КОНТРОЛЬ ЯКОСТІ, ІНФОРМАЦІЙНІ І ВИМІРЮВАЛЬНІ СИСТЕМИ

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RESEARCHING GEOMETRY OF NORMAL WEAR OF A CARRIER DIE USED FOR CERAMIC BRICKS PRODUCTION

Досліджується геометрична форма природного зносу робочої поверхні фільєри. Дослідження проведені за допомогою вимірювальної системи на базі трьохкоординатного верстату з числовим програмним керуванням. В результаті вимірювань отримано множину точок, за якими побудовано екпериментальний профіль поперечного перерізу робочої поверхні зношеної фільєри. Встановлено, що профіль природного зносу фільєри з високим ступенем достовірності описується поліномом третього порядку.

Ключові слова: природний знос, поперечний переріз, фільєра.

In the article the geometrical form of normal wear of the working surface of a die is investigated. The research has been done using the measuring system on the base of three-coordinate machine-tool with numerical program control. As a result of measuring there was obtained a set of points on which the experimental cross-sectional profile of the working surface of the worn die was built. It had been found that the profile of natural wear of the die is described by the polynomial of the third order with the high degree of authenticity.

Key words: natural wear, cross-sectional profile, dies.

Identification of the task. Recently, the domestic enterprises [1, 2] specialized in production of ceramic goods have been upgraded with foreign equipment of high performance and a special feature of it is availability of a range of versatile carriers for manufacturing listed products, for example bricks, blocks, tiles and so on. The main components of such carriers [3] are a core, a die and a void former (cones) (Fig. 1). As follows from practical experience of the plant “Zakarpatska Budivelna Kompaniia” of “Rusiniia” Ltd, for example with output 75-80 mln. bricks per year a replacement of the core is carried out every six months, cones replacement – every month and a die replacement – every two weeks.

Thus, the die is the weakest part of the technological equipment. The main reason of the die replacement is its wear. Due to die wearing geometry of the block is disturbed, consumption of raw materials and energy increases. The process of the die replacement also requires stopping the production line that decreases efficiency of the production on the whole.

Therefore the task of increasing geometrical firmness of the die is up-todate in the ceramic production of building materials.

The analysis of recent researches and publications. Regarding to the fact that dies of such construction have appeared in a domestic production relatively recently, relationship between the design parameters of their elements, in particular dies and firmness in the operation process are not studied essentially nowadays.

As it follows from the previous studies of the brick extrusion process, in the contact area of charge with a die there is an abrasive wear, adhesive bond and erosion of shape forming surfaces [4, 5]. However, the most negative influence on the die reliability is caused exactly by abrasive wear [4].

The groups of scientists worked on the problem of abrasive wear [5, 6, 7, 8]. Somebody of them, estimating dependence of the wear intensity on the shape of the worn surfaces used a term is a "normal form of wear". In particular Shults V. V. in the book [8] expresses opinion: "Formation of steady form of normal wear results not only in reduction of speed or intensity of wear but also to the power cost cutout on a friction". This idea is also confirmed by Reshetov D. N. [9]: "Wearing out surfaces should be given shape if it is possibly which is similar to the form of normal wear that is distorted least in the process of wear".

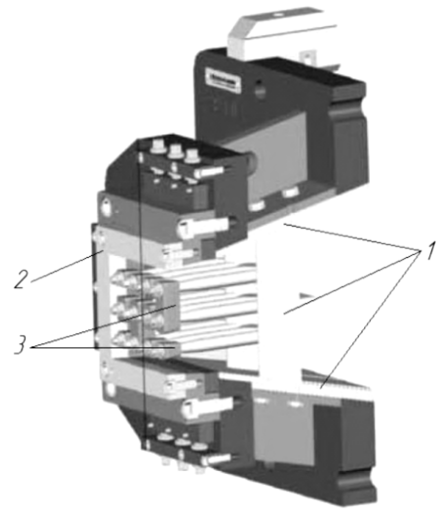

Fig. 1. The cross-section of die carrier Bongioanni 1 – core; 2 – die; 3 – void formers

Formulating the aim of the study. Thus, in order to optimize the die construction due to the criterion of minimization of wear intensity there is a task of making die working surfaces close to the shape of ones with normal wear.

To achieve the desired goal, in this research the study of normal shape of demolition work surfaces dies and formalization description of their geometry by the analytical methods is carried out.

Main data of the research. As an object of researches the die of the extruder carrier is used for producing ceramic hollow bricks made by the firm Bongioanni (Italy). Analyzing the state of the shape forming elements of the worn die it has been stated change of working surfaces geometry in comparison with initial. Since a steel die works in the conditions of free contact with the stream of clay mass, it can be concluded that it got the shape of normal wear. On the first stage of research it is necessary to digitize the shape of the worn surfaces for subsequent analysis using modern information technology.

The problem of the geometric measurement consists in that the worn surface is of a complex spatial shape. For it description it is necessary to conduct a large number of measurements. The required results were obtained by scanning the worn surface using a special measuring system created by us on the base three-coordinate desktop milling machines with numerical control (CNC) (Fig. 2), which allows you to place and monitor a measuring module in space. As the last one the engineer's dial gauge was used with a scale division of 0.01 mm.

Scanning the surface is carried out in semi-automatic mode – the positioning of the measuring device is done automatically by the CNC system commands, and indicator readout is performed manually by the operator.

Measuring the profile of the inner working of worn dies was carried out in 25 points with vertical spacing of 1 mm in die height. Measurements were repeated 10 times along the die hole. According to the obtained experimental values of the coordinates there were built the lines of cross sections of the die working surface that describe the shape of the surface of die normal wear along the direction of the clay mass motion. The results of measuring are shown in Table 1. According to the given experimental data the average values were determined at the key points and the result is shown graphically in Fig. 3.

A carrier die for the ceramic bricks production is steel part of prismatic habit 25 mm thick with a rectangular-shaped hole, through which the clay mixture is extruded. Line ABC (see Fig. 3) describes the theoretical profile of the die hole in cross-section according to the working drawings. Segment BC describes the forming part of die 19 mm thick, and the segment AB of the calibrating part 6 mm thick.

Fig. 2. Measuring system during scanning of the die working surface

The analysis of the profile shape of the working surfaces of worn die allows visually to select two areas – close to the line on the interval $z = [0; 3]$ mm line *DE*, which describes the profile of the calibrating part of the die working surface and the curve of *EC* on the interval $z = [3; 25]$ mm, which describes the profile forming the die working surface. Approximately we can assume that the shape of the curve *EC* corresponds to the cubic parabola.

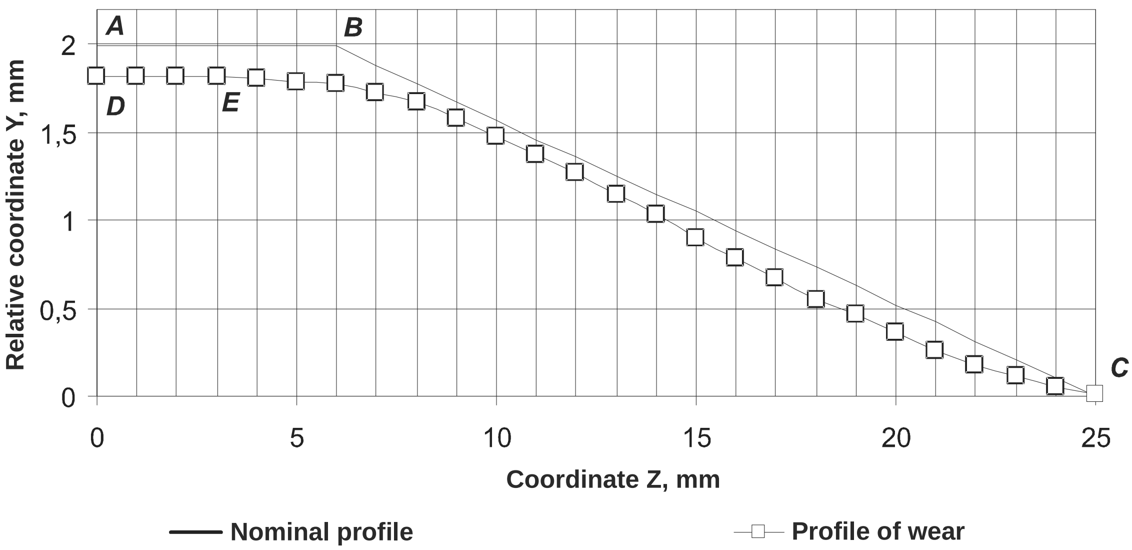

Fig. 3. Measurement results of the work surface profile of the worn die

Approximation of experimental data by a polynomial of the third order

$$Q_3(z) = a_0 + a_1 z + a_2 z^2 + a_3 z^3 \qquad (1)$$

is performed by the least squares method on the interval $z = [3; 25]$ mm. The rates values a_0, a_1, a_2, a_3 of polynomial (1) we find from the set of equations

The coordinates of the profile of the worn die

Coordinate Z	The relative Y coordinate of the cross section №										Mean value
	1	2	3	4	5	6	7	8	9	10	
25	0,00	0,02	0,01	0,02	0,02	0,02	0,02	0,02	0,01	0,01	0,01
24	0,04	0,05	0,04	0,05	0,05	0,05	0,05	0,04	0,03	0,03	0,05
23	0,10	0,11	0,10	0,11	0,11	0,11	0,10	0,10	0,09	0,10	0,11
22	0,17	0,18	0,17	0,18	0,17	0,18	0,16	0,17	0,15	0,16	0,18
21	0,25	0,26	0,25	0,26	0,25	0,25	0,24	0,24	0,23	0,24	0,26
20	0,35	0,36	0,34	0,35	0,34	0,34	0,33	0,33	0,32	0,33	0,36
19	0,45	0,46	0,44	0,45	0,44	0,44	0,45	0,44	0,42	0,43	0,46
18	0,55	0,56	0,54	0,55	0,53	0,53	0,525	0,53	0,52	0,53	0,55
17	0,66	0,67	0,66	0,67	0,65	0,65	0,64	0,64	0,63	0,64	0,67
16	0,77	0,78	0,77	0,78	0,77	0,77	0,77	0,76	0,75	0,76	0,78
15	0,89	0,90	0,88	0,90	0,90	0,89	0,88	0,88	0,87	0,88	0,9
14	1,02	1,02	1,01	1,02	1,02	1,02	1,00	1,05	1,00	1,00	1,03
13	1,15	1,15	1,14	1,15	1,15	1,15	1,13	1,13	1,13	1,13	1,15
12	1,26	1,27	1,26	1,27	1,27	1,26	1,25	1,25	1,24	1,25	1,27
11	1,37	1,38	1,37	1,37	1,37	1,37	1,36	1,36	1,35	1,36	1,37
10	1,48	1,48	1,48	1,49	1,48	1,48	1,46	1,46	1,46	1,47	1,48
9	1,58	1,61	1,58	1,58	1,58	1,58	1,56	1,56	1,56	1,56	1,58
8	1,67	1,67	1,66	1,67	1,66	1,66	1,65	1,66	1,65	1,65	1,67
7	1,72	1,73	1,72	1,72	1,72	1,72	1,71	1,71	1,70	1,70	1,73
6	1,76	1,76	1,76	1,76	1,76	1,76	1,75	1,75	1,74	1,74	1,78
5	1,78	1,78	1,78	1,78	1,78	1,78	1,76	1,76	1,76	1,76	1,79
4	1,80	1,80	1,80	1,81	1,80	1,80	1,79	1,79	1,78	1,78	1,81
3	1,81	1,81	1,81	1,81	1,80	1,80	1,79	1,79	1,78	1,79	1,82
2	1,81	1,81	1,81	1,81	1,81	1,80	1,79	1,79	1,78	1,79	1,82
1	1,81	1,81	1,81	1,81	1,81	1,80	1,79	1,79	1,78	1,79	1,82
0	1,81	1,81	1,81	1,81	1,81	1,80	1,79	1,79	1,78	1,79	1,82

$$\begin{cases} 23a_0 + 322a_1 + 5520a_2 + 105616a_3 = 22.81 \\ 322a_0 + 5520a_1 + 105616a_2 + 2153628a_3 = 223.11 \\ 5520a_0 + 105616a_1 + 2153628a_2 + a_3 = 2745.77 \\ 105616a_0 + 2153628a_1 + 45735592a_2 + 998881260a_3 = 39501.51 \end{cases} \qquad (2)$$

For solving systems (2) in in matrix form we use environment MatLab (Fig. 4) and get the result:

$$a_0 = 1.65143; \quad a_1 = 0.09503; \quad a_2 = -0.01442; \quad a_3 = 0.00032.$$

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Y=[22.81; 223.11; 2745.77; 39501.51];
B = [23     322     5520        105616;
     322    5520    105616      2153628;
     5520   105616  2153628     45735592;
     105616 2153628 45735592    998881260];
 A = B\Y;
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Рис. 4. Програма розв'язку системи рівнянь

Assessment of the reliability of playback obtained by approximating polynomial of the third order (Fig. 5)

$$y = 1.65143 + 0.09503z - 0.01442z^2 + 0.00032z^3$$

the experimental curve (Fig. 3) on the interval $z = [3; 25]$ mm to the value of the square of the Pearson criterion equals to

$$r^2 = \left(\frac{\sum (z - \bar{z})(y - \bar{y})}{\sqrt{\sum \left(z^2 - \bar{z}^2\right) \sum \left(y^2 - \bar{y}^2\right)}} \right)^2 = 0{,}99956 .$$

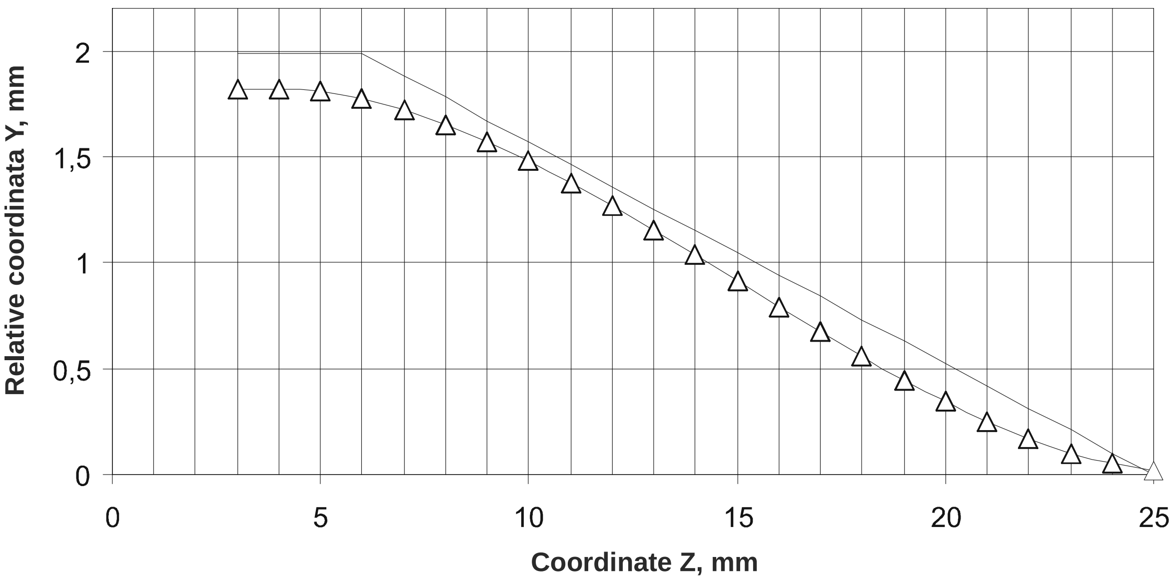

Fig. 5. Measurement results of the working surface profile of the worn die

Criterion value $r^2 \approx 1$ shows a high degree of reproduction of the experimental data obtained by polynomial.

Conclusions. Thus, in the work on the basis of experimental studies it has been found that the profile of the normal wear of the die working surface approximately with high degree of reliability is described by a polynomial of third order. The received data will be used in the future to improve the die design aimed to upgrading its performance.

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SYSTEM OF PROCESSING OF TECHNOLOGICAL INFORMATION

Розглянуто питання опрацювання інформації під час розв'язання задач технологічної підготовки виробництва. Для цього пропонується використовувати ефективні методи багатовимірного статистичного аналізу і штучні нейронні мережі. Програмно реалізовано алгоритми стиснення початкових масивів інформації методами факторного, компонентного аналізу і багатовимірного шкалування, алгоритми класифікації і розпізнавання образів методами дискримінантного і кластерного аналізу, а також алгоритми моделювання методами групового врахування аргументів і штучних нейронних мереж. Ці програми наведені у вигляді системи автоматизованого опрацювання технологічної інформації. Наведено структурну схему розробленої системи, а також послідовність інтерфейсних вікон під час використання цієї системи.

Ключові слова: технологічна підготовка виробництва, обробка інформації, багатовимірний статистичний аналіз, метод групового врахування аргументів, штучні нейронні мережі.

The problems of information processing in solving the technological preparation of production were considered. For this purpose use the effective methods of multivariate statistical analysis and artificial neural networks. Compression algorithms in the original array of information by factor analysis methods, component analysis and multidimensional scaling, classification algorithms and pattern recognition methods of discriminate and cluster analysis, as well as algorithms for modeling of group account of arguments and artificial neural networks were implemented with software. The programs are presented in the form of automated processing technology information. Structural scheme of the developed system, as well as the sequence of interface windows in the application of this system is shown.

Key words: technological preparation of production, information processing, multivariate statistical analysis, method of group account of arguments, artificial neural networks.

Setting of problem. Technological preparation of production is characterized by the set of tasks. The quality of their decision on a computer significantly depends on the initial information for a specific task, the mathematical model of the object or process and the method of solving the problem. Analysis of scientific and technical domestic and foreign literature has shown that improving the efficiency of technological preparation of production is limited to insufficient use of modern information technologies at all stages of the design. For proper solving technological problems it is necessary to reduce the number of inputs, while retaining their original informative, perform classification, clustering and pattern recognition, modeling and prediction of output parameters.