Mathematical Model In Smaill Quadrate For The Specific Consummation Of The Electric Motor

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Summary
The Latin squares are known since the time of Oler, which he used in thematathematical analysis, while Fisher was the first who used them in the theory and in the practice of the modern experimental plans. The Latin squares are marked with the sign (n x n), the table is formed in square shapeconsisting of elements (n = 3) in such a way that in all of its kind and in the colon which is appeared in all elements only once i.e. without repetition because the influencing factors of the transporter ribbon and excavator are fixed. The mathematical analysis of the small square models will be done by solving the engineering problems in the industrial area of Kosovo. InKosovo,different Energy Industry electromotors areusedfor the transport of overburden. The purpose of this paper is to build an Engineering mathematical modelwith asmall square that analyzes the specific "consumption" of the electro motors transporter ribbons which are used in Kosovo's Industrial Energy sector.

Key words:
Latin squares, electric motors, specific consumption, transporter ribbons.

1. Introduction

The mathematical matrix model used while processing results of transporter ribbons when two excavators pour their products into a transporter ribbon is based on regression and many factor correlation methods, the model confidence for specific consumption is verified based on factors that have reciprocal action on one another (ribbon and excavator). In the industrial field are used experimental records that are directly documented in practice as well as other processing records by applying mathematical models using the Latin squares method. The specific e-consumption (electrical consumption) of the electromotor during the operation of the transporter ribbons are calculated accordingtotheoretical formula [1].

$$e = \frac{3.1 vt\,et}{Q_h {k_{sh}}^2}[(0.5\times10^{-2}\times L + 0.523)\times B^2 \times K_{sh} + \gamma(0.01\times L + 0.4\times i \times L + 31)] \quad (1)$$

The input data for industrial transporter ribbons are:
The Ribbon Speed..V=4.25[m/s]
Tonnage transportation..t=1[h]
Capacity...Qh=2080[m3/h]
Length of the ribbon..L=793 [m]
Industry Transportation Angle..................................i = rad
Extraction coefficient..ksh = 1.3

Theoretical-practical specific consumption is calculated using aformula based on theoretical-practical data.

$$e = \frac{N}{Q}[kw/m^3] \quad (2)$$

2. Mathematical model of small squares

Elements of the influential facts are listed in their particular types and columns, factors are written in smaller or larger Latin/Greek characters or with Arabic or Roman numbers. The number of the factors is 3x3 i.e. N = 3, when we present them in capital letters then we have: A B C, B C A and C A B. The larger the values of the optimum capacity of the transporter ribbon and of the capacity of the excavator are, the greater will be the number of the possible variances of the Latin squares for a visible value (n). The Latin squares variation called the standard is formed with the help of the cyclic step, while the other type is obtained by placing this element in the last order. By studying the influencing factors in the optimum capacity of the transporter ribbon and excavator capacity, the total number (N) of the possible size factors (n x n) will be presented by the relation:

$$N = \varphi \times n!(n-1)! \quad (3)$$

where: φ –Number of the conic squares determined by size (n).

$\varphi = 1 \ for \ n = 3, we \ have \ N = 1\times 3!(3\times1)!, N = 6\times(2)! = 12$

In general, the number of the experiments increases significantly with the increase in the number of factors which can beseen from the relation:

$$N_1 : N_2 : N_3 : N_K = n : n^2 : n^3 \ ... \ n^k \quad (4)$$

The planes that are formed according to the structure a, b and c are called composite central order of the second order which is shown Fig.1.

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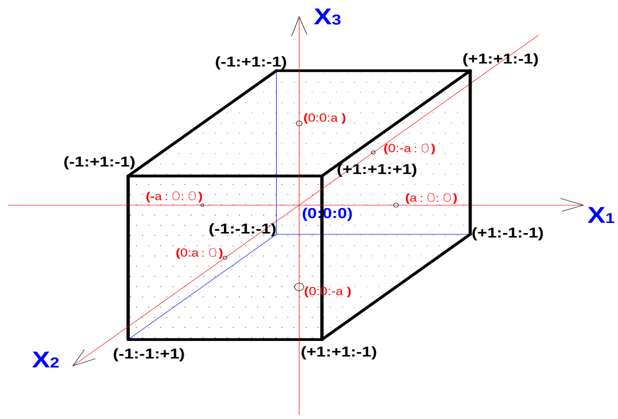

Fig. 1 Geometric appearance of three-factor experiment planning X1, X2, dhe X3.

The relation (4) expresses the ratio of the total number of the experiments (without repetition), all level combinations are called full experimental plans. The results of the measurements obtained with their realization are presented with this mathematical model.

$$Y_{ijq} = \mu + \alpha_i + \beta_i + \gamma_q + \alpha_i \beta_i + \alpha_i \gamma_q + \beta_i \gamma_q + \alpha_i \beta_i \gamma_q \quad (5)$$

In the Latin squares plan, the number of experiments can be reduced significantly if in the base experimental plan we useLatin square (n x n). Under the rules set above for the formation of the Latin squares, the third factor (the width of the strip material) is also planned. They form the table in which experimental plans are developed n = 3 and n = 9.

Table 1: The experimental plan of n = 3 and n = 9 of Latin squares.

Number of Experiment	A	B	C	Y
1	292.7	307.5	301.5	0.017
2	332.1	298.7	312.4	0.090
3	406.5	354.9	345.8	0.014
4	446.2	409.5	294.2	0.065
5	298.8	478.2	311.2	0.085
6	343.4	412.3	356.9	0.054
7	421.1	469.4	459.2	0.087
8	471.1	478.2	489.7	0.073
9	425.3	421.3	419.8	0.077

From Table 1, three factorial experiment plans have been created, in which are formed three levels. In the following, we present the dispersion analysis algorithm of the three-factor experimental plans (without repeating the experiments) under which mathematical results derive.

Table 2: The results of the influencing factors measurements capacity, specific consumption

A	B				Y
	b_1	b_2	b_3	b_4	
800	800(0.017)	2481(0.054)	1560(0.090)	800(0.098)	0.098
1460	1460(0.017)	1679(0.054)	1980(0.090)	1000(0.100)	0.010
2700	2700(0.017)	2904(0.054)	2151(0.090)	1100(0.200)	0.054
3360	3360(0.017)	596(0.054)	2500(0.090)	1320(0.021)	0.017
∑	B_1	B_2	B_3	B_4	

The calculation of the influencing factors is performedin the order of which is given in the algorithm: The sum of the measurementsby type Aiare determined according to the relation:

$$A_1 = \sum_{i=1}^{4} yi,\ A_2 = \sum_{i=5}^{8} yi,\ A_3 = \sum_{i=9}^{12} yi,\ \ A_4 = \sum_{i=13}^{16} yi \quad (6)$$

The sum of the measurement results by column (Bi) for the given example are:

$$\begin{aligned} B_1 &= Y_1 + Y_5 + Y_9 + Y_{13} \\ B_2 &= Y_2 + Y_6 + Y_{10} + Y_{14} \\ B_3 &= Y_3 + Y_7 + Y_{11} + Y_{15} \\ B_4 &= Y_4 + Y_8 + Y_{12} + Y_{16} \end{aligned} \quad (7)$$

The Sum of the measurement results according to Latin letters.

$$\begin{aligned} C_1 &= Y_1 + Y_8 + Y_{11} + Y_{14} \\ C_2 &= Y_2 + Y_5 + Y_{12} + Y_{15} \\ C_3 &= Y_3 + Y_6 + Y_9 + Y_{16} \\ C_4 &= Y_4 + Y_7 + Y_{10} + Y_{13} \end{aligned} \quad (8)$$

The Sum of the squares of all measurement results (according to all types and all columns of the plan).

$$S_1 = \sum_{i=1}^{n} \sum_{j=1}^{n} yij^2 = 0.85.2 \quad (9)$$

The sum of the squares of all types separated for (n).

$$S_2 = \frac{1}{n} \sum_{i=1}^{n} A_i^2 = 45.21 \quad (10)$$

The Sum of the square columns separated for (n).

$$S_3 = \frac{1}{n} \sum_{j=1}^{n} B_j^2 = 39.5 \quad (11)$$

The sum of the Latin letters of squares separated for (n).

$$S_4 = \frac{1}{n} \sum_{q=1}^{n} C_q^2 = 42.6 \quad (12)$$

The square of sums of measurement by type, column or Latin letters divided by the total number of all experiments $N = nxn = n^2$.

$$S_5 = \frac{1}{n^2}(\sum_{i=1}^{n} A_i)^2 = \frac{1}{n^2}(\sum_{j=1}^{n} B_j)^2 = \frac{1}{n^2}(\sum_{q=1}^{n} C_q)^2 = 0.086 \quad (13)$$

The Sum of the squares and degrees of freedom.

$$S_A = S_2 - S_5 \quad for \quad f_1 = n-1$$
$$S_B = S_3 - S_5 \quad for \quad f_1 = n-1$$
$$S_C = S_4 - S_5 \quad for \quad f_1 = n-1$$
$$S_O = S_1 - S_5 \quad for \quad f_0 = n^2 - 1 \quad (14)$$

The Sum of the squares and error of experiments (experimental errors) and the degrees of freedom.

$$S_E = S_O - (S_A + A_B + S_C) = S_1 - S_2 - S_3 - S_4 + 2\ S_5 =$$
45.87 withe degrees of freedom $f_2 = (n-1)(n-2)$ (15)

Dispersion (distribution of experiments in the most influential factors).

$$S_A{}^2 = \frac{S_A}{n-1} = 0.087 \quad (16)$$

Dispersion (distribution of the experiments for point B).

$$S_B{}^2 = \frac{S_B}{n-1} = 87.3 \quad (17)$$

Dispersion in the C point.

$$S_C{}^2 = \frac{S_C}{n-1} = 74.2 \quad (18)$$

The Factor dispersion while calculating of the errors in experiments and freedom degrees.

$$S_e{}^2 = \frac{S_E}{(n-1)(n-1)} = 0.049 \quad (19)$$

Calculation ofvalues according to the Fisher's Criterion-F.

$$F_{rA} = \frac{S_A{}^2}{S_E{}^2}, \quad F_{rB} = \frac{S_B{}^2}{S_E{}^2}, \quad F_{rC} = \frac{S_C{}^2}{S_E{}^2} \quad (20)$$

The Fisher Criteria values are obtained for $f_1 = 3$, $f_2 = 6$ and $\alpha = 0.05\%$.

$F_{tA} = F_{TB} = F_{tC}$
$F_{tA} = f (f_1 = n-1 , f_2 = (n-1) (n-2) , \alpha)$.
$F_{tB} = f (f_1 = n-1 , f_2 = (n-1) (n-2) , \alpha)$.
$F_{tC} = f (f_1 = n-1 , f_2 = (n-1) (n-2) , \alpha)$.

At the end of the mathematical model, the hypothesis is set to zero$H_o : \alpha_i = 0$, $\beta_i = 0$ and $\delta_q = 0$, i.e.The influence of the factors (A, B, C and D) on the optimization characteristics of the transporter ribbon SHT-1400 are non-signatory.If it is verified that $\mathbf{F_{rx} > F_{tx}}$ (for the factors of the effective excavator capacity, thehourly capacity of the transporter ribbon,and the consummation of the specific consumption of the electromotor which is carrying the material wastes, then the mathematical model is rejected as unprincipled.Based on the small square mathematical model, the required power of the electro motorincreases for driving the transporter ribbon and wastingthe specific consumption.

Table 3: presentation of the real and coded variables.

N0.	*Coded Variables*				*Real variables values*			
	x_0	A_1	B_2	C_3	Q_1	Q_2	e-consumption	N thepower of the elek.
1	1	-1	-1	-1	400	600	0.017	675
2	1	1	-1	-1	860	400	0.017	347
3	1	-1	-1	-1	379	245	0.017	714
4	1	1	-1	-1	856	1978	0.017	689
5	1	-1	1	1	367	576	0.090	578
6	1	1	1	1	961	432	0.090	573
7	1	-1	1	1	290	1789	0.090	479
8	1	1	1	1	760	2176	0.090	860
9	1	1.115	0	0	1234	1543	0.054	726
10	1	-1.115	0	0	456	1567	0.054	765
11	1	0	0	0	454	2145	0.054	867
12	1	0	0	0	399	312	0.054	543
13	1	0	1.115	1.115	410	567	0.098	623
14	1	0	-1.115	-1.115	432	589	0.021	612
15	1	0	0	0	476	654	0.054	631

3. Diagrams obtained on the basis of the measurement results with real values of variables

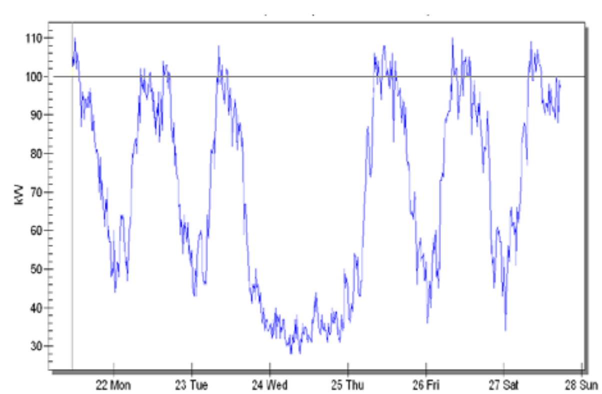

Fig. 1 Diagram of the electromotor during the work with the transporter ribbon in the industry with average load of power for 7 working days.

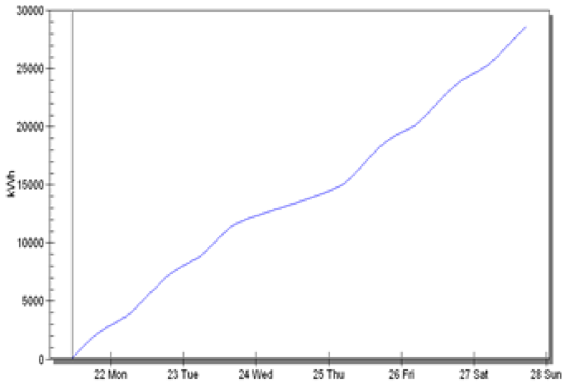

Fig. 2 First stage diagram according to the power load of the electro motor for 7 days

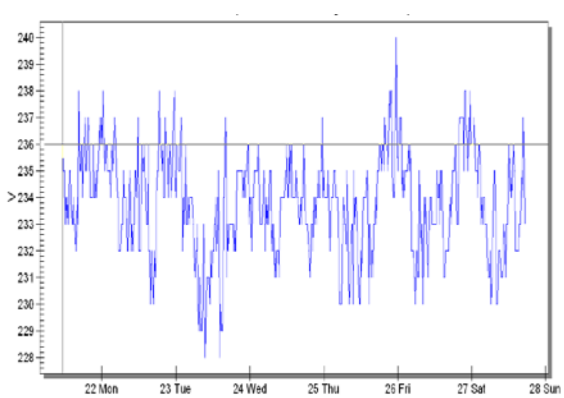

Fig. 3 The electromotor diagram during operation with transporter ribbon in the industry with average voltage load for 7 working days.-A

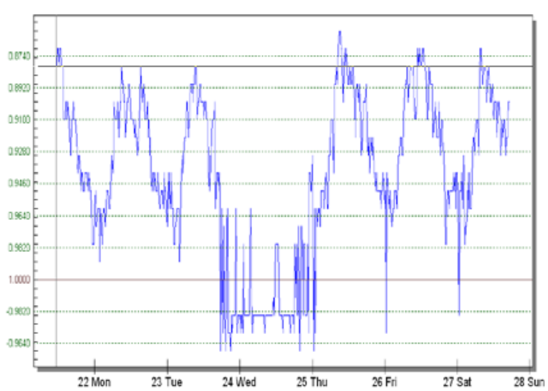

Fig. 4 The electromotor diagram during operation with transporter ribbon in the industry with minimum of power factor load for 7 working days.-B

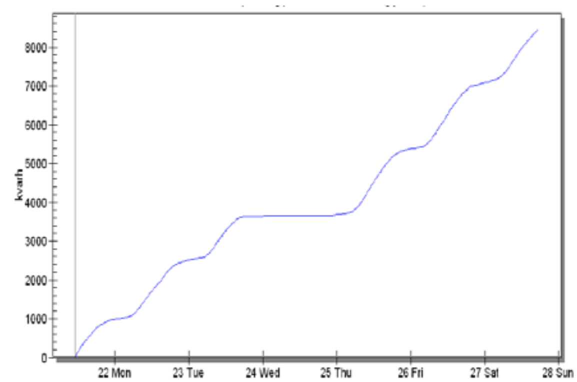

Fig. 5 The electromotor diagram during operation with transporter ribbon in the industrywith reactive energy for 7 working days

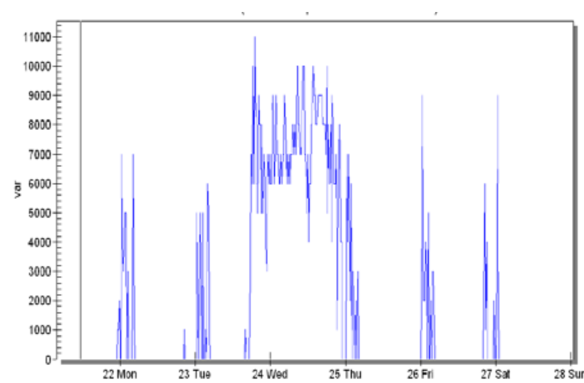

Fig. 6 The electromotor diagram during operation with transporter ribbon in the industry with maximum reactive of power load for 7 working days.-C

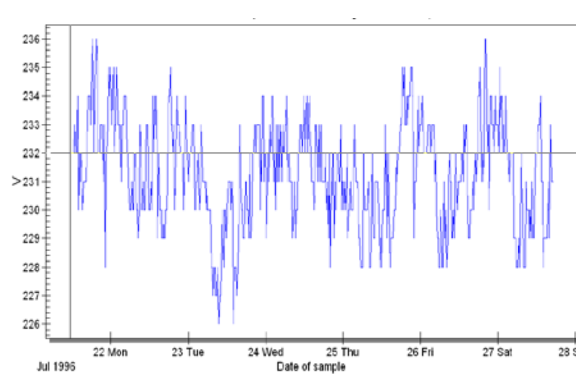

Fig. 7 The electromotor diagram during operation with transporter ribbon in the industrywith aminimumof voltage load for 7 working days.-C.

4. CONCLUSION

After processing the mathematical model with the Latin square and the verifications directly made with practical experiments in the groundfor the specific consumption of electromotor of the transporter ribbon the following results have been achieved:The electromotor of the transporter ribbon with the width of 1800mm is equivalent to the conditions for exploitation of the overburden with excavators (two excavators) of the type SchRs-650 and SRs-470.The results verified directly in practice and the implementation of mathematical models with the Latin squares method with reciprocal actions show that the specific consumption of the electromotor of the sh-1800 is remarkably large.

Calculating the reliability of the electromotor, it’s concluded that the reliability of the mathematical model in practice and based on the diagrams obtained the following results can be excluded:

- 75.9 % of the production capacity of the two excavators is equivalent to the 1800-mm electromotor transporter ribbons which are used in the Kosovo electro-energetic industry, ± 24.1% remain in working conditions of the non-realization excavators in open terrain.

- b) 89.7% theoretical-mathematical model with Latin squares corresponds to the conditions of the electromotor transporter ribbons and excavators in production,± 10.3% remain unrealized due to the overburden gauge (large pieces) which are included in mathematical model calculations, this can be observed in the diagrams for power and voltage of the electromotors, see diagrams 3,4, 6 and 7.

This percentage indicates that the mathematical model of the Latin squares defines the minimum, optimum and the maximum values which ca be used to approximate specific consumption calculations for transporter ribbons of 1800 mm with loads of two excavators.

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