STATISTICAL ANALYSIS OF EXPERIMENTAL DATA ON THE INDICES OF OPERATION OF THE LOADING UNITS OF THE BAUXITE COMPANY OF GUINEA (CBG)

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Abstrat

The natural resources, the technical level and the value of a nation's human resources largely determine its economic development.

The proper management of these resources requires reliable information on their nature, importance and conditions of existence in order to determine the most rational methods of exploitation.

In the specific case of the Republic of Guinea, bauxite is of prime importance because of its immense resources which can be exploited according to current technology. It is the country's largest mineral resource and the main source of foreign exchange.

Guinea is the world's second largest producer of bauxite after Australia, with an estimated bauxite potential of over 40 billion tons, which would ensure centuries of production at the current rate of exploitation. The bauxite deposits in the Republic of Guinea constitute a special geological phenomenon, which some have described as a "geological scandal".

The Bauxite Company of Guinea, which is the largest mining company, responsible for about 60% of the country's exports, exploits the exceptionally high-grade bauxite reserves of the Boke region. In recent years, the company's profit has decreased as a result of an increase in financial charges related to investments in the replacement and modernization of production machinery and equipment. Although the bauxite reserves of the region of Boke are no longer of the exceptional quality of the past, the quantity assessed on the site, still allows it to envisage a significant increase in production; however, each prospect of increase in production, necessarily entails a new investment.

This is a major handicap and raises questions: "How do we increase production with less expenditure?"

This is why, despite the large number of equipment and resources involved in mining, the CBG is still faced with problems of efficiency in order to increase its production in order to meet the demands of its customers.

In order to find a solution to this thorny problem, a systematic analysis of all the technical and natural factors affecting the efficiency of production equipment such as (availability factor, utilization factor defined and loading factor of the bucket of excavators having a direct influence on the cycle time;

Therefore, after evaluation of the current parameters of the operations by the statistical method to obtain their theoretical characteristics, these values are compared with their practical average or experimental values in order to estimate the efficiency of the operations.

As a result of this comparison, we found on average per day and per piece of equipment lost time deviations from the planned value. By relating these losses of time in the calculation of the technical production parameters, we have found a significant production margin; because when one proceeds to the reduction of the lost time of the cargo and transport units, one certainly ensures an improvement in the rate of use of the equipment. This ensures an average cycle of 28 minutes per race and per truck for 16 races per shift; an actual production margin of 30% of its planned value for the study period

Introduction

The harmonious development of science and technology would be impossible if man did not proceed to extract the useful minerals which today constitute the framework on which the technological progress of the world today is built.

Thus aluminum by its properties (non magnetic, ductile, light, decorative, good electrical and thermal conductor), by the diversity of its uses (thermite, Aeronautics, shipbuilding, civil construction...) to name only these is at present the most familiar of metals after Iron having a competitive price on the world market.

Demand for aluminum increased dramatically during and after the Second World War and remains strong for several decades of technological progress and economic growth in countries (from 1946 to the mid-1970 s).

Since the end of this period, demand has declined, as the market for aluminum products in the industrialized countries was approaching saturation point on the one hand and on the other hand due to the general economic recession in the world.

However, economic growth and the promising future of previous years led industrialists to build a large number of alumina and aluminum plants around the world. Since many of them were put into operation at the very moment when demand was falling, it was the imbalance between production capacity and demand that was the result.

Today the aluminum industry is increasingly cut with a large number of isolated alumina and electrolysis plants that sell their products on the open market.

These various opportunities have made the global aluminum industry intensely competitive. It is hoped that global demand for aluminum and therefore for alumina and bauxite will continue to grow. Each mining company today faces three major challenges.

In view of the increasing competition, a high-quality product must be supplied in sufficient quantity. ;

Economic issue: to maximize the gain, it is necessary to ensure the projected production at a competitive cost. ;

Technological challenge: in order to keep customers, it is necessary to reduce production time, by maintaining the efficiency of technological equipment and installations, correct planning and rigorous monitoring of production operations.

In addition to these main issues, there is also the issue of the environmental impact of mining, which ultimately determines the feasibility of all mining projects, regardless of their industrial value.

The Bauxite Company of Guinea, which is the largest mining company, responsible for about 60% of the country's exports, exploits the exceptionally high-grade bauxite reserves of the Boke region.

For years this company has contributed between $ 100 million and $ 200 million in revenue to the state budget, constituting a major part of the dividends that the government draws from its participation, despite all funding coming from outside.

As part of its commitment to provide quality and quantity bauxite that meets customer requirements and meets specification limits, any deviation from targets results in a loss of revenue that is detrimental to the company's profitability.

In recent years, the main objective of the Company des Bauxites de Guinee is to increase the value of its production each year by keeping the total cost of production constant.

It is in this perspective and in the perspective of making our modest contribution to the search for a solution to the problems related to the management of the efficiency of the mining machines at the Company des Bauxites de Guinea (CBG) that we present this monograph, in which we have carried out a statistical analysis of the experimental data on all the technical indices of operation of the mining machines from:

Availability factor which characterizes the condition of the various types of equipment;

Utilization factor which characterizes the way in which the company's work is organized;

Load factor of the bucket of the loading units as well as the average number of buckets to load a bucket, having a direct influence on the duration of a run (production cycle).

Actual efficiency of loading units

Loading is a major technological operation affecting the technical and economic indices of exploitation. This is why, in order to ensure a better exploitation efficiency, it deserves special attention in the organization the management of the time of production.

At the Sangaredi mine (CBG), the loading of the damaged mass is carried out by two types of machines: hydraulic excavators (PC-1800 and PC-3000) and hydraulic loaders (Caterpillar 992-GK and Komat'su WA-900-3).

As an example we study the trend parameters of the statistical distribution of the real yields of the excavator PC-1800 in the month of April 2019 which are presented in Table №1.

Since this statistical series is linear, and contains several data, we proceed with the transformation of this linear series into a classified series.

For this, the number of classes is determined by the formula : $K=1+3.3 \log n$

where K - number of classes;

n - total number of employees in the series.

In our case $n=88$ then $K=1+3.3 \log 88 \approx 7$ so $K=7$

Let us calculate the class I interval by the following formula

$$I = \frac{Q_{\max} - Q_{\min}}{K},$$

where I-class interval;

- Maximum value of the yield (as of April 2019 equal to 2300t/poste) ;
- Minimum value of the yield (as of April 2019 equal to 200 t/poste). i=300

Following these results, we get the following table

Table 1

Absolute and relative frequency distribution
for the excavator PC-1800

Class no	Class	Center class	Effective	Relative frequency
1	200-500	350	8	0,09
2	500-800	650	20	0,23
3	800-1100	950	28	0,32
4	1100-1400	1250	22	0,25
5	1400-1700	1550	2	0,02
6	1700-2000	1850	7	0,08
7	2000-2300	2150	1	0,01
K=7			n=88	1

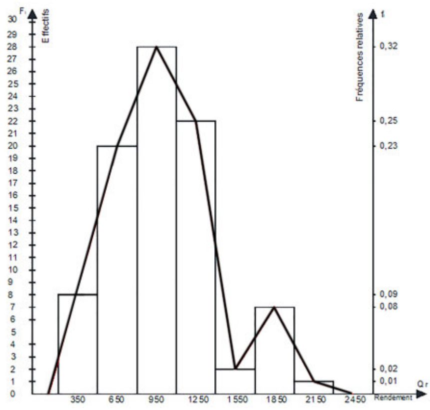

Fig. 1. Frequency range: excavator PC-1800

Determination of trend parameters of the series:

Arithmetic mean for the linear series it is calculated from the expression

$$\bar{X} = \bar{Q}_r = \frac{1}{n}\sum_{i=1}^{n} X_i$$

But for a classified series, it is accompanied by absolute frequencies such as

$$\bar{Q}_r = \frac{1}{n}\sum_{i=1}^{n} F_i Q_{ri} \quad \text{(for } n\text{>30)}$$

where n - sample size; F_i - effective or absolute frequency; X - Class center.

For our case we have

$$N\text{>}30\ \bar{Q}_r = \frac{1}{n}\sum_{i=1}^{n} F_i Q \ \text{(t/p) or } \sum_{i=1}^{n} F_i Q = 88100$$

Table 2

Calculation of trend parameters of the series: Excavator PC-1800

Centre des classes	$\lvert Q_{ri} - \bar{Q}_r \rvert$	$\left(Q_{ri} - \bar{Q}_r\right)^2$	F_i	$F_i\left(Q_{ri} - \bar{Q}_r\right)^2$
350	651	423801	8	3390408
650	351	123201	20	2464020
950	51	2601	28	72828
1250	249	62001	22	1364022
1550	549	301401	2	602802
1850	849	720801	7	5045607
2150	1149	1320201	1	1320201
				12939680

Variance: calculated by the following formula

$$Q_r^2 = \frac{1}{n}\sum_{i=1}^{n} F_i\left(Q_{ri} - \bar{Q}_r\right)^2$$

Standard deviation: it represents the square root of the variance

$$\vartheta = Q_r \text{ thus } \sqrt{Q_r^2} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} F_i\left(Q_{ri} - \bar{Q}_r\right)^2} \quad Q_r\text{=383,46 t/p}$$

The probability density function: the distribution is described by the probability density formula

$$\phi\left(Q_{ri}\right) = \frac{1}{Q_r^2\sqrt{2\pi}} e^{-\frac{\left(Q_{ri} - \bar{Q}_r\right)^2}{2\vartheta^2}}$$

According to the values of Q_{ri} we will have the values $\phi(Q_{ri})$ of in Table 3

Table 3

Summary of the values of the probability density function

Q_{ri} (t/p)	350	650	950	1250	1550	1850	2150
$\phi(Q_{ri})\,10^{-4}$	2,46	6,85	10,32	8,44	3,73	0,89	0,12

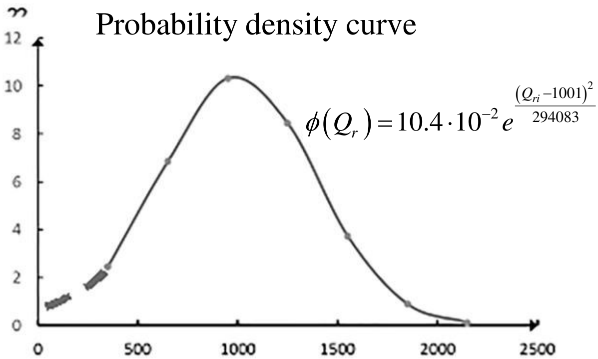

Fig. 2. Probability density curve for the excavator PC-180**0**

Theoretical data Distribution:

The theoretical distribution of data plays an important role in solving problems in many practical areas. Several laws of distribution are used for this purpose, such as : binomial law, poison law, uniform law, normal law among which the normal or Gaussian law is the most used because it can be exploited to solve a large number of problems of interpretation, namely the description of the distribution of experimental errors.

It can serve as a mathematical model for the representation of a large number of theoretical distributions.

This is why in our case if the actual Q_r performance meets the following conditions:

If Q_r is the result of several independent cases with additive effects and each of the cases has a negligible effect on the whole, then Q_r is distributed according to the normal law.

The probability density function in this case is as follows

$$Y = f\left(Q_r\right) = \frac{1}{Q_r\sqrt{2\pi}} e^{-\frac{\left(Q_{ri}-mQ_r\right)^2}{2Q_r^2}}$$

where mQ_r-mathematical expectation of the variable Q_r;

Q_r - standard Deviation of the variable

The curve Y is symmetrical with respect to the line perpendicular to the X-axis in $Q_r = mQ_r$;

On each side of the summit there are inflection points *A* and *B* from which the curve approaches the X-axis.

When Q_r tends to $\pm\infty$; Y tends to zero.

The probability density function at the center of symmetry of the curve is equal to

$$f\left(Q_r\right) = Y_{\max} = \frac{1}{Q_r\sqrt{2\pi}} e^{-\frac{\left(Q_r-mQ_r\right)^2}{2Q_r^2}}$$

when $Q_r = mQ_r$ we will have $e^{-\frac{\left(Q_r-mQ_r\right)^2}{2Q_r^2}} = e^0 = 1$

As well $f\left(Q_r\right) = Y_{\max} = \frac{1}{Q_r\sqrt{2\pi}}$

$$f\left(Q_r\right) = Y_{\max} = \frac{1}{383.46\sqrt{2\cdot 3.14}}$$

$$Y_{\max} = 10.43\cdot 10^{-4} \quad \text{t/p}$$

By integration, the cumulative normal function is equal to

$$F\left(Q_r\right) = \int_{-\infty}^{+\infty} f\left(Q_r\right) dQ_r = \frac{1}{Q_r\sqrt{2\pi}} \int_{-\infty}^{+\infty} e^{-\frac{\left(Q_r-\bar{Q}_r\right)^2}{2Q_r^2}} dQ_r = 1$$

If the change of origin and scale is done in the following way

$$t = \frac{Q_r - \bar{Q}_r}{Q_r}$$

We obtain the reduced normal centered variable defined on *R* by the probability density

$$Y = f\left(t\right) = \frac{1}{\sqrt{2\pi}} e^{-\frac{t^2}{2}}$$

Then the Laplace function defined by

$$Q(t) = \int_0^t Q(t)dt = \frac{1}{\sqrt{2\pi}} \int_0^t e^{-\frac{t^2}{2}} dt$$

$$Q(t) = \frac{1}{\sqrt{2\pi}} e^{-\frac{t^2}{2}} = 0.4e^{-\frac{t^2}{2}} \quad Q(t) = 0.4e^{-\frac{t^2}{2}}$$

According to the values of t in this function, the following table is obtained

Table 4

Summary of the values of the probability density function as a function of the reduced centered variable (t)

t	-3	-2	-1	0	1	2	3
$f(t)$	0,004	0,05	0,24	0,4	0,25	0,05	0,004

Kolmogorov-Smirnov hypothesis Test

In the statistical treatment of experimental data, it is usually assumed that the distribution of these data follows a certain theoretical law depending on the nature of the characters studied, which is a hypothesis.

Thus, the test of Kolmogorov Smirnov allows to answer the question: Can this hypothesis be applicable to these data or not or can one consider as true a sample drawn from a population of theoretical distributions of data?

Kolmogorov Smirnov's test is a means of comparing a theoretical and observed distribution.

According to the data in the table of values of the density function of the reduced centered variable (t) which is equal to

$$t = \frac{X_i - \bar{X}}{\vartheta}$$

where X_i - center classes; $\bar{X}$ - arithmetic average; ϑ - standard Deviation.

For the case of yields we will have

$$t = \frac{Q_{ri} - \bar{Q}_r}{\vartheta}$$

where Q_{ri} - class center; $\bar{Q}_r$ - arithmetic average; ϑ - standard deviation

For the theoretical and the observed frequency to have the same scale, the value of the function f(t) found in the table of values of the density function shall be corrected by the following scale coefficient:

$$K_{echelle} = \frac{n\omega}{\vartheta} = \frac{88 \cdot 250}{383.46} = 57.37$$

where n - total staff ; ω - class interval; ϑ - standard deviation

Table 5

Calculation of parameters to test the yield distribution. For the PC-1800 shovel

Q_{ri}	$\lvert Q_{ri} - \bar{Q}_r \rvert$	t	$f(t)$	Freq theoriq	Freq cum	Freq obse	Cumul	Ecart
350	651	1,70	0,3123	17,91	17,91	8	8	13,49
650	351	0,91	0,2637	15,12	33,03	20	28	1,85
950	51	0,13	0,3956	22,69	55,72	28	56	0,77
1250	249	0,65	0,3230	18,53	72,25	22	78	0,23
1550	549	1,43	0,1435	8,23	82,48	2	80	7,87
1850	849	2,21	0,0347	1,99	84,47	7	87	5,38
2150	1149	2,00	0,0044	0,25	84,72	1	88	0,70
$K_{\text{échelle}}$=57.37								

Of the maximum deviation found and the number of samples observed, the parameter λ_n is given by the following formula:

According to the table for the Kolmogorov-Smirnov test, we find the probability $P(\lambda_n)$. If $P(\lambda)$ is greater than 0.05 then we can say that the studied distribution follows the normal law. In our case the maximum deviation $Ecart_{\max}$=13.49; n=88

Then $\lambda_n = \frac{9.91}{\sqrt{88}} = 1.0564$ λ_n=1,06

Depending on the values of λ_n, the corresponding values of $P(\lambda_n)$ are chosen. So for λ_n=1,06 then $P(\lambda_n)$=0.2700

This value of $P(\lambda_n)$ is greater than its lower limit, so this distribution follows the normal law.

Confidence interval

The question can be answered as to the quality of the estimation of the mean m of the distribution by the mean of the sample.

If A and B are the random values, (a, b) is the confidence interval at the rate if the probability P. P($a \leq m \leq b$)≥1-α

Estimate the mean m at the rate of 95%, the confidence interval will be

$$\left(\bar{X} - 1.96\frac{\vartheta}{\sqrt{n}}; \bar{X} + 1.96\frac{\vartheta}{\sqrt{n}}\right)$$

The precision is thus calculated by the formula

$$R = 1{,}96\left(\vartheta/\sqrt{n}\right)$$

The above expressions are valid for sufficiently large samples (n>30).

Since in our case n is greater than 30 (n>30) we will have

$$\left(\bar{Q}_r - 1.96\frac{\vartheta}{\sqrt{n}}; \bar{Q}_r + 1.96\frac{\vartheta}{\sqrt{n}}\right)$$

For an estimate of the average at the 95% rate, the precision is therefore

$$R = 1.96\frac{383.46}{\sqrt{88}} = 80.12 \quad R\text{=80,12}$$

So $\bar{Q}_r = 1001 \pm 80.12$

In the same way, we have processed the experimental data on the actual performance of the three (3) other models of loading equipment, namely:

Excavator PC-3000; CAT – 992-GK Loader and Komat'su Wa – 900-3 Loader. The treatment results are shown in Tables 7, 8 and 9.

Table 7

Summary of the results of the calculation of the trend parameters of the distribution of the real yield of the three gears

Parameter / Gear	Average $\left(\bar{Q}_r\right)$ t/post	Variance (V) t/post	Standard deviation (Q_r) t/post
Excavator PC-3000	917	184019	429
Loader Caterpillar 992-GK	1036	185075	430
Loader Komat'su WA-900-3	1108	257460	507

Table 8

Summary table of the values of $P(\lambda_m)$ as a function of the values of λ_m

Parameter / Gear	$Ecart_{\max}$	$\Sigma F_i = n$	λ_n	$P(\lambda_n)$
excavator PC-3000	11,18	90	1,17	0,1122
Loader Caterpillar 992-GK	10,47	84	1,14	0,1777
Loader Komat'su WA-900-3	11,70	74	1,36	0,0681

In conclusion, all the values of the probabilities found $P(\lambda_n)$ are above the threshold of $P(\lambda_n)$=0,05; then we can affirm that the distributions of the real yield of the three (3) cargo gear according to the normal law.

Since the sample size is greater than 30 (N>30) for the three (3) loading units then we can estimate the average at the 95% rate with the following confidence interval

$$\left(\bar{X} - 1.96\frac{\vartheta}{\sqrt{n}}; \bar{X} + 1.96\frac{\vartheta}{\sqrt{n}}\right)$$

Table 9

Summary table of confidence intervals of the actual yield per shift of the three gears with 95% probability

Gear \ Parameter	Arithmetic averages	Confidence intervals
Excavator PC-3000	917	917±89
Loader Caterpillar 992-GK	1036	1036±92
Loader Komat'su WA-900-3	1108	1108±109

Analysis of technical indices affecting the performance of loading units

The operating efficiency of loading units is calculated by the following formula

$$Q_{Ex} = \frac{3600 \cdot E \cdot T_p \cdot K_r \cdot K_u}{t_c \cdot K_f}\gamma \text{ t/p}$$

In the course of studies on the variation of the values of the actual efficiency of loading machines, we have found that there are three (3) main technical indices which directly affect the efficiency, depending on the condition of the slag mass (grain size, bulking, geometric dimensions, physical condition, etc.) and the way in which

- Utilization factor (K_u);
- Load factor (K_r);
- Duration of the working cycle (t_c);
- Coefficient of availability (K_d)

Utilization factor study (K_u)

The utilization factor represents the ratio between the time worked and the programmed time and is written as follows

$$K_u = \frac{T_{trav}}{T_{prog}}\ ;\ (\%)$$

où T_{trav} - time worked by post; T_{prog} - time programmed by post.

This formula is actually applied to find the utilization factor (K_u) at the first workstation. For the other two (2) items, the following expressions are used

$$K_{u_{II}} = \frac{Q_{II}}{Q_I} K_{uI} \text{ et } K_{u_{III}} = \frac{Q_{III}}{Q_I} K_{uI}$$

where K_{uI}, K_{uII} and K_{uIII} are the utilization factor for the 1st, 2$^{\text{nd}}$ and 3$^{\text{rd}}$ shift respectively.

Statistical processing of experimental data on coefficients of utilization of loading units

We treat the experimental data in the same way as the previous method applied to real yields. The results of the treatment are shown in Table 10.

Table 10

Summary of confidence intervals for shift utilization factors of loading units, with 95% probability

Parameter / Gear	Arithmetic average	Confidence interval
Excavator PC-3000	0,70	0.7±0.0294
Loader Caterpillar 992-GK	0,54	0.54±0.0337
Loader Komat'su WA-900-3	0,71	0.71±0.0305
	0,65	0.65±0.0373

These confidence intervals show that the value of each distribution is very close to the average of the utilization factors of each loading unit. This means that the organization of loading work at the Sangaredi mine affects the cycle time of the machines.

Study of the filling factor of the bucket

In practice, the extracted ore does not occupy exactly the geometric volume of the excavator bucket. Depending on The Shape of the load and the bulking of the rock, the actual capacity of the bucket may be lower or higher than its geometric volume. When the ore is well fractured during mining, the degree of bulking increases, which favors normal filling of the excavator bucket. But on the contrary, when the cut Mass contains a high percentage of pieces of Rock whose dimensions are outside the gabarie, that is to say, exceeding the geometric dimensions of the bucket of the excavator, then the filling of the bucket of the excavator is called into question and the duration of the cycle of loading of the trucks will increase.

This is why, in calculating the efficiency of the machines, we have taken into account the degree of utilization of the capacity or the coefficient of filling of the excavator bucket expressed by the actual quantity of ore in the bucket compared to its geometric capacity

$$K_r = \frac{V_r}{E}$$

where K_r - filling factor of the bucket ;

V_r - actual volume of rock in excavator bucket;

E - capacity of the excavator bucket, given by the manufacturer.

To determine the values of this coefficient we used the results of the average tonnages loaded in the trucks during our research period (April 2019).

According to this method, the expression of the filling coefficient of the bucket becomes

$$K_r = \frac{Q_g}{Q_r}$$

where Q_g - actual quantity of ore in the bucket of the excavator; determined by the average tonnages put in the trucks, by the expression

$$Q_g = \frac{T_{moy}}{N_g},$$

where T_{moy} - average tonnage loaded in trucks during the month of April 2019; N_g - average number de godet pour charger un camion.

A cause de son impact sur le nombre de godet, la durée du cycle de chargement ainsi que le rendement d'exploitation des équipements, le coefficient de remplissage mérite une attention particulière

Analysis of the filling factor and the number of buckets in the loading units

This analysis is based on the study of the interdependence between the load factor and the average number of excavator buckets to fill the dump truck.

To determine the interdependence between these two parameters for each of the loading units, the actual values of these indices were used to determine their correlation using the correlation coefficients (table 11).

Table 11

Summary of the results of the calculation of the correlation coefficients

Loading units	Correlation Coefficients	Interpretation
Excavator PC-1800	- 0,82	Negative strong
Excavator PC-3000	- 0,90	Negative strong
Cat 992-GK loader	- 0,84	Negative strong
Komat'su WA-900-3 loader	- 0,91	Negative strong

On the basis of the results of the calculation of the correlation coefficient of these two technical indices, it can be confirmed that there is a strong but inverse correlation between the filling coefficient and the number of buckets.

Study of the availability factor of loading units

The availability coefficient is the ratio between the time available and the time programmed

$$K_d = \frac{T_d}{T_p},$$

where T_d - time available; T_p - time planned.

The treatment of the experimental data is carried out in the same way as the previous method applied to the utilization factor. The results of the treatment are shown in Table 12.

Table 12

Summary of the results of the calculation of the technical indices of loading units

Loading units	K_d real	K_d provide	K_u real	K_u provide
Excavator PC-1800	0,82	1	0,70	0,95
Excavator PC-3000	0,81	1	0,54	0,95
Cat 992 - GK loader	0,87	1	0,71	0,95
Komat'SU WA-900-3 loader	0,85	1	0,65	0,95

From this table it appears that the actual average values of the availability coefficient of the loading machines are below their forecast values of 18% which shows that, according to the data of our research period, the planned time management organization for the loading machines is not respected, because of the frequency of stoppages caused by unexpected breakdowns.

The utilization factors are lower than the planned values of 30%, which explains the decline in the production efficiency of loading units.

This phenomenon can be caused either by poor management of the available time, or by the poor physical quality of the ore or by the various conditions of use of the machines, such as: the state of the flat, the size of the slashed mass, the percentage of the big blocks, the incompetence of the operators.

Conclusion

Systematic study and analysis of production processes to improve the production of CBG is a very important and very complicated task from the point of view of the need to increase the efficiency of the machines without spending much. But the current practice of the CBG, other mining companies, and mining sector actors in this specific area of mining, shows us that almost 30% of equipment operating time is lost due to lack of rationality in time management and proper monitoring of production equipment.

The development of this work has enabled us to identify in general, the complexity of the organizational problems of the Bauxite Company of Guinea; but in particular the problems related to the management of the productivity of the machines as well as of the operating cycle at the Sangaredi mine.

Based on CBG's technical capabilities and production objectives under normal conditions, we have theoretically assessed all the parameters of the production sector in relation to planning, namely:

Yields, to estimate the productivity of production equipment;

Technical indices to measure their effects on gear performance.

Following this evaluation, we analyzed the values of these parameters under actual field conditions to determine the shortfall, comparing the results of the practical analysis with their theoretical values. This comparison enabled us to discover significant differences between these two values in terms of time, efficiency, production and the number of production equipment.

Thus, to reassure ourselves and confirm with certainty the existence of these important margins on all the parameters evaluated, we used an effective instrument for diagnosing technical procedures, called the statistical method.

This method enabled us, using the results of the statistical processing of the experimental data on yield and on all the technical indices having a direct or indirect influence on the yield of the loading units , to answer the question whether or not these loading units are capable of meeting the production objectives.

From these analyses it can be seen that the average values of the technical indices (coefficient of use, coefficient of availability ...) are well below their company's target average values, which gives the opportunity to increase production capacity with less expense.

It should also be noted that this study is characterized by a twofold interest:

Scientific: to provide useful information on the operating strategy and management of production equipment; possibility of using statistical methods to diagnose operating processes;

Economically: avoid spending unnecessarily on each production increase project by applying the principles of organization and management of the working time of each piece of equipment in order to improve their performance.

This would result in a production surplus of about 30% of the planned production at the Sangaredi mine.

Bibliography

1. **Bernard Barriau** : Métallurgie générale Paris, 1971
2. **Michel Kerfanto** : Technique statistique- Traitement des Solides ;1971
3. **Geliot** : Technologie d'appareil de l'industrie chimique. Paris 1976
4. **Pascal Montagneux** Manuel de boute feu Nitrobigford 2003
5. **Géologie Minière E**. Kazakov 1975
6. Echantillonnage et Préparation Christian 1999
7. Audit technique d'échantillonnage CBG/Sangaredi
8. Prospection Minière des gisements des minéraux utiles **Anatoly Bortinikov**
9. Procédé de contrôle qualité CBG 2003
10. Stratégie d'amélioration constante de la Qualité/ CB Juin 2001

11. Statistique Appliquée et outils d'amélioration de la qualité 2ème Edition 2001
12. Introduction aux méthodes statistique et contrôle qualité Edition SMGM.
13. Guide caterpillards « Matériel et méthodes, Edition 1990 »
14. Cours de contrôle statistique de procédé CSP enregistré au CDF de Kamsar 1993.
15. Traitement statistique des données expérimentales (Première partie) 2001
16. R**. Dorfman, P Samuelson et R Solow** : programmation linéaire et gestion économique.Dunod 1962 ;
17. **M Desplas** :Mathématique de la décision économique, complement et exercices Dunod 1967
18. **La prar Benayoun** : La pratique de l'optimisation dans l'entreprise PUF 1974
19. **R. Faure** : Guide de la recherche opérationnelle (tome 2) Masson 1990
20. **R faune**, Precis recherche opérationnel Dunod 1979
21. **B Guerrien et G Archinard** : Analyse mathématique pour l'économiste.
22. **AlBouy**. :La régularisation econopmique des entreprises Dunod 1982
23. François Monchy :Maintence : Méthode et organisation 2ème Edition Dunod 2007
24. **Cébo Maurice** GBILIMI : Cours de Statistique appliquée à la recherche et à l'exploitation minière 2003
25. **M. Kamien et N Schwartz** North Holland Méthodes et modele de la recherche opérationnelle 1981.
26. Rapport du plan minier :CBG 2015.
27. Gestion de la valeur dans le secteur minier : Wold Economic Forum 2013
28. **Hoover, H.C** 1909, Principles of Mining ; New York
29. **Vallée,M**. 1986 Mineral inventory ; from Resource reconnaissance and Evaluation
30. **Leigh, O.E** 1986 : Reportingon Reserves.
31. **Carlier A**. 1963 : Contribution aux méthodes d'estimation des gisements Paris France
32. Wold Class : 1989 : Editorial, The Northern Miner
33. **V.Giard** : Gestion de la production, économica. 1988
34. **D. Hague** : Economie du management. Dunod 1971
35. **I.Horowitz** : An introduction to quantitative busness analysis Mac. Graw Hill 1965
36**. L.Kantorovitch** : Calcul économique et utilisation optimale des ressources. Moscou 1960. Dunod 1963
37. **S.Sethi et G Thomson** : Optimal Control Theory. Application to management science : Martnus Nijh.