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Mathematical Model of Belts Conveyor

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Abstract

Mathematical model of the technological process of belt conveyors is-1800-1600 mm and this process enables us to control charger and also to determine how to achieve optimum conditions of the process for loading the coal on this tape, maximizing the amount of coal extracted the technological process with two rotor excavator, the power of EM on tape. This model is based on modern statistical procedures for data processing and design of the experiment.

Statistical methods of experiment design enables us to from many factors influencing the process, to highlight the factors with greater impact, to determine optimal process conditions, to determine the effects of the interaction of factors that interact, thereby minimizing the number of experiments and definitely, processing based on data obtained from the experiments, the mathematical model of the process formed the coal conveyor.

In order to determine the optimal parameters and the assignment of mathematical model of the process conveyor coal mine "Kosovo" KEK to extract the coal, are developing a series of experiments in the open field. This paper is laid out the central composite plan, with three independent variables, at two levels.

The purpose of this paper is to determine a mathematical model of system functioning rotary excavator manufacturer in case of transfer of carrier tape measure is used-1800-1600mm

Notes obtained by experiment, are derived mathematical models of these two indicators, each technological feature with three parameters: the capacity of excavators E1 (X1), capacity excavators E2 (X2) and slope angle φ (X3).

Key words: plan of the experiment, mathematical model, excavator's rotor, carrier tape.

INTRODUCTION

Exploitation of coal mining KEK has a tradition of 40 years and this time collected many experiences on technology exploitation and transportation of coal. The experience gained, but also professional and scientific research has consistently helped to accumulate ample knowledge about the process of exploitation and transportation of coal, as well as technological parameters to be applied in different terrain conditions and situation when two excavators the same time charge of coal measures in a tape carrier. However, a modern review of the impact of technological parameters of the two excavators in a carrier tape is not realized so for.

In KEK mining field to open when they loaded two rotor excavator on a tape carrier, are holding a series of experiments, that these results are designed according to orthogonal central composite plan (Plan's Box, Central Composite Design)[1,4].
Records are processed with advanced software + + a DOE (Design of Experiments). With designed experiments, is considered the impact of three technological parameters (the amount of capacity of the excavator-E1 (1), the amount of capacity excavator-E2 (2) and slope angle of the line transportation φ (3)), two indicators important carrier of coal: (1) in-band conveyor is 1600mm, and (2) the amount of capacity of the two excavators.[1]

The series of experiments were conducted in relative locations of surface mining experiments. In order to achieve orthogonal condition, the basic point experiment is repeated several times, and the results obtained with ANOVA (Analyst of variance) determined the impact of each perimeter, the function obtained arkoses.

Analysis of variance is made in confidence level $\alpha = 5$, respectively with 95% reliability. In the paper, orthogonal central plan type 2^3 is used for laying the basic experiments, and experiments were conducted on points with $\lambda = \pm 1215$ for each variable.

In this way, is examining the impact of three parameters mentioned above in two indicators of the capacity of two rotor excavators loading coal measures in one is depending on the angle of the slope.
For each of key indicators (dependent variables in the process), was established mathematical model of second instance.

With MATLAB's application for mathematical models definitive answers are paved surfaces in the form of lines (contour map) and form the surface of the responses (surface) [1,2].

EXPERIMENTATION

Entire Open In Surface Mining "Kosovo"

For the purpose of reviewing and correcting the occasional technological process of excavator with ribbon-conveyor is 1600mm, and for the purposes of scientific research and professional exploitation of coal, the SURFACE MINING "Kosovo" in Mirash, is preparing the ribbon conveyor lines (Figure. 1).

Capacity analysis of two rotor excavators with search step is 330 to 950 m3 / h.

Transportation of coal made with different types of belt conveyors and stored in cache power plant Kosovo A & B, which has storage capacity of 1mil t[5].

Technology exploitation of coal contains the following phases: excavation excavator, loading on the carrier tape to the TC. This kind of organization is needed to avoid obstacles come up in the work of other excavators SURFACE MINING. Each excavator in KEK SURFACE MINING contains the combined devices called systems; these systems in themselves contain the following equipment: excavator, self-propelled tape, transport tape, storage of coal measures up to the warehouse TC.

In SURFACE MINING KEK in Mirash and Bardh have different types of belts conveyor ranging from 1200 mm to 1800mm, the supply of belts conveyor in MS is realized by the company "New Co Balkan, former Rubber Factory" Balkan "in Suva Reka which produces strips of rubber of various kinds. According to international nomenclature belts conveyor recorded 1200 / 4 EP 6 / 3 N 1000 mm, while in mining KEK international nomenclature used by the standard B = 1600-2000/5 (5XEP-400 +6 / 3, X). Belts Conveyor broken down under: Road transport angle (horizontal, easy slope and the slope below the corner transport 18^0), the number of movements in the drum, the type of transport and their construction, shape and consistency form of the letter V axis table, type of transport and attractive body. When belts Conveyor should work top corner of the road size depends on the type of material and its content fine, in such cases is preferable to slope in the increase but not to be taken greater than 18^0-ordinary for coal, ore and barren crushed thorough, 20^0-for coals of crushed, 25^0-26^0-to wet sand. For transportation of the material with tape carrier and this time capacity depends mainly on the width of ribbon belts and angle of natural material $\varphi = 15^0$.

Experimental measurements for review are derived from both the technological process of rotor excavators who have charge of the coal measures in a carrier tape, carrying coal to the conveyor tape-1600 is a carrier bar angle $\varphi = 1\text{-}3^0$. Generally stations moving belt conveyors include: engine, slowdown, braking system, stations moving, stations consist of: construction carrier, Electric motor (which can be between 1.2 and 3 engine), slowdown, electrical contact, braking, equipment to regulate the movement back, equipment for cleaning tape and drum.

The belts conveyor with large attractive force usually placed two same engine powers due to

Their characterization, the carrier ribbon placed slowdown plumber who has shown work safe. In the construction of the station is located driving.

All plumbing and electrical harnesses are used for the normal functioning of ribbon belts.

Figure. 1. Technological scheme of the Two rotor excavators in a carrier tape

MATERIALS and METHODS

Transportation of coal from the mine is-1800mmm KEK "Kosovo" in Mirash, is taken for all experiments conducted according to this paper. For each experiment is formed lot of 330 to 1091 m3 / h, which is treated and is measured by AR-5 camera in open terrain technological scheme put forth above. Coal which was excavated in the open degree is shipped with the carrier tape, and then is sent to funnel warehouse for transportation to the TC (Figure.1).

In the experiment was followed only coal which has been in high level of mining and who is digging excavator with two different types of SRS 1300 and SRS-470. Table 1 Relevant

Table 2. Calculation of main parameters of the engine To bar conveyor is 1600 mm with the camera-**AR-5**

expressed in radians fk fk = [rad]	Two excavators capacity Q = Q1 + Q2	The engine power required for driving the CB-1600 mm Nm = [kw]	Required Power-CB=1600 mm is loaded Under [kw]	Effective power needed NEF = [kw]	Attractive force is necessary to drum Pt = [dan]
0.017	800	292.7	167.4	248.8	**478.3**
0.017	1460	332.2	201.0	282.4	**574.3**
0.017	2700	406.5	264.1	345.5	**754.7**
0.017	3360	446.0	297.7	379.1	**850.7**
0.090	800	298.8	172.6	254.0	**493.2**
0.090	1460	343.4	210.5	291.9	**601.5**
0.090	2700	421.1	281.7	363.1	**804.9**
0.090	3360	471.7	319.6	400.9	**913.9**
0.054	2481	425.0	279.9	361.2	**799.6**
0.054	1679	366.7	230.4	311.7	**658.1**
0.054	2904	455.7	306.0	387.4	**874.2**
0.054	596	288.1	163.5	244.9	**467.1**
0.098	800	307.0	179.6	260.9	**513.0**
0.010	800	311.1	183.0	264.4	**522.9**
0.054	800	315.1	186.5	267.9	**532.8**

Table 3. Are shown coded levels and real values with each experiment was conducted:

Table 3. Coded and natural levels of factors

Factor variables	**-1.215**	**- 1**	**0**	**+ 1**	**+ 1.215**
X1: The capacity of excavator-E1	**870**	**300**	**330**	**960**	**986**
X2: The capacity of E-2 excavator	**635**	**500**	**950**	**2400**	**1091**
X3: The slope angle cb	**0.035**	**0.017**	**0.0185**	**0.054**	**0.052**

indicators are presented for each experiment the amount of coal transportation and power measurement results needed for the transportation of coal.

In experiment explored the effects of parameters (independent variable), two key indicators of process (dependent variable). The Experimental measurements are conducted in the open field in SM "Kosovo" in Mirash. As a dependent variable (Xi) are taken: (1) capacity of the excavator-E1, (2) the capacity of the excavator E2 and (3) slope angle of the ribbon conveyor-φ is defined as the total angle of the material stay on the bar conveyor.

The Experiments were conducted under Central Plan orthogonal (Central - Composite Design) [1].

The design of the experiment was carried out, making real the relationship variable factor:

$$X_1` = \frac{960-630}{330} = 1$$

$$X_2` = \frac{630-630}{330} = 0$$

$$X_3` = \frac{300-630}{330} = -1$$

In these reports, the X1 ', X2', X3 'are listed with real values that is performed the experiments in points with relative coordinates X1j, X2j, X3j.

Thus, the relative coordinates X1 = 1 corresponds to the real value of the amount of transportation of coal from X1 '= 960 m3 / h in the process of `pet carriers, relative coordinates X2 = - 1 corresponds to the real value of the variable X2' = 630 m3 / h, and X3 = 0 corresponds to the real value of the amount of transportation X3 '= 330 m3 / h. Using these rules, in Table 3 is laid matrix experiments with coded values of independent variables and the results measured in each experiment.

Table 4. Matrix of experiments

Nr.Exp	X_1	X_2	X_3	Y_1	Y_2
1	1	1	1	657	599.46
2	1	1	-1	779	883.61
3	1	-1	1	909	875.97
4	1	-1	-1	900	913.57
5	-1	1	1	594	549.48
6	-1	1	-1	738	703.08
7	-1	-1	1	920	914.99
8	-1	-1	-1	963	1084.03
9	1.215	0	0	761	870.70
10	-1.215	0	0	945	986.86
11	0	1.215	0	635	671.14
12	0	-1.215	0	1060	990.70
13	0	0	1.215	780	745.63
14	0	0	-1.215	738	738.98
15	0	0	0	770	883.00

The Experiments with the serial numbers 1 to 8, were carried out according to plan 2^3, the Experiments with the serial numbers 9 to 14 are made on the values ± α = X1, X2 and X3 = ± α = ± α. In the central point (relative coordinates 0, 0, 0) 1 experiments were also repeated (serial number 15). High values of this measure have been attributed to the experiment 14.

The total number of experiments (N) is given by:

$$N = L^k + 6 + 1 = 2^3 + 6 + 1 = 15$$

Highlights of reply, if you followed the rules of the Box-Room, will be determined by the relation:

$$\alpha = k_p \sqrt{2^{\frac{n-p}{2}}\left(\sqrt{N} - 2^{\frac{n-p}{2}}\right)} =$$

$$= 0{,}706 \cdot \sqrt{2^{\frac{3-0}{2}}\left(\sqrt{15} - 2^{\frac{3-0}{2}}\right)} = 1.215$$

The value calculated for α = ± 1.719 reply, since experimentation reply on these points would be problematic, with the correction factor kef = 0.706, to the determined of rotation full model is taken

α = ± 1.215.

These reports were used to calculate the free parameters amative polynomial second degree:

$$a_i = b_1 \sum_{k=1}^{N} X'_{ik} \cdot \hat{y}_k ,$$

$$a_{ij} = b_2 \sum_{k=1}^{N} X'_{ik} \cdot X'_{jk} \cdot \hat{y}_k$$

$$a_{ii} = b_3 \sum_{k=1}^{N} (X'^{2}_{k} - \beta)\hat{y}_k$$

$$a_0 = \frac{\sum_{k=1}^{N} \hat{y}_k}{N} - \beta \sum_{i=1}^{n} a_{ii}$$

$b_o = 883.6$ $b_1 = 47.80$

$b_2 = 131.5$ $b_3 = -2.7$

$b_{11} = 30.6$ $b_{22} = -35.7$

$b_{33} = -95.7$ $b_{12} = -29$

$b_{13} = 9.25$ $b_{23} = 22.3$

$$\beta = \frac{2^{n-p} + 2 \cdot \alpha}{N} = \frac{2^{3-0} + 2 \cdot 2.215}{15} = 0.73$$

parameters	Function Y1		Function Y2	
	Calculated values	P Value	Calculated values	P Value
b_1	50.46	-107	47.80	30
b_2	125.7		131.5	
b_3	-9.8		-2.7	
b_{12}	-15.9	74	-29.0	178
b_{13}	-1.88		9.25	
b_{23}	9.9		22.3	
b_{11}	32.8	79	30.6	87
b_{22}	-26.9		-35.7	
b_{33}	-81.5		-95.7	

$$Y = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_{11} x_1^2 + b_{22} x_2^2 + b_{33} x_3^2 + b_{12} x_1 x_2 + b_{13} x_1 x_3 + b_{23} x_2 x_3$$

RESULTS AND DISCUSSION

The Factors model or response surface is done to prove their viability in the pattern of spread.

This is done for each factor of the model by applying: zero hypotheses with a number of degrees of freedom f = 3, as degrees of freedom for the error of coefficients and a security level = 0:05 is found according to the criterion value table Student: T*= 3.183, is made under the "t" reports the following equation:

$$t_i = \frac{|b_i|}{\sigma\{b_i\}}$$

$t_1 = 74.50$ $t_{11} = 48.9$ $t_{12} = 34.57$

$t_2 = 204.9$ $t_{22} = 57.1$ $t_{13} = 11.02$

$t_3 = 4.26$ $t_{33} = 153.1$ $t_{23} = 26.52$

The analysis of the "t" calculated to reports the factors considered positive when the values of all the factors are outside the range of (-2.03:2.03) and are significant, so the mathematical model of the surface that regression has the form of spread.

An ANOVA test (Analyze of variance) underwent all the estimated coefficients. Analysis of variance of the coefficient qualifies as influential all except the coefficient t13 = 11.02, which eliminated the function somatic coefficients Y1 and B3 = B22 = -2.7 and - 35.7 the function Y2. While in Table 3 present the values of the calculations and obtained values of the parameters influence.

Analysis of variance was made for 0:05 confidence level (reliability 95%). For motive mathematical model is polynomial complete select the second instance, three independent variable. After eliminating the coefficients that are no less important or influential in variable dependent, these patterns are won or surfaces of the answers:

1. The model represents the Electric motor power required from the acquisition of specific energy consumption (Y1) to is-1800 mm, depending on the independent parameters in the process (X1-capacity excavator E1), (X2-capacity excavator E2) and (X3 - slope angle of the ribbon conveyor φ) is the model:

$Y_1 = 883.6 + 47.8 x_1 + 131.5 x_2 - 2.7 x_3 + 30.6 x_1^2 - 35.7 x_2^2 - 95.7 x_3^2 - 29 x_1 x_2 + 9.25 x_1 x_3 + 22.3 x_2 x_3$

2. Response surface that represents the values calculated with the surface to grade par-1800 which is divided by (Y2) in independent parameters of technological process of excavator (excavator capacity X1-E1), (X2-capacity the excavator E2) and (X3-slope angle of the belt conveyor φ) is the model

$Y_2 = 789.6 + 50.46 x_1 + 125.7 x_2 - 9.8 x_3 + 32.8 x_1^2 - 26.9 x_2^2 - 81.5 x_3^2 - 15.9 x_1 x_2 - 1.88 x_1 x_3 + 9.9 x_2 x_3$

Seen that although the two models obtained are the second instance, they certainly do not represent the complete dependence of the parameters examined, the factors not dependent but are in a mutual dependency with each other. To draw conclusions on full respect for these institutions, the figures presented below are the lines responsible ken surfaces, considering every time factor that is missing, the model takes the value 0.But the acquisition of values for factors such as angle,, φ ", the capacity of the excavator Q2 And Q1

According to levels of analysis, these effects can take the power of the guild gases and handled the following cases: While the acquisition of values for angle,, φ ", the capacity of excavator Q2 and Q1, according to levels of analysis, can take these effects gases power unit:

(Case 1): $X_3 = 0$, $Y_1 = f(X_1, X_2)$:

(Case 2): $X_2 = 0$, $f(X_1, X_3)$:

(Case 3): $X_1 = 0$, $f(X_2, X_3)$:

Contours of the surface of the responses are processed with MATLAB software.

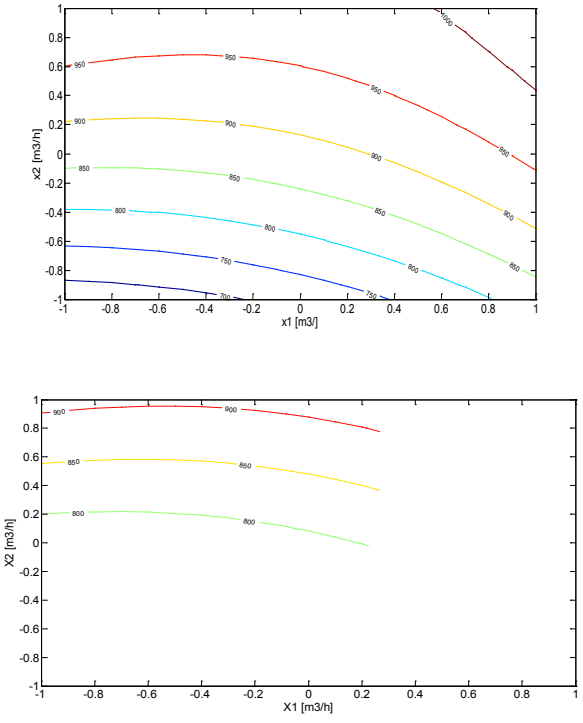

Fig. 2. Case 1 (a) The exploitation of coal (the function Y1), (b) Electric motor power of the exploitation of coal (the function Y2), the amount of coal axis x E1, y axis amount of coal E2.

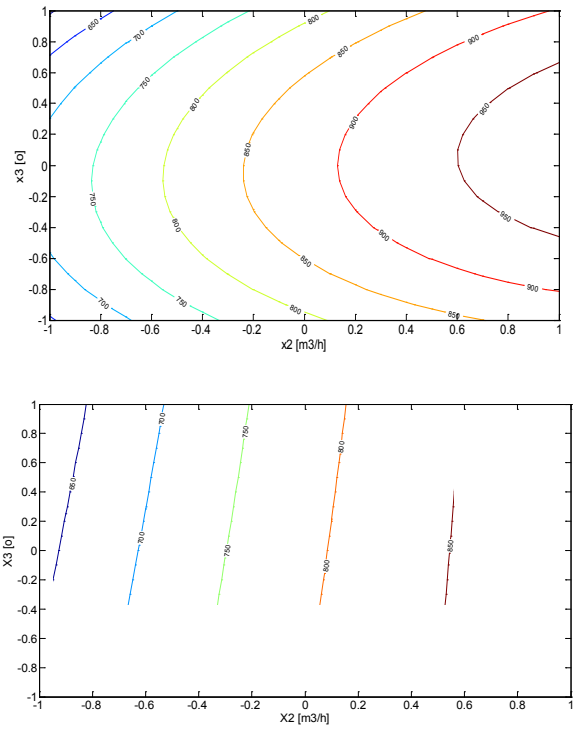

Figure 4. Case 3. Graphic Interpretation (a) Diagram of the power capacity of the excavator SRS-470 X1 = 0 (Q1 = 630 [m3 / h]), b).Diagram of the power for excavator capacity SRS 470 X1= 0(Q1=630[m^3 / h].

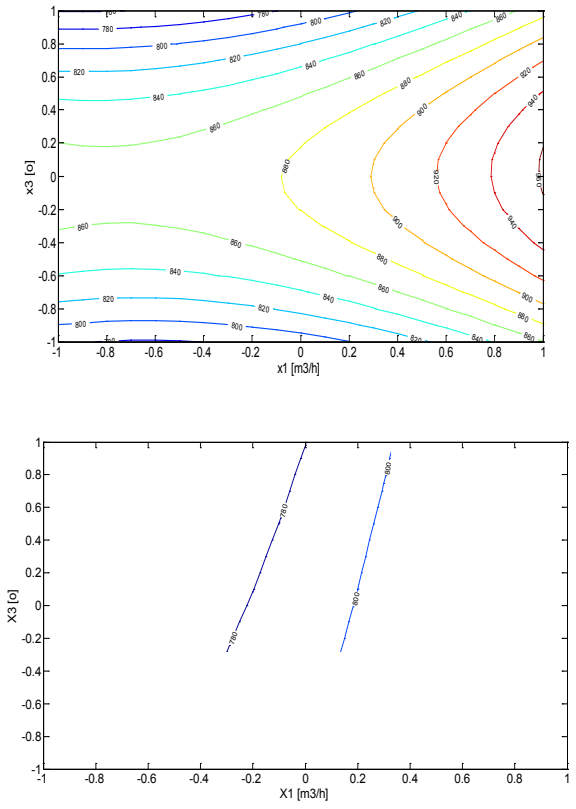

Fig.3. Case 2, (a) diagram of the power capacity of the excavator SRS 1300 X2 = 0 (Q2 = 1450 [m3 / h]), (b) graphical diagram of power for excavator capacity SRS 1300 X2 = 0 (Q2 = 1450 [m3 / h])

(1) Area-specific responses of the electricity consumption depends on Electric motor power (function Y1) in the case when the angle of slope of ribbon (φ) remains constant X3 = 0, the growth of both factors (X1) -capacity of the excavator (E-1) and (X2)-capacity of the excavator (E2) did not increase the power of Electric motor for transporting coal. Reducing the capacity of the two excavators significantly reduces the power of Electric motor for belts conveyor, while the best result is achieved when the capacity of excavator reaches the value for X2 = 0, and increase the capacity for X2>

(2) At the same time, increasing the capacity of excavators (X1> 1) Electric motor power influences that increase the value 15% of capacity in early transportation of coal, if it be constant at the start at point 1, then power The Electric motor will decrease.

(3) In case when the capacity of the excavator (E2) then (E2) remains unchanged for X2 = 0, then the difference of two other parameters is not important except to note the impact of small growth as Electric motor power and the expected impact of raising the specific energy consumption for transportation of 1 [m3 / h] coal.

(4) The angle of slope of the conveyor belts and the capacity of excavators when reduced at the same time significantly affect the decline of the power of Electric motor (Y2), and their positive effect in raising Y2 is only when their change is reversed.

(5) Increase the capacity of the two excavators (X2) and increasing the slope angle of the ribbon conveyor (X3), has resulted in a significant increase of Electric motor power (Y1). On the other hand, the rise of one parameter and reducing the other and vice versa, adversely affecting power Electric motor for transporting coal.

(6) Increase the capacity of excavator-time (X2) and slope angle (X3), affects the growth of Electric motor power, and the rise of the slope angle (X3) on the value of the capacity of the excavator (X2 = -1) maximizes power Electric motor (Y2).

Lines kantar surfaces answers worked with MATLAB, helped us to impact parameters factored in two important indicators of excavator.

In any case, the concept of choice of research (experiment plan by central composite design), in terms of experimentation in the open field, has proven suitable for investigating the impact of parameters influencing multivariable and concentration of their effects on key indicators Calculation of Electric motor power. Obviously, future research, the number of influencing factors should be expanded, considering the influence of slope angle on the biggest corner in our mines amounts to 12 0, the influence of this angle is very important.

Under these conditions, the search for the optimal regime of the technological process of the two excavators will be accomplished with minimal risk potential. Obviously in this case it comes to searching local optimum KEK mine, and research and discussion of the global optimum of this optimum from case to case, it remains to be investigated**.**

CONCLUSIONS

Experimentation in KEK mining in the open field and the application of the plan of the experiment by the central composite design is shown as effective for examining the impact of the parameters influencing multivariable in different ratios of the belt conveyor unit is 1600 and is- 1800 mm.

Determines the optimal region for two types of belts conveyor and is -1600-1800 mm ($Y1_{max}$, $Y2_{max}$) and optimal solution (values of the variable X1, opt, X2, opt, and X3, opt) are within the acceptable range of variations of design factors. Also, the analysis of mathematical models applied, has eliminated factors with little impact outside the band to determine statistical reliability.

The effectiveness of the plan of the experiment shown in this case, gives us the right in future experiments included in the review and other parameters influencing the process, in order to research an area of optimal reliable Department of belt conveyors.

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