the cylinder is also heat-insulated. It increases the average temperature of measurement, reduces the temperature distortion on the cold side of a surface of the material and reduces heat dispersion in the environment.



1 - case;
2 - thermal isolation;
3 - studied material;
4 - warmed plate;
5 - cooleplate;
6 - electric heater;
7 - ammeter;
8 - voltmeter;
9, 10 - thermocouples;
11 - refrigerator;
12 - mechanism of a subpress;
13 - digital caliper

Figure 1 - The scheme of an experimental installation

The chain ofthe temperature measurements consists of thermocouples, the thermocouples switchand the universal eight-channel measuring instrument regulator – OVEN TRM 138 whose indications are transferred to the computer. The thermocuples' simplicity and universality are the main advantages of thermocouples. At a choice of the materials for thermocouples it is necessary to ensue to that they allow to receive the big thermo-e.m.p. (electro moving power) and that properties of the thermocouple changed slightly at the repeated heating. Therefore, in this experiment the chromel-copel thermocouples, working at the temperatures up to 800 °C [3], are applied.

The following materials were taken for the analysis of the influence of the insulating material'sstructure on its coefficient of heat conduction: 1) a quilted mat out of the mineral cotton of the mark 100 and 150 (GOST-21880-94); 2) material SuperSIL; 3) quilted basalt mats TU 5769-001-73902414-2005 [4-5].

The samples of the studied materials were placed into the experimental installation. The coefficients of heat conduction of these fibrous materials depending on the various options of the factors were defined.

The calculation is made on the ECM according to the developed program for the determination of these coefficients (a programming language – Pascal). Except the calculation of regression coefficients, the program determines the sum of squares of mistakes and defines the adequacy of a model.

Table 2 - Matrix of the experiment planning

Experiment number	Planning				Result
№	x_0	x_1	x_2	x_1x_2	y, Вт/м°С
1	+	+	+	+	0,131
2	+	-	+	-	0,126
3	+	+	-	-	0,051
4	+	-	-	+	0,048
b_i	**0,098**	**25,36**	**-19,28**	**7,89**	

Thereby, the interpolation formula for mineral cotton is as follows

$$y = 0{,}098 - 19{,}28x_1 + 25{,}36x_2 + 7{,}89x_1x_2. \quad (5)$$

Using this technique, the heat conductions of other materials were investigated. The interpolation formula for basalt isolation has the following aspect

$$y = 0{,}038 - 25{,}78x_1 + 36{,}54x_2 + 11{,}22x_1x_2. \quad (6)$$

The interpolation formula for the material Super Sill is as follows

$$y = 0{,}138 - 14{,}55x_1 + 21{,}33x_2 + 6{,}46x_1x_2. \quad (7)$$

Finally, the dependences of heat conduction on density and temperature of the material, received by the method of experiment planning, show the approximately equal influence of these factors on the experiment output.

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ТҮЙІН

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Түрлі параметрлердің кейбір жылу өткізбейтін материалдардың жылу өткізгіштігіне әсері

Мақалада процестін негізгі факторлардың жылу оқшаулағыш материалдардың жылу өткізгіштігіне әсерін талдау нәтижелері келтірілген. Негізгі факторлар ретінде тығыздық, температура және ылғалдылық қарастырылған. Зерттеулер тәжірибені жоспарлау теориясы негізінде өткізілген. Материалдың тығыздығы мен температурасына жылуөткізгіштіктің алынған тәуелділіктері осы факторлардың эксперимент нәтижесіне шамамен бірдей әсер ететінін көрсетті.

Түйін сөздер: *жылу өткізгіштік, тәжірибені жоспарлау, жылу оқшаулағыш материал, температура, тығыздық*

РЕЗЮМЕ

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Анализ влияния различных параметров на теплопроводность ряда теплоизоляционных материалов

В статье приведены результаты анализа влияния основных факторов процесса на теплопроводность теплоизоляционных материалов. В качестве основных факторов были рассмотрены: плотность, температура, влажность. Исследования проведены на основе теории планирования эксперимента. Полученные зависимости теплопроводности от плотности и температуры материала показывают примерно равное влияние этих факторов на выход эксперимента.

Ключевые слова: *теплопроводность, планирование эксперимента, теплоизоляционный материал, температура, плотность.*

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Пути повышения энергосбережения при производстве агломерата на Аксуском заводе ферросплавов ТНК «Казхром»

Аннотация: *В данной статье рассмотрены вопросы рационального использования отходов производства ферросплавов для экономии затрат, выполнен расчет энергоэффективности производства агломерата, приведены данные теплового баланса спекания на материалах Аксуского завода ферросплавов. Согласно расчету годового экономического эффекта получено: за счет рециркуляции аглогазов экономия топлива составила 1334,5 т.у.т.; за счет дожигания СО – 1491 т.у.т.; с установкой тирристорных преобразователей на агрегате годовая экономия электроэнергии составила 1714 тыс. кВт·ч. Таким образом, выявлено, что, кроме энергосберегающих мероприятий при переработке твердых и газообразных отходов, использование агломерата также повысит производительность электропечей АЗФ, снизит удельный расход электроэнергии и расход восстановителя, а, значит, себестоимость готовой продукции.*

Ключевые слова: *аглогазы, отходы металлургического производства, утилизация ферросплавных газов, рециркуляция, экономия тепла.*