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Influence of firmness of cutters with plates of polycrystal superhard material (PSHM) on the basis of cubic boron nitride (CBN) for probability of technological operation completion

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Abstract

Complex analysis of influence of durability of cutters with plates made of polycrystalline super hard materials (PSTM) based on cubic boron nitride (CBN) on probability of completion of technological operation was performed. The probability of cutter operation was defined and curves of reliability of operation of the tool were constructed.

Key words: CUTTING TOOL, DURABILITY, NON-FAILURE OPERATION, RELIABILITY, RELIABILITY CURVES

The problem and its connection with scientific and practical tasks

Increasing of effectiveness of mechanical processing with cutting is an extremely important task for machinery, where the volume of spare parts processing made of high manganese content steel and representing the part of mining & metallurgical equipment was increased over the last years. Effectiveness of mechanical processing is determined by scientific & technical figures of cutting process depending also on durability of tool cutting part, i.e. its operational reliability, grade of processed material, and material of cutting part of the cutter. Labor intensity of crusher's armor processing is comparable to the tool resource.

Shutdown of process due to the tool wear is often the cause of high cost product defect.

Basic task of research was identifying and mathematical formulation of partition law, reflecting the actual service life of the cutter with a high degree of reliability.

Analysis of research and publications

Reliability of the tool is conditioned with non-failure operation of the cutting tool. The most commonly encountered types of failures of cutting tool made of PSHM on the basis of CBN is its wear, equal in size to blunting criterion or exceeding its destruction – chipping, separation of hard alloy plate etc. [1]. Forecasting of cutting tool reliability is impossible without determination of its operating conditions [2]. Forecasting methods based on measuring of signals characterizing

cutting process are of special interest. Replacement of cutting component forces is the parameter, first of all reacting the wear of the plate up to its destruction. Among all analyzed direct and indirect control methods the most perspective was vibroacoustic method based on registration of spring vibrations arising in the processing area. Cutting forces are increased together with the increase of wear, non-stability of processing and square of contact surfaces are also increased causing the increase of vibration amplitude and its amount per time unit. This could explain the correlative relationship between vibration parameters and wear rate.

It was identified that in general case while destruction of cutter edge the cutting force in decreased, and amplitude of acoustic emission signal in increased. The most sensitive before starting of destruction was the tangential one [3].

Problem definition

In spite of a lot of researches in this sphere, the question of influence of durability of the cutter made of plates with PSHM based on CBN for its reliability is still rather actual [1,2,3], so the target of this work is to determine the influence of durability of cutters made of plates with PSHM based on CBM for probability of technological process completion.

Presentation of material and results

While implementation of diagnostic monitoring based on vibroacoustic method of the tool working ability the effectiveness of resource-resolving technology for increasing of tool durability was researched, that was approved based on statistic research (table 1, 2, 3, 4,5, 6,7, 8). While research of durability of the plates made of PSHM based on CBN at the time of billets processing with absolute destruction of plates because of processing conditions (10 % of total plate volume) the program STATISTICA V 6.1 was used.

To determine parameters for separation of tool working ability in the process of providing the effectiveness of mechanical processing for spare parts made of high manganese content steel 110Mn13 alloyed, the completed records of operation of plates made of PSHM based on CBN done while operation research of armor processing at PJSC “Kryvyi Rih Plant of Mining Equipment” were used. While processing of data given in the records it was decided to create the new data by way of determination of each plate durability from the

total data. Statistic research of new massive helped to analyze the separation of durability values, and also calculate the probable value of average durability [4].

In such a way the data files were created.

1) To the file 1 operational data of the plate, which was used only at rough armors processing was edited.

2) To the file 2 operational data of all the plates, used while processing of billets having the casting defects was edited.

3) To the file 3 operational data of plates, which were used while final armors processing was edited.

4) To the file 4 operational data of plates used while sequential processing (rough + final) of casted billets in the case of no destruction action of hazardous processing conditions was edited.

Processing of research results is done by the calculations using the values of wear as random characteristics of tool durability, i.e. considering their statistical characteristics and constructing diagrams of non-failure operation probability functions (figure 2,4,6,8).

To determine the probable operation of the cutting tool it is advised to use the methodology [5]. Intervals of probability of values of edge state operation for plates made of PSHM based on CBN while processing of high manganese content steel is calculated as per the formula (1).

$$f(t) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(t-T_1)^2}{2\sigma^2}}, \tag{1}$$

where t – edge state operation;

T_1 - mathematical assumption of edge state operation values;

σ – dispersion of scattering of the values (t_i).

Probability of plates non-failure operation:

$$P(T) = \int_0^T f(t)dt, \tag{2}$$

Where T -limit of research interval.

$$P(T) = \sqrt{\frac{1}{2\pi}} \int_0^T e^{-\frac{u^2}{2}} du, \tag{3}$$

$$P(T) = \sqrt{\frac{1}{2\pi}} \int_0^T e^{-\frac{(t-T_1)^2}{2}} dt, \tag{4}$$

$$P(t>T)$$

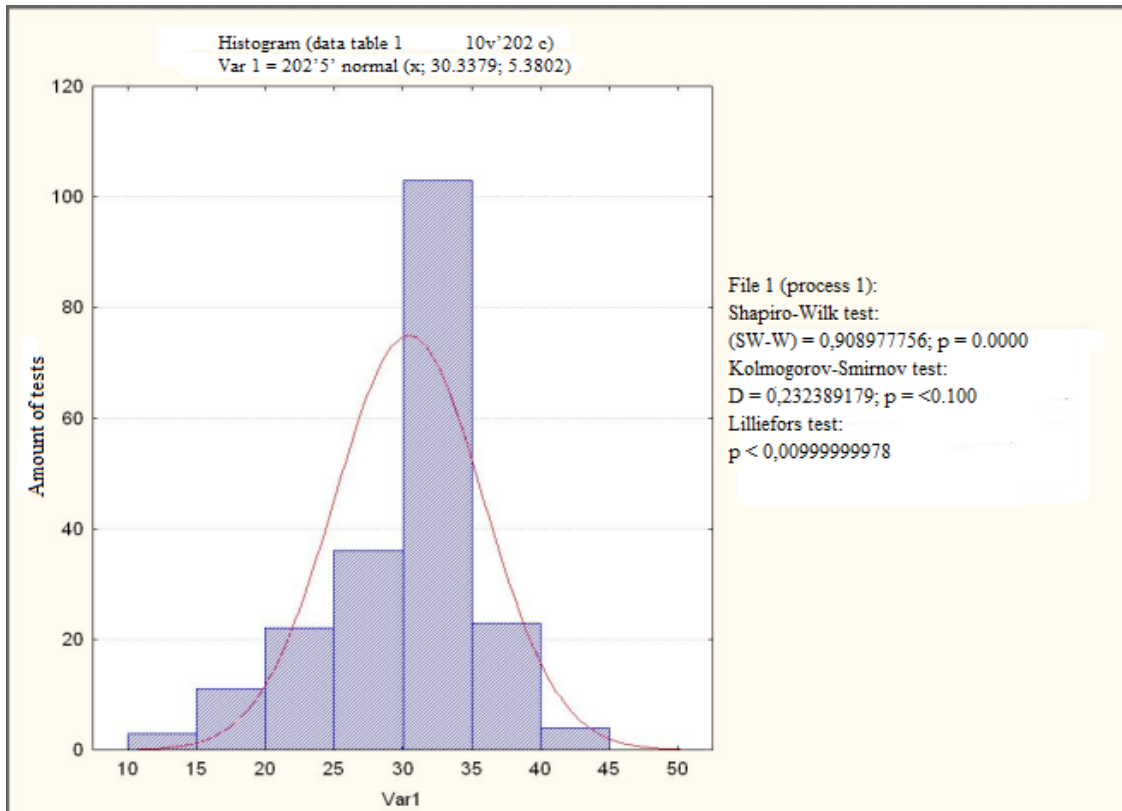
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Table 1. Descriptive characteristics of the file 1

Run ning	Descriptive statistics (table 1)								
	No	Averag e	Average geometric	Harmonic average	Median	Sum	Min	Max	Low quartile
Var1	202	30,337 87	29,77395	29,09122	31,00000	6128,250	13,30000	44,00000	30,0000

Table 2. Descriptive characteristics of the file 1

Run ning	Descriptive statistics (table 1)								
	No	Upper quartile	Dispersio n	Standard deviation	Standard error	Asymmetry	Standard error asymmetry	Excess	Stan dard error exces s
Var1	202	33,0000 0	28,94693	5,380235	0,378552	-0,913384	0,171084	1,19555 9	0,34 0544



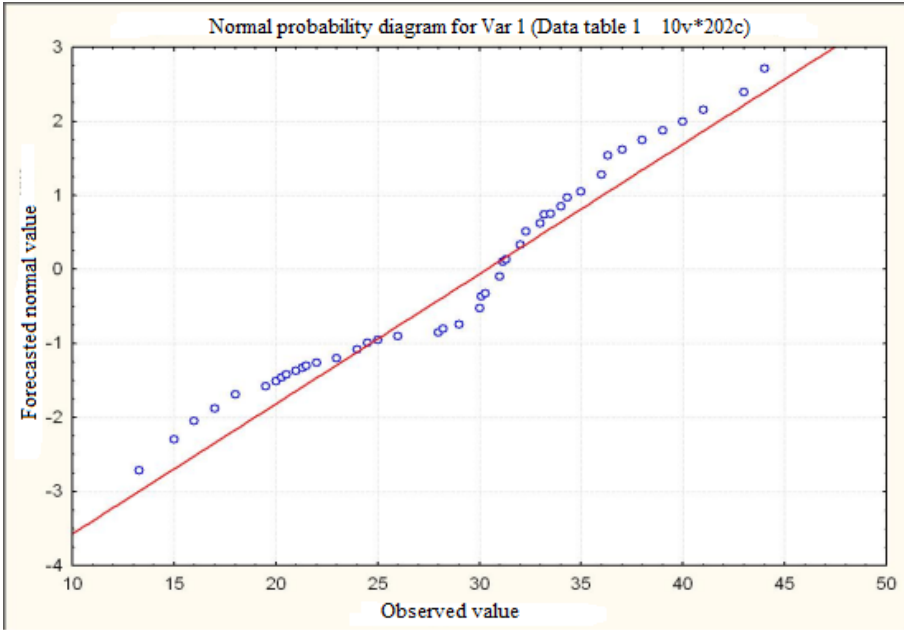


Figure 1. Histogram of the file 1 and normal probability diagram of the file 1

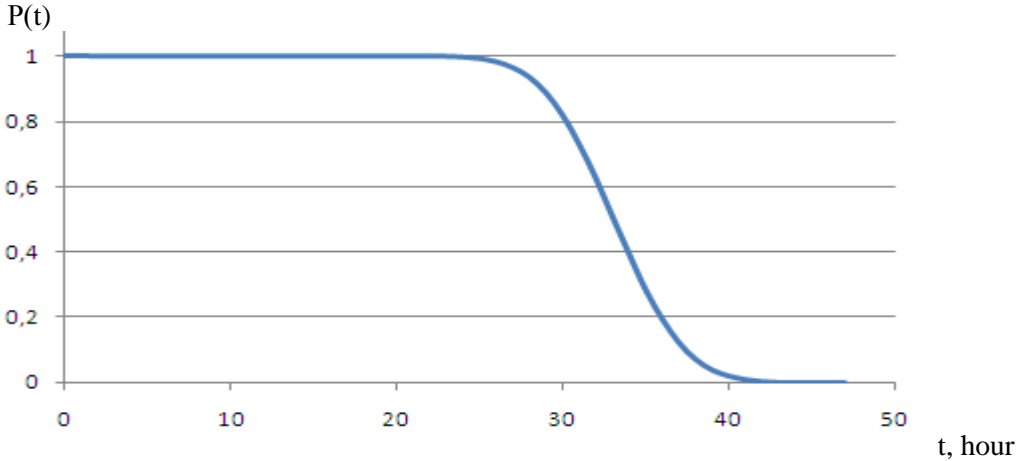


Figure 2. Diagram of probability function of non-failure operation of plates made of PSHM

Based on CBN while processing of final crushers armors for the file 1

Table 3. Descriptive characteristics of the file 2

Run ning	Descriptive statistics (table 1)								
	No	Average	Average geometr ic	Harmon ic average	Median	Sum	Min	Max	Lowe quartile
Var 2	238	30,8097	30.2536	29,5750 6	32,00000	7332,75 0	13,3000 0	46,0000 0	30,0000

Table 4. Descriptive characteristics of the file 2

Run ning	Descriptive statistics (table 1)								
	No	Upper quartile	Dispersi on	Standar d	Standar d error	Asymmet ry	Standard error	Excess	Standard error excess

Materials science

				deviatio n			asymmetry		
Var2	23	34,0000 0	28,8309 7	5,36944 8	0,34805 0	-0,944344	0,157788	1,55581 9	0,314297

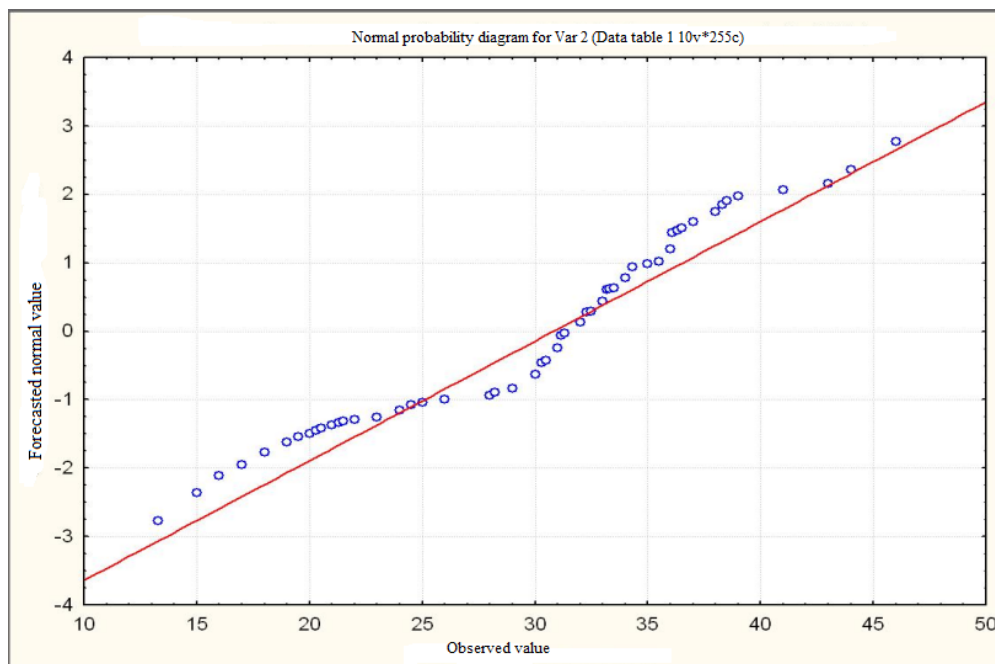
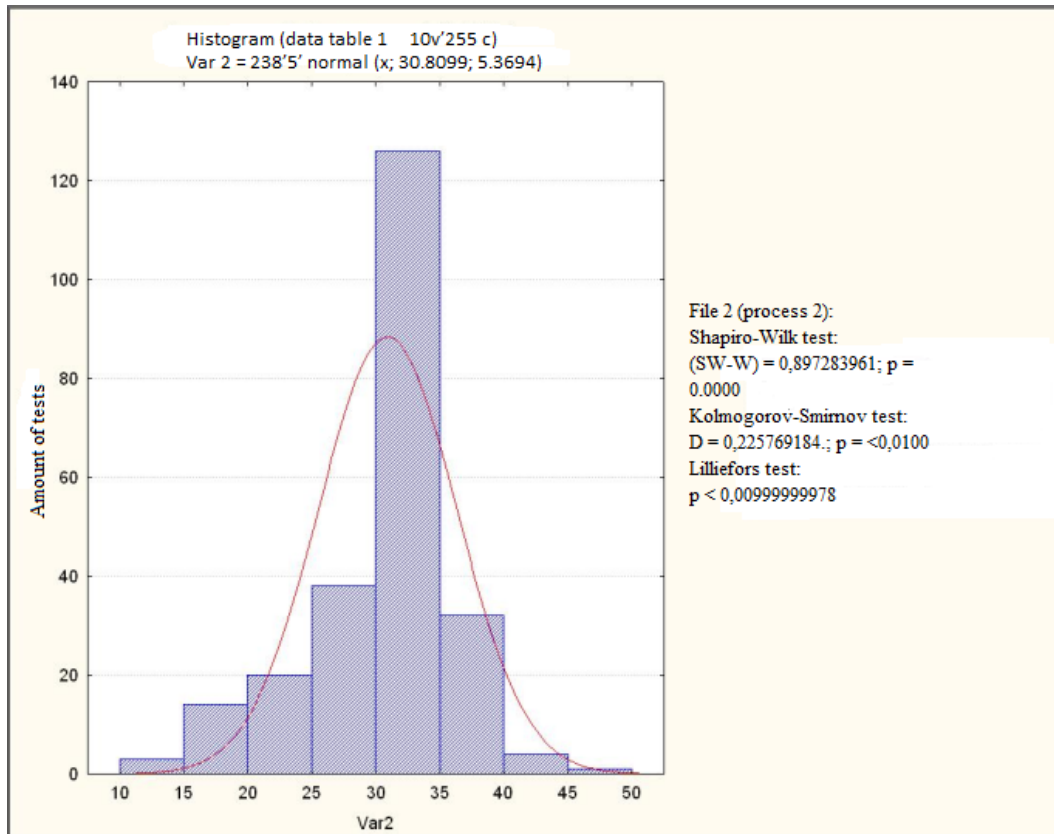


Figure 3. Histogram of the file 2, normal probability diagram of the file 2

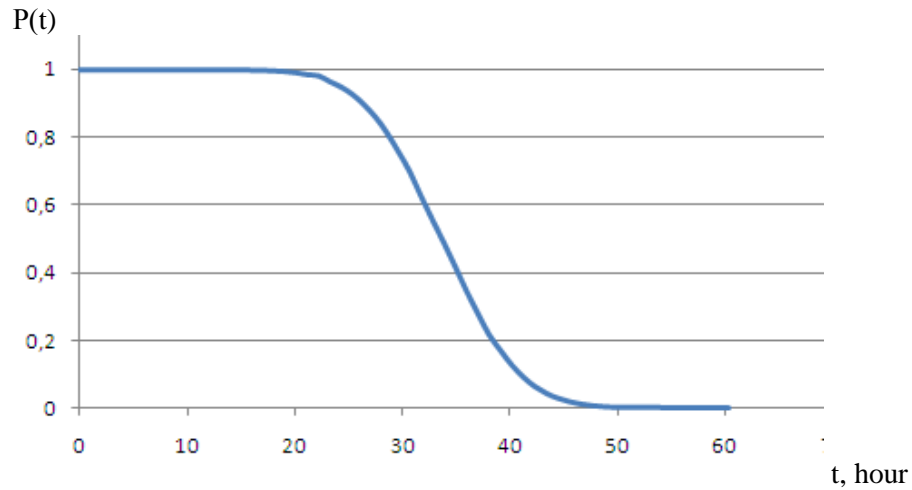


Figure 4. Diagram of probability function of non-failure operation of plates made of PSHM based on CBN while processing of final crushers armors for the file 2

Table 5. Descriptive characteristics of the file 3

Runni ng	Descriptive statistics (data table 6)										
	No	Average	Average geometr ic	Harmon ic average	Median	Mode	Mod e frequency	Sum	Min	Max	Low e quartile
File 3	159	33,0839 6	32,6836 4	33,0000 0	32,0000 0	32,0000 0	25	5260 ,350	19,0 0000	46,0 0000	31,0000

Table 6. Descriptive characteristics of the file 3

Runni ng	Descriptive statistics (data table 6)								
	No	Upper quartile	Dispersio n	Standard deviation	Standar d error	Asymm etry	Standard error asymmetr y	Excess	Standard error excess
File 3	159	34,5000 0	11,33482	5,369448	3,36672 2	- 0,60798 8	0,192458	6,046720	0,382622

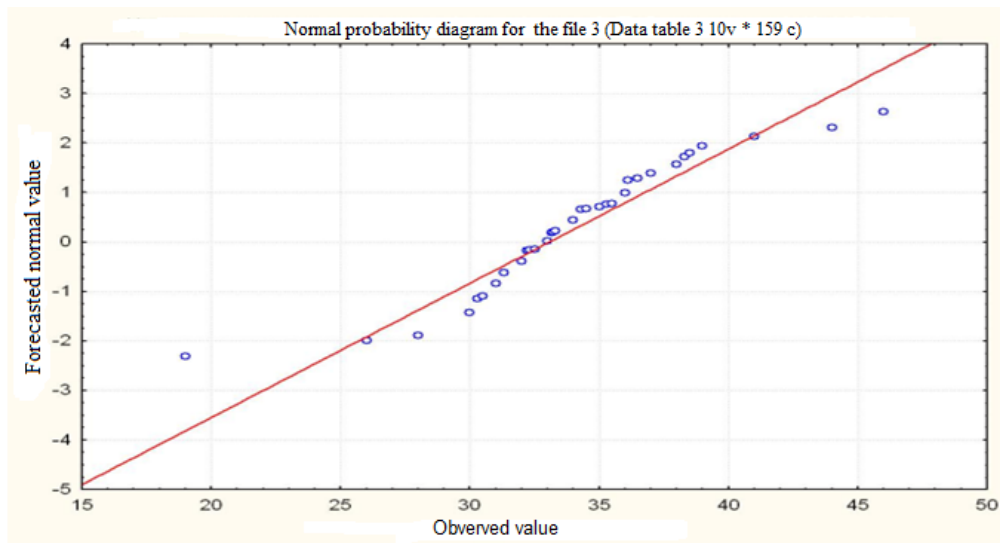
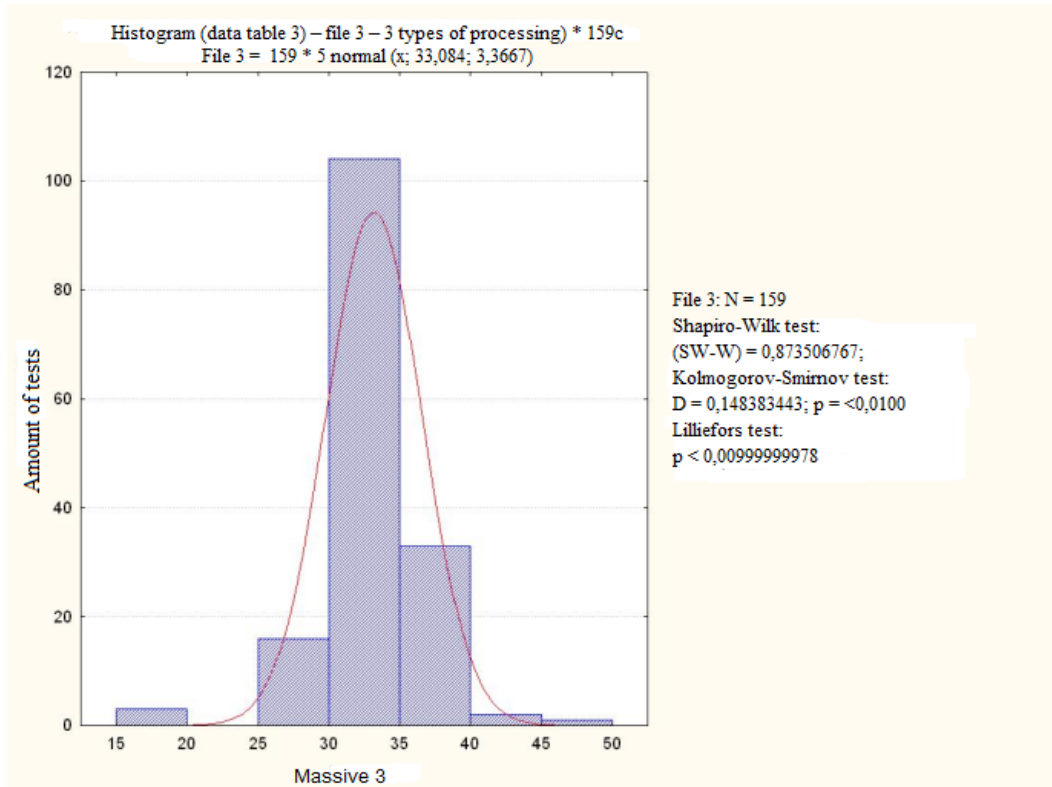


Figure 5. Histogram of the file 3, normal probability diagram of the file 3

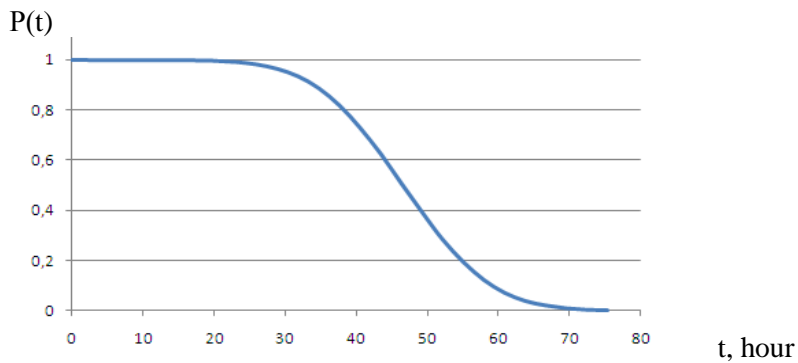


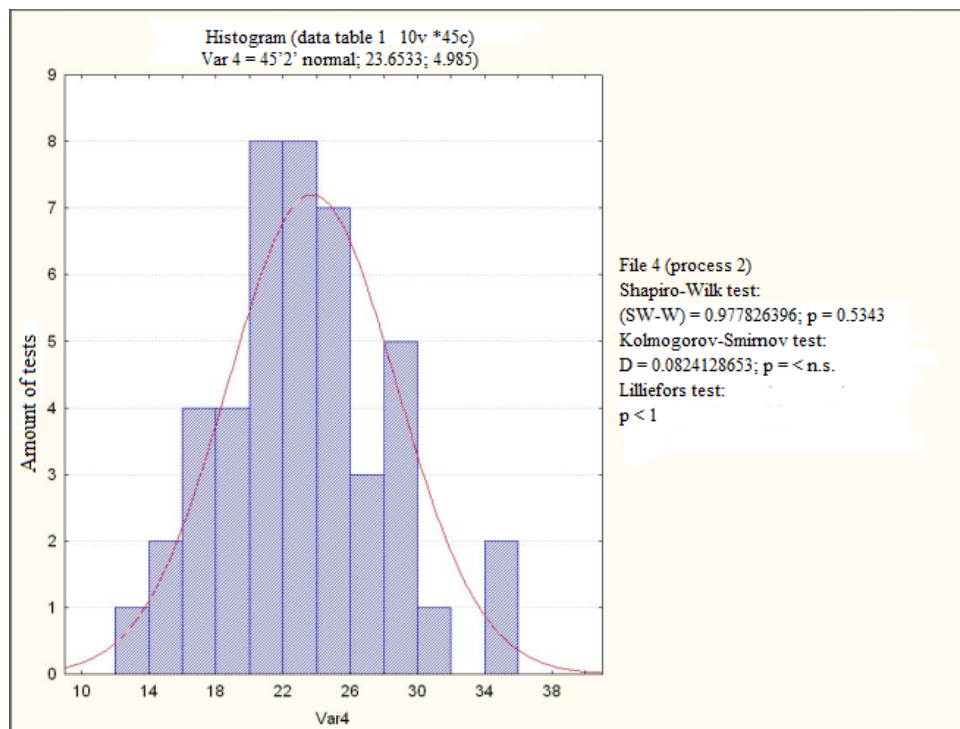
Figure 6. Diagram of probability function of non-failure operation of plates made of PSHM based on CBN while processing of final crushers armors for the file 3

Table 7. Descriptive characteristics of the file 4

Runni ng	Descriptive statistics (table 1)								
	No	Average	Average geometric	Harmonic average	Median	Sum	Min	Max	Low quartile
Var4	45	23,6533 3	23,13946	22,62089	24,00000	1064,40 0	13,3000 0	36,000 00	20,3000 0

Table 8. Descriptive characteristics of the file 4

Runni ng	Descriptive statistics (table 1)								
	N o	Upper quartile	Dispersio n	Standard deviation	Standard error	Asymm etry	Standard error asymmetr y	Excess	Standard error excess
Var4	4 5	26,0000 0	24,84982	4,984959	0,348050	0,38386 2	0,353732	0,22380 2	0,694544



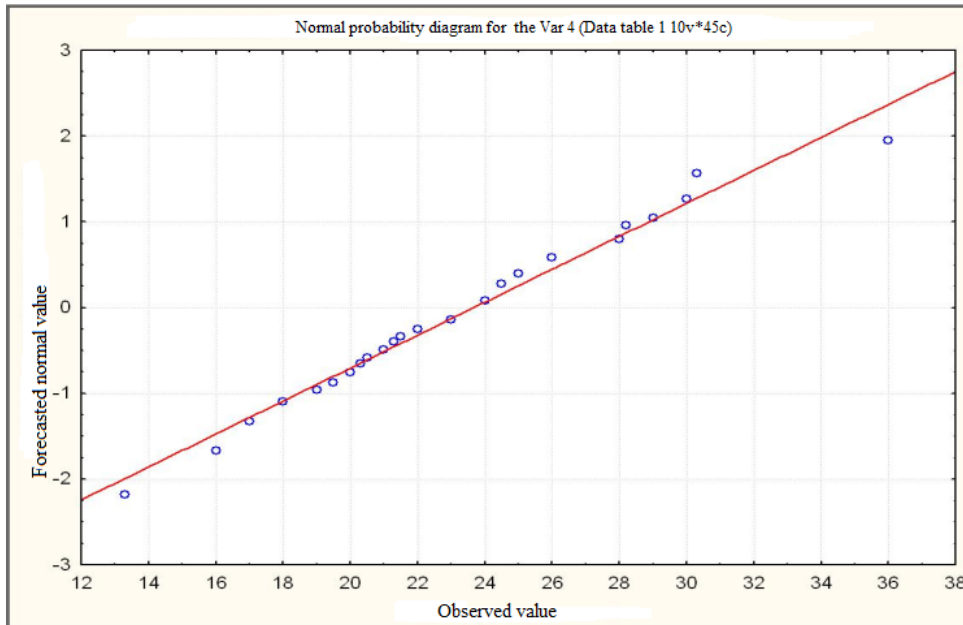


Figure 7. Histogram of the file 4, normal probability diagram of the file 4

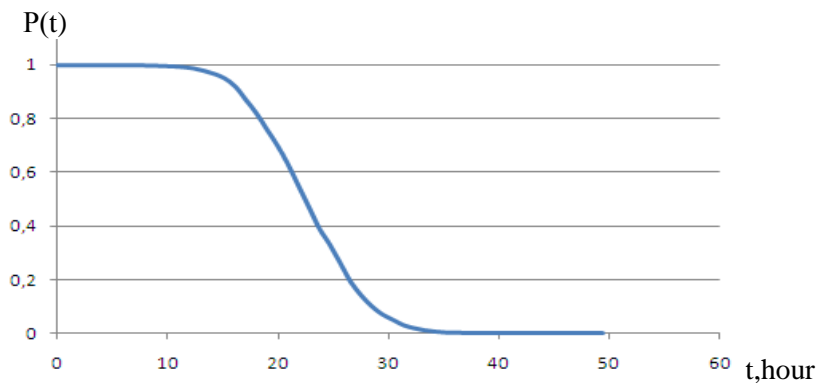


Figure 8. Diagram of probability function of non-failure operation of plates made of PSHM based on CBN while processing of final crushers armors for the file 4

Conclusions

Based on results of experimental and theoretical research it is possible to make a conclusion that the wear of cutting tool, equipped with plates made of PSHM based on CBN comes to normal separation of non-failure operation time.

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