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Research Article

OPTIMUM ENERGY CALCULATION FOR A DRILL HAMMER-BLOW RH571- 4W

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ABSTRACT

Consumption of raw materials has steadily increased. Rich countries explore several raw materials such as phosphate, ore and copper. For this, exploitations must be large, highly mechanized and produce in large quantities to be profitable. Also, the use of drilling means requires good productivity on the one hand and a long service life on the other hand. The satisfaction of these requirements is possible if the drilling method chosen is suitable for the geological and mining conditions as well as the drilling parameters. The choice of the machine therefore has a direct impact on costs and results. The aim of this work is to ensure a proper exploitation with an optimum energy calculation for a drill hammer-blow taking into account their economic or technical conception characteristics. To find out the energy losses of a hammer blow, the Baron and Ghrainer formula which, has been applied, allows us to calculate the drilling speed and to deduce the blow energy. Then, to calculate the energy losses and to extract the optimal values for different parameters, a statistical model of GAUSS-MARKOV theorem has been introduced.

Keywords: Hammer drill; statistical model; Drilling speed; Rock; Energy of a blow.

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1. INTRODUCTION

The exploitation of natural resources has continued to increase. Countries around the world are exploiting raw materials such as ore, iron, zinc and copper for which exploitations must produce a large proportion of these resources with various varieties of drilling machines to be profitable.

Many researchers have realized laboratories tests in order to determinate the use indexes and the technical characteristics. The methodical basis of the research work consists of finding the combination of machine control parameters satisfying the enumerated requirements in the concrete conditions, and to exploit machines in the rational regime. In 1857, the French engineer Sommeiller modified a steam machine into a drilling machine which operates using compressed air [1]. This machine was used during the digging of a tunnel in the Hautes Alpes (France). After, in underground works, drilling can be done using various machines, which can be gathered into two major groups: percussion drills and drills [2].

Other works have proposed the concept of specific energy as a guide to evaluate the drill ability in the rock [3-5]. According to the literature declared that specific energy can be expressed in unit volume or in new surface which is not a fundamental intrinsic property of the rock because percussion drilling is widely used in mining and construction to drill holes in the rock [6]. Usually, the perforator, containing an alternative hammer, is placed outside the hole. The mode of percussion drilling is very widespread during the exploitation of ore deposits [7].

In 1968, the first hydraulic perforator was born, designed by the French firm Montabert and put into operation two years later. This type of perforator presents several advantages relatively to pneumatic perforators [8], such as: a high yield of 4 to 6 times, a power of 4 to 5 times greater, a drilling speed of 1.5 to 2 times greater and power consumption less than 70% [9]. These advantages accelerated the evolution of these perforators and their construction was generalized through the other specialized firms.

The progress of the construction technique of the perforators was accompanied by the corresponding perfection of the drills, the foils, the sharpening machines as well as their manufacturing technology. Among the used tools, we can mention the button drills [6], latest creation nowadays which does not require sharpening.

The energy criterion is very effective for the destruction of bulky rocks in the empirical calculations of drilling technology and which is theoretically validated; thus, experimentally proven in rotary percussion drilling in mines in Russia [10]. Some articles talk about real-time prediction of drill wear by combining rock energy and drilling force concepts [11].

In this work, an optimal calculation is done to determine the energy of a drill hammer blow. This allows to ensure a proper exploitation of the machine in order to evaluate their technical and economic conception characteristics, as well as to ensure a minimum cost price for one meter of drilled hole. The calculations of the energy losses of a blow are effectuated by the formula of Baron and Ghrainer, which allows us to calculate the drilling speed and to deduce a blow the energy. Then, in order to extract the optimal values of the productivities through the determination of the rational parameters of the operating mode of the machines, a statistical model of GAUSS-MARKOV theorem was introduced.

First of all, a description of the hammer drill machine is given in section 2. Then, we talk about the operation of the perforator is ensured by means of the distributing device of the compressed air, which alternately feeds the left and right chambers of the cylinder in section 3. Afterwards, the drilling productivity is determined by the drilling speed, using the BARON and GHRAINER Formula as shown in section 4. Section 5 outlines a lot of research that has been done in order to arrive at determination methods to calculate the optimal productivity of drilling machines in the marble ore quarry. Sections 6 and 7 discuss the energy losses calculations based on the energy of a foil blow will be determined in two cases and the table 4 presents 11 tests to calculate the energy losses, the drilling speed, the technical & exploitation coefficients and the results of the productivities in the 1st case. In sections 8 and 9, present eleven tests to calculate the energy losses, the drilling speed, the technical and operating coefficients, the results of the productivities in the 2nd case and present also, the comparison of the empirical and statistical results. Finally, a conclusion illustrated in section 10.

2. DESCRIPTION OF THE HAMMER DRILL MACHINE

Figure 1 shows the RH571-4W drill hammer which is designed for heavy works such as face drilling. Second drillings are boreholes and drilling for blasting shots. To work in hard rock, the RH571- 4W drill hammer was equipped with a helical grooves rotation mechanism and high percussion energy.

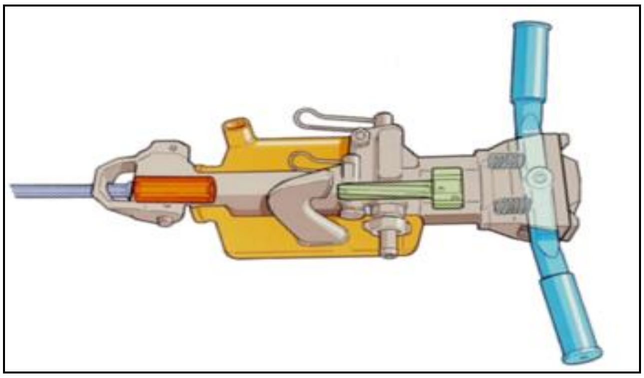

Fig.1. RH571- 4W Drill Hammer

3. PRINCIPLE OF OPERATION

The operation of the perforator is ensured by means of the distributing device of the compressed air, which alternately feeds the left and right chambers of the cylinder (Figure 2). This allows the piston to perform its alternative movement (back and forth) and a rotational movement to the foil with a sharpening angle achieved by ratchets.

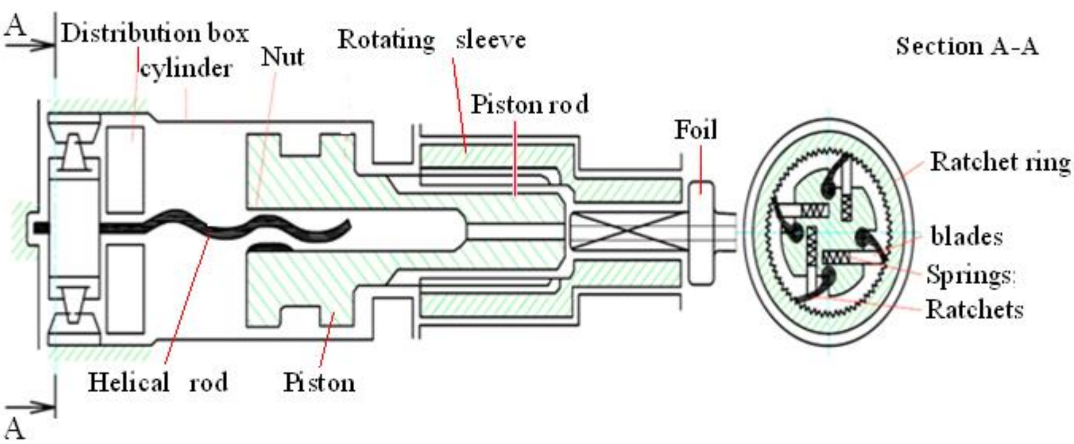

Fig.2. Longitudinal section of RH571- 4W drill Hammer [12]

4. EMPIRICAL CALCULATION

4.1 Drilling Speed Calculation

The drilling productivity is determined by the drilling speed, using the BARON and GHRAINER Formula (equation 1). This one depends on the technical parameters of the machine and the drilling conditions. The technical parameters of the perforator are determined by the power and the construction. The drilling conditions are determined by the mechanical-physical properties of the rocks and the parameters of the drilled whole (diameter and depth). The expression of the drilling speed V_f can be written as follows:

$$V_f = \frac{30.E_{ou}.n_p.Z.\tan\left(\frac{\alpha}{2}\right)}{\pi.d_f^2.C_{us}.\delta_d.\left(\tan\left(\frac{\alpha}{2}\right)+C_f\right)} \quad \text{, m/min} \tag{1}$$

Where:

$E_{ou} = E_c$: energy of a hammer blow,

n_p: number of positions per day,

Z: number of tools,

C_{us}: the coefficient taking into account the wear of the drilling tool, C us = 1, 2 - 1, 3.

C_f : the coefficient of friction, (C_f = 0.5).

d_f : diameter of the drilled hole, m .

α : the sharpening angle of the drilling tool, in degrees,

δ_d : Specific resistance of the rock to destruction, kgf/cm2

The specific resistance is determined as follows:

$$\delta_d = 300.\left(5 + f + \sqrt{25 + 10.f}\right) \tag{2}$$

With: f = 4 which has a coefficient of the hardness of the drilled rock

4.2 The characteristic parameters

Technical characteristics of the Atlas Copco RH *571-4W* type pneumatic perforator (table 1).

Table 1: Technical characteristics RH 571-4W

Parameter	index	Value
Piston diameter	D	55 mm
Piston rod diameter	d1	37 mm
Helical Rod diameter	d2	20 mm
Piston weight	G	1,3 kgf
Piston stroke	L	65 mm
Perforator mass	M	23 kg
Comprimed air pression	P	$3 \div 8$ Kgf/m2

5. EMPIRICAL FORMULAS OF PRODUCTIVITIES

Numerous researches have been made in order to arrive at some methods of determination to calculate the optimal productivities of the drilling machines of the marble ore quarry in Filfila, Skikda, Algeria which are based on the following assumptions:

- The theoretical productivity, which corresponds to the mechanical speed of drilling.
- The technical productivity takes into account the time losses which are linked to the carrying out of the auxiliary operations taking place during the drilling of the hole, while taking into account the need to exercise the preparatory operations.
- The operating productivity depends on the degree of use of the technical possibilities of a perforator under the concrete conditions of the operation.

5.1 Theoretical productivity

$$Q_{theo} = V_f .\ 60.T \qquad ;(m/post) \tag{3}$$

T : duration of a post; T = 7 hours.

5.2 Technical productivity

$$Q_{tech} = 60.Q_{theo}.K_{tech} \quad , \text{m/hour} \tag{4}$$

$$\text{with:} \quad K_{tech} = \frac{T_f}{T_f + T_{aux}} \quad , \tag{5}$$

Where: T_f is the productive working time of the perforator during a cycle, (min)

$$T_f = \frac{L}{V_f} \tag{6}$$

With: L depth measurement of the drilled hole, (m) ;

T_{aux} : Overall loss of time in carrying out auxiliary work at times when the perforator stops due to its imperfection.

$$T_{aux} = T_{man} + T_{al} + T_{disp} + T_{rep} + T_{repl}, \tag{7}$$

T_{man} : preliminary handling time before drilling each hole, (min)

T_{al} : time of lengthening and lifting of the train of rods, (min)

T_{disp} : displacement time from the perforator to the new hole, (min)

T_{rep} : repair time of the perforator to the new hole, (min)

T_{repl} : drilling tool replacement time, (min)

From where:

$$K_{tech} = \frac{1}{1+\frac{T_{aux}}{T_f}} = \frac{1}{1+\frac{T_{man}+T_{al}+T_{disp}+T_{rep}+T_{repl}}{L}.V_f} \quad , \tag{8}$$

In order to appreciate the influence of various factors on technical productivity we admit that the coefficient K_{tech} is equal to:

$$K_{man} = \frac{T_f}{T_f + T_{man}} \tag{9}$$

If there are only preliminary manipulation operations

$$K_{al} = \frac{T_f}{T_f + T_{al}} \tag{10}$$

If there are only extension and perforator operations,

$$K_{disp} = \frac{T_f}{T_f + T_{disp}} \tag{11}$$

If there are only operations to move the perforator to the new hole,

$$K_{rep} = \frac{T_f}{T_f + T_{rep}} \tag{12}$$

If there is that the repair operations of a perforator,

$$K_{repl} = \frac{T_f}{T_f + T_{repl}} \tag{13}$$

If there are only operations to replace the drilling tool, after transformation of the formula 8 we receive:

$$K_{tech} = \frac{1}{1+\left(\frac{1}{K_{man}}-1\right)+\left(\frac{1}{K_{al}}-1\right)+\left(\frac{1}{K_{disp}}-1\right)+\left(\frac{1}{K_{rep}}-1\right)+\left(\frac{1}{K_{repl}}-1\right)} \quad (14)$$

The expression obtained highlights the technical possibilities of the machines examined by comparing the results of the tests carried out.

5.3 Exploitation productivity

$$Q_{\exp} = Q_{tech}.K_u$$

, m/post (15)

Where: Q_{exp} is the Operating productivity depends on the degree of use the technical possibilities of a perforator are used in the concrete operating conditions.

$$Q_{\exp} = 60.Q_{theo}.K_{\exp} \quad , \quad (16)$$

with: K_{exp} is the coefficient taking into account the continuous work of the perforator during its operation.

$$K_{\exp} = \frac{T_f}{T_f + T_{aux} + T_{org}} \quad , \quad (17)$$

Where : T_{org} is the loss of time due to work organization.

In this case it is necessarily a question of carrying out the preparatory operations and the existence of time losses due to the organization of work as an example; rest of the workers and lack of size front.

K_u: Coefficient of perforator use during a post.

The analysis of the exposed method of determining the productivity of drilling machines shows that it has some drawbacks among which we distinguish:

- The division of time losses into two groups according to their character (regular and fortuitous) in some possible cases, example replacement of the drilling tool.

- This method does not allow appreciating separately the degree of influence of the construction of the drill machine, or the organization of work on the level of productivity.

As in the previous case, we consider that it is necessary to distinguish the theoretical, technical and exploitation productivities as presented in table 2.

6. ENERGY LOSSES CALCULATION (application of empirical formulas [12])

The energy losses calculations based on the energy of a foil blow will be determined in two cases: The first case drill hammer with a single stem equal to 1 meter. The second case drill hammer with five stems of which each equal to 1 meter.

6.1 First case of a single stem

Foil-blow energy with *l* = one meter is determined as follows:

$$E_f = E_c\, e^{-2(\alpha_1)} \tag{18}$$

Table 2. Productivities calculation

Test	$E_{ou} = E_c$ (Kgf.m)	V_f (m/min)
1	2,68	0,080
2	3,29	0,098
3	3,88	0,116
4	4,49	0,134
5	5,11	0,153
6	5,70	0,171
7	6,31	0,189
8	6,82	0,204
9	7,51	0,225
10	8,11	0,243
11	8,71	0,261

6.2 Second case of many stems

Foil-blow energy is determined as follows:

$$E_f = E_c . e^{-2(\alpha_1 . l+\alpha_2 . n+\alpha_3)} \tag{19}$$

Where:

e: base of natural logarithm (e = 2 ,71828 ≅ 2 ,72),

α_1: energy losses in one meter of foil,

α_1 = 0,004: for the round section foil,

l: Length foil,

α_2 : energy losses in a junction between foil stems,

α_2 = 0 ,025: for junction with threaded handle,

n : foil Junction number,

α_3 : energy losses in the junction between the foil and the crown

α_3 = 0 ,07 : for conical junction

Length foil is estimated as follows:

$$l = (l_f + 0, 5) \tag{20}$$

l : total length of the foil,= 1 m.

l_f: Length of a drilling = 0,5 m.

Junction number of the foil is calculated as follows:

$$n = \frac{l_f + 0,5}{\Delta l} = 1, \tag{21}$$

Δl : Length of a foil stem, m, we take :

Δl = 0.9 to 1.2 m when $f \leq 10$,

Δl = 0.7 to 0.9 m when $f > 10$,

7. PRODUCTIVITIES RESULTS IN THE FIRST CASE

Table 4 presents 11 tests to calculate the energy losses, the drilling speed, the technical&exploitation coefficients and the results of the productivities in the 1st case.

Table 4. Calculation of the productivities at 1st case

tests	E_f (kgf .m)	V_f (m/min)	Q_{theo} (m /p)	k_{tech}	Q_{tec}(m/p)	K_{exp}	Q_{exp}(m /P)
1	2.66	0.08	38.40	0.84	32.40	0.73	28.02
2	3.26	0.098	47.04	0.80	37.45	0.72	33.86
3	3.85	0.116	55.68	0.79	43.98	0.71	39.53
4	4.45	0.131	62.88	0.78	49.04	0.70	44.01
5	5.06	0.151	72.48	0.77	55.80	0.67	48.56
6	5.65	0.161	77.28	0.74	57.18	0.64	49.68
7	6.25	0.181	86.88	0.75	65.16	0.60	52.12
8	6.76	0.201	96.48	0.74	71.40	0.58	55.95
9	7.44	0.222	106.56	0.66	70.63	0.50	53.20
10	8.03	0.242	116.16	0.58	68.55	0.45	52.75
11	8.63	0 .252	120.96	0.50	61.00	0.42	51.40

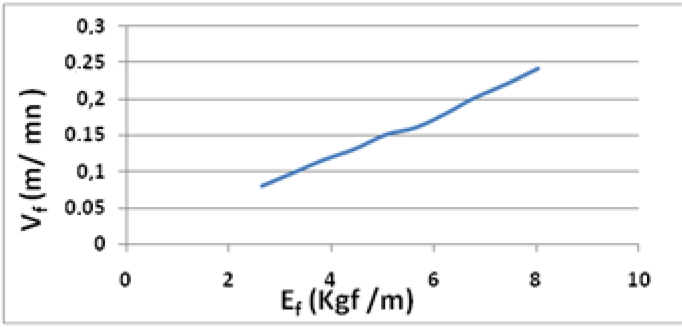

Fig.3 Profile of variation in drilling speed

Figure 3 clearly shows that there is a proportional relationship of the drilling speed $\boldsymbol{V_f}$ as a function of the blow energy $\boldsymbol{E_f}$. La vitesse $\boldsymbol{V_f}$ augmente de 0.8 m/min jusqu'à 0.252 m/min, par contre la productivité d'exploitation est de valeur crete à la vitesse V_f = 0.201 m/min.

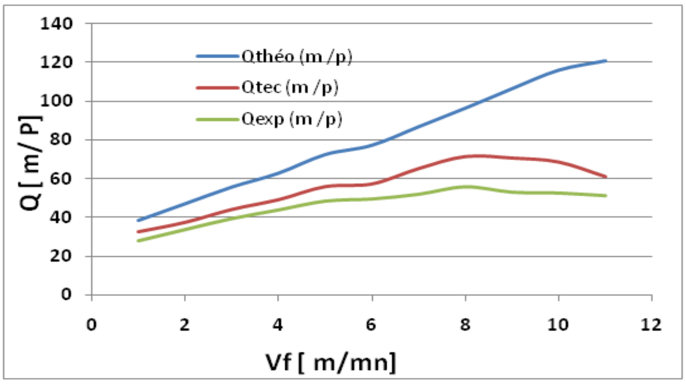

Fig.4 Productivities variations in the first case

According to the previous curves in Figure 4, we note that the values of technical productivity (Q_{tech}) increase from 32.40 to 71.40 and also of exploitation productivity (Q_{exp}) increase from 28.02 to 55.95, after these values they decrease, which explains the losses in the properties of the tool.

8. PRODUCTIVITIES RESULTS IN THE SECOND CASE

Table 5 presents 11 tests to calculate the energy losses, the drilling speed, the technical&exploitation coefficients and the results of the productivities in the 2nd case.

In figure 5, it is noticed that the drilling speed is proportional with the energy of a blow piston. After the value 88.92 the technical productivity (Q_{tech}) and the exploitation productivity value 74.69 (Q_{exp}) decrease simultaneously. These also explain the losses of the properties of the tool.

Table 5. Calculation of the productivities at 2nd case

Tests	E_f(kgf .m)	V_f(m /min)	$Q_{théo}$(m /p)	k_{tech}	Q_{tec}(m/p)	K_{exp}	Q_{exp}(m /P)
1	3.27	0.098	47.04	0.90	42.30	0.77	36.22
2	4.00	0.120	57.60	0.89	51.26	0.76	43.51
3	4.73	0.142	68.16	0.88	59.98	0.75	51.12
4	5.46	0.161	77.28	0.86	66.46	0.74	57.18
5	6.21	0.185	88.80	0.83	73.70	0.72	63.93
6	6.94	0.200	96.00	0.80	76.80	0.70	67.20
7	7.67	0.223	107.04	0.79	83.49	0.65	69.57
8	8.30	0.247	118.56	0.71	88.92	0.63	74.69
9	9.13	0.272	130.56	0.61	79.00	0.56	73.30
10	9.87	0.300	144.00	0.52	75.80	0.48	70 .52
11	10.60	0 .310	148.80	0.48	71.28	0.46	68.32

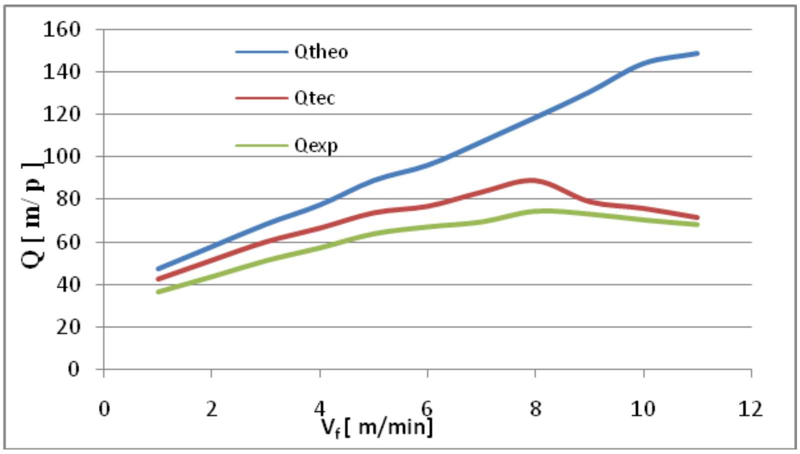

Fig.5 Productivities variations in the second case

9. APPLICATION OF A STATISTICAL MODEL

Error correction was done by processing the results, using regression analysis. This is done by an assumption of a relation between the drilling speed and the percussion energy which is represented by a straight line whose function is of the form:

$$V_f = b_1 \cdot E_C + b_2 \,, \tag{22}$$

Where: b_1 and b_2 are the unknowns of the equation, which must be determined by the empirical results. Using the **GAUSS_ MARKOV** theorem, which assumes that the line best fitted to the data is the one for which the sum of the squares of the residues is minimal.

9.1 Case of a single stem

The naming of the parameters was done below in order to use the **GAUSS-MARKOV** method to determine the speed as a function of energy loss of a blow-drill $V_f = f(E_f)$. The assumption of correspondence was made as follows: $N=11$: is the tests observation number; $E_f = X_i$; $V_f = Y_i$; $\sum X_i = 62,04$; $\sum Y_i=1,835$;$\sum (X_i . Y_i) = 11,49$; $\sum X_i^2 = 349,85$; X_i :

The marginal average of x; Y_i: the marginal average of y. $X_i = \frac{\sum Xi}{N} = \frac{62,04}{11} = 5,64;$

$Y_i=\frac{\sum Yi}{N} = \frac{1,835}{11} = 0,166.$

The equation of the GAUSS-MARKOV line is written as follows:

$V_f= b_1 . E_C + b_2 \Leftrightarrow \quad y_i^1 = b_1^1 x_i + b_0^1$

So: $b_1^1 = \frac{N \cdot \sum(x_i \cdot y_i) - \sum(x_i \cdot y_i)}{N \cdot \sum x_i^2 - \sum x_i^2}$ ==> $b_1^1 = \frac{11 \cdot 11,49 - 11,49}{11 \cdot 349,85 - 349,85} \approx 0,032$

$b_0^1 = \bar{y} - b_1^1 \cdot \bar{x}$ ==> $b_0^1 = 0,166 - (0,03) \cdot (5,64) \approx -0,02$

$$y_i^1 = 0,032\, x_i - 0,02$$

Parameter calculations E_f, V_f, Q_{theo}, K_{tech}, Q_{tec} , K_{exp} , Q_{exp} are shown in Table 6.

Figure 6 clearly shows that using GAUSS-MARKOV method eliminates errors and straightens the curve.

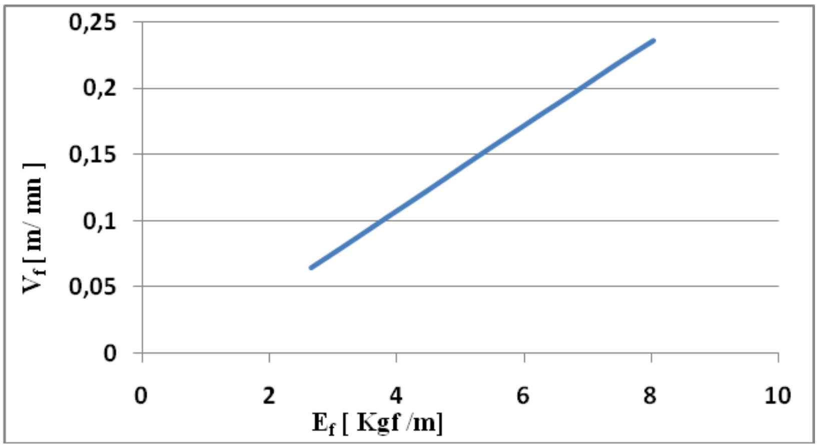

Fig.6 The variation of the drilling speed

The Interpretation of the curves presented in Figure 7 leads to a recommendation on the improvement of work organization, which gives us the possibility to increase the productivities of the drill machine.

Table 6. Calculation of the productivities at 1st case.

Tests	E_f(kgf.m)	V_f(m /min)	Q_{theo}(m /p)	K_{tech}	Q_{tec}(m /p)	k_{exp}	Q_{exp}(m /p)
1	2,66	0,065	31,20	0,91	28,39	0,76	23,71
2	3,26	0,084	40,32	0,90	36,28	0,75	30,24
3	3,85	0,103	49,44	0,89	44,00	0,73	36,10
4	4,45	0,122	58,56	0,87	50,94	0,71	41,57
5	5,06	0,142	68,16	0,86	58,61	0,69	47,04
6	5,65	0,161	77,28	0,84	64,91	0,67	51,77
7	6,25	0,180	86,40	0,83	71,71	0,64	55,56
8	6,76	0,196	94,03	0,80	75,22	0,60	56,42
9	7,44	0,218	104,64	0,70	73,44	0,52	54,60
10	8,03	0,236	113,28	0,62	70,23	0,46	52,88
11	8 ,63	0,256	122,88	0,53	65,27	0,42	51,61

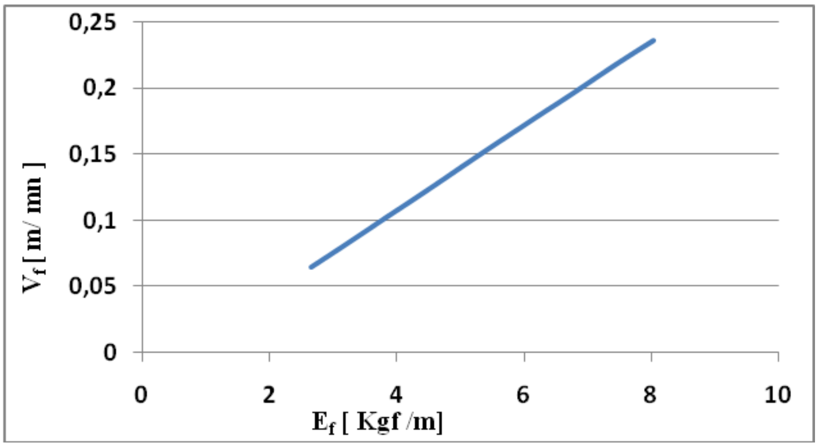

Fig.6 The variation of the drilling speed

Figure 6 clearly shows that using GAUSS-MARKOV method eliminates errors and straightens the curve.

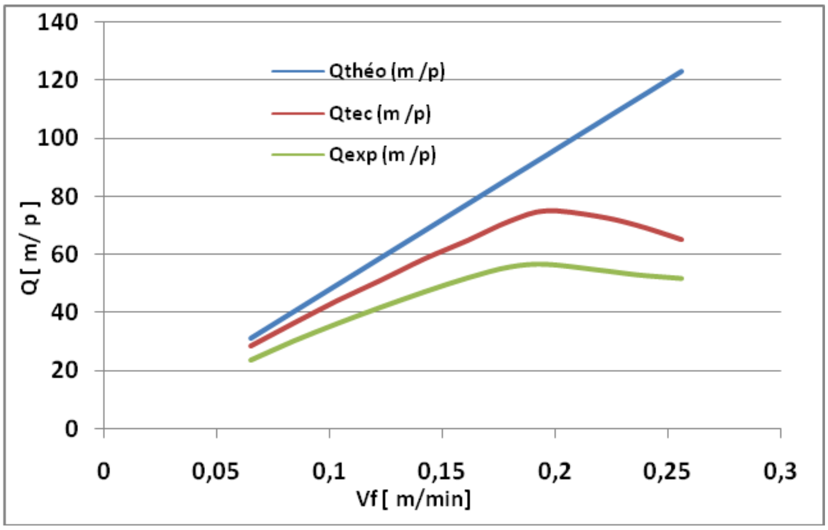

Fig.7 The variation of productivities

Figure 7 clearly shows all the theoretical, technical and operating productivities, using the GAUSS-MARKOV method to eliminate errors and straighten the curve.

9.2 Case of many stems

$V_f = f(E_f)$, $\sum X_i = 66{,}31$, $\sum Y_i = 2{,}258$, $\sum (X_i . Y_i) = 18{,}256$, $\sum X_i^2 = 586{,}452$

$$X_i = \frac{\sum Xi}{N} = \frac{66{,}31}{11} = 6{,}03 \quad , \qquad Y_i = \frac{\sum Yi}{N} = \frac{2{,}258}{11} = 0{,}2$$

The equation of the straight line: $y_i^1 = 0{,}031\,x_i - 0{,}02$

Figure 8 shows the relationship between drilling speed and energy losses of 2nd case is proportional, as well as the use of Markov corrects the errors of the curve and makes it in the form of the straight line.

In Figure 9, the Markov method determines the optimal values of the three productivities. The optimal value of the technical productivity (Q_{tech}) is 75.22 and the optimal value of the exploitation (Qexp) is 56.42 allowing to deduce the optimal value of Q_{theo} equal 94.03.

9.3 Comparison of empirical and statistical results

The results obtained by the method of BARON and GHRAINER carries the qualitative character which can be considered as approximate method, that is why it is necessary to continue the research in question based on the empirical study of drilling process seen its difficulty. In order to simplify the calculation process and obtain the results quickly, we performed the calculations statistically using the GAUSS-MARKOV method, calculating the coefficients of the equations of the system in order to extract the optimal values of the

Table 7. Calculation of the productivities at 2nd case

Test	Ef(kgf.m)	Vf(m /min)	Qthéo(m /p)	Ktech	Qtec(m /p)	kexp	Qexp(m /p)
1	3,27	0,081	38,88	0,82	31,88	0,70	27,21
2	4,00	0,103	49,44	0,80	39,55	0,68	33,61
3	4,73	0,126	60,48	0,77	46,87	0,66	39,91
4	5,46	0,150	72,00	0,75	54,00	0,63	45,36
5	6,21	0,172	82,56	0,72	59,44	0,62	51,18
6	6,94	0,195	93,60	0,70	65,52	0,60	56,88
7	7,67	0,217	104,16	0,67	70,78	0,58	61,37
8	8,30	0,237	113,76	0,65	73,94	0,57	64,56
9	9,13	0,263	126,24	0,57	72,70	0,50	62,80
10	9,87	0,285	136,80	0,51	70,65	0,44	60,82
11	10,60	0,308	147,84	0,45	67,24	0,40	59,14

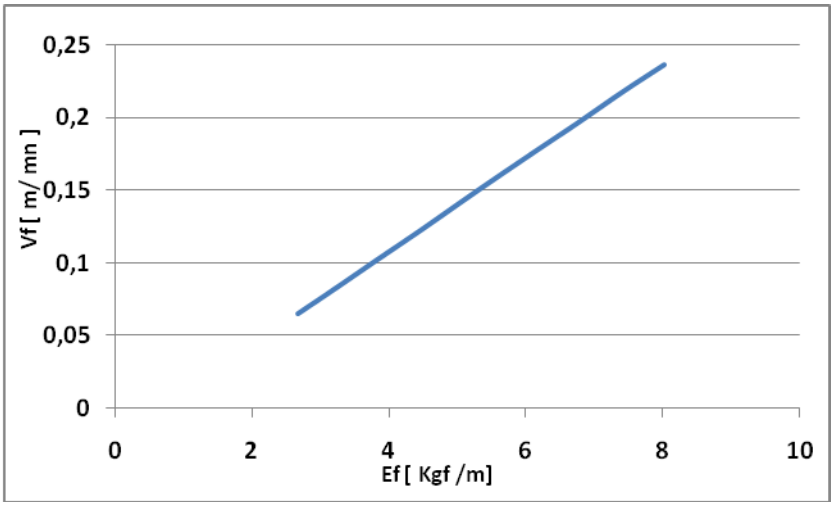

Fig.8 Variation in drilling speed

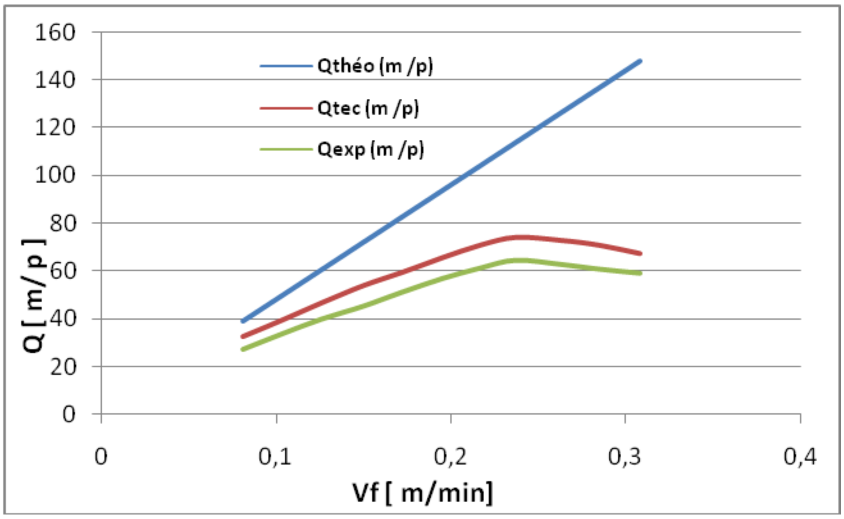

Fig.9 The variation of productivities

Figure 9 shows all the theoretical, technical and operating productivities, using the GAUSS-MARKOV method to eliminate errors and straighten the curve, depending on drilling speed V_f (m/min).

Table 8. Overall results in the case of a single stem and the case of many stems

Parameter / **Case**	**E_f (kgf .m)**	**V_f (m /min)**	**Q_{theo} (m /p)**	**Q_{tec} (m /p)**	**Q_{exp} (m /p)**
1st case	6,76	0,196	94,03	75,22	56,42
2nd case	8,30	0,237	113,76	73,94	64,56

Productivities (table 7) through the determination of the rational parameters of the operating mode of the machines. The latter gives of optimal values of all the parameters and an operating regime rational of the drilling machines. All the results obtained clearly illustrate the overall study of all energy losses in the case of a single stem and the case of many stems. Table 8 shows the optimal values of the parameters cited above.

10. CONCLUSION

In the empirical part, we studied the influence of the borehole footage on the drilling speed. Knowing that the setting parameters have a significant influence on the output parameters; the factors studied represent the variables in the field at which the study of the drilling process begins with the aim of obtaining the optimal values of these factors. The factors studying the drilling process (Productivities and energy of a hammer-blow) that can give them determined values. The best productivity of the perforator depends on the parameters of the empirical drilling; we can give them certain values.

The results obtained by the method of BARON and GHRAINER carries the qualitative character which can be considered as approximate method, that is why it is necessary to continue the research in question based on the empirical study of drilling process seen its difficulty.

For this raison a method is used for simplify the calculation process and obtain the results quickly, we performed the calculations statistically using the GAUSS-MARKOV method, calculating the coefficients of the equations of the system in order to extract the optimal values of the productivities through the determination of the rational parameters of the operating mode of the machines. The latter verifies exactly the rationality of the operating regime of the drilling machines.

In addition to these results, increasing the axial force and the energy of a hammer blow to both to their optimal values causes the speed of penetration to increase. Beyond these limits, the productivities of the drilling machine decrease, which is explained by the deterioration of the energy of a hammer blow of the drilling tool.

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