# Use of Modern Computing Technique to Improve the Energy Indicators of Drive Motors of the Coal Mills

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***Abstract*** **- In this paper, the authors present a study on the energetic opportunity to replace derated motors of the five mills which are in service at a power plant with other motors by a rated power closer to the actual load. To this end, it has previously been drawn up a suggestive comparative analysis of diagrams of active and reactive power balance in absolute and percentage values for each case of considered constructive variants. Thus for drawing up, using the complete mathematical model (BEMAS) chosen for the asynchronous machine, of the electric balances for different operating regimes of these asynchronous motors, it was necessary to determine the parameters of the equivalent diagram. Considering the complexity and large volume of computation, the authors developed for this purpose, specific computational algorithms. For all these computational algorithms, computation programs have been drawn, being developed in the programming environment Mathcad Version 7.0, of own conception and which in principle can be used for any other similar motors that have different nominal data. It has also been highlighted that the starting point to establishing the opportunity of replacing of the analyzed asynchronous motors operating derated in steady state, is determining the actual load degree that is achieved through active power measurement for the considered regime.**

**Keywords:** *electric balance, complete mathematic model, energy indicators, coal mills, power plant.*

## I. INTRODUCTION

At the boiler with steam rated flow from the high pressure, 1035 t/h equipping a power plant, the coal is burned in powder form.

The preparation of the coal dust is made with six mills, combined with hammers and a fan. The six mills of the boiler and associated coal dust burners are placed so around the boiler that their axes are tangent to an imaginary circle with a diameter of 1500 mm with centre in the centre of the outbreak (swirling outbreak), Fig. 1.

The coal mills dry and mill the coal in a single operation after it has been crushed at the fuel household to a particle size of the 0 - 30 mm, with the maximum particle size 40 mm up to 15 %. The six mills are modernized mill type DGS-100. The mill DGS-100 is built in two versions: the right and left, the difference between these variants consisting of the sense of rotation of the fan rotor. The mill DGS-100 has the rated flow in an operation cycle of the hammers 100 t/h and is driven by an asynchronous motor having the following rated parameters: $P_n$ = 1400 kW, $U_n$ = 6 kV, synchronous speed $n_s$ = 1500 rot/min.

The fan mill (Fig. 2) with hammers is composed of a supply casing, the casing of the mill itself, the fan casing, the separator (1), the connection pipelines to the burners, a shaft hingeably provided with five rows of hammers and the fan mill and the mill drive (2). Above the supply casing flange is located the insulation shutter of the mill (3) with the gas pipeline and supply pipeline.

As it is shown in Fig. 3, the mill drive is composed of (M) the asynchronous electric motor - MIB-2A-630L-150-4, (CH) the hydraulic coupler - CHR 850 E-0 and (R) the speed reducer, with the transmission ratio i = 1:3.1.

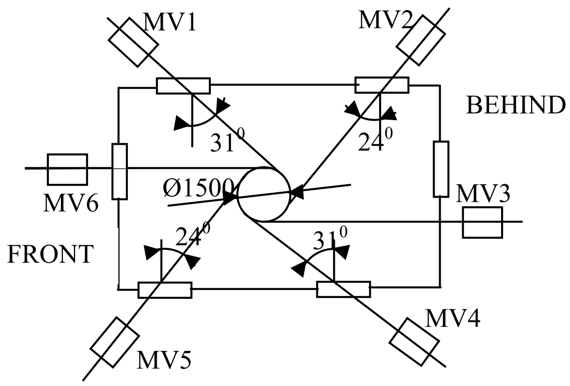



Fig. 1. Arrangement of mills around the boiler and their numbering.

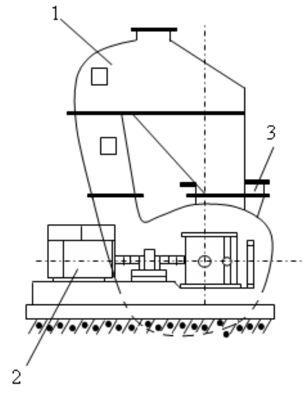



Fig. 2. View of the fan mill with hammers DGS-100.

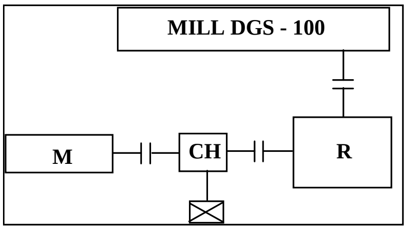



Fig. 3. Electric drive of the mill DGS-100.

## II. THE ELECTRIC BALANCE OF THE ASYNCHRONOUS MOTOR TO DRIVE A COAL MILL USING THE COMPLETE MATHEMATIC MODEL

### A. *Determination of parameters of the asynchronous motor to drive a DGS-100 coal mill*

It is considered the squirrel cage asynchronous motor with high rectangular copper bars in two constructive variants Variant I and Variant II, having the catalogue data as in Table I.

TABLE I.
THE TECHNICAL CHARACTERISTICS OF THE ASYNCHRONOUS MOTOR TO DRIVE A COAL MILL

| The technical characteristic name | Variant I | Variant II |
|---|---|---|
| | MIB 2-Ax 630L 150-4 | MIB-X 630L 150-4 |
| Rated power, $P_n$ [kW] | 1400 | 1400 |
| Rated voltage, $U_n$ [kV] | 6 | |
| Rated current, $I_n$ [A] | 155 | 156 |
| Rated speed, $n_n$ [rot/min] | 1488 | 1492 |
| Power factor, $\cos\varphi_n$ | 0,91 | 0,91 |
| Efficiency, $\eta$ [%] | 95,2 | 95,2 |
| Rated slip, $s_n = (n_s - n_n)/n_s$ | 0.008 | 0.005333 |
| Number of pole pairs, $p$ | 2 | |
| Starting current, $i_p = I_p/I_n$ reported to $U = U_n$ | 4,8 | 5,8 |
| Starting torque, $m_p = M_p/M_n$ reported to $U = U_n$ | 1,4 | 1,1 |
| Maximum torque, $m_m = M_{max} / M_n$ reported to $U = U_n$ | 2,2 | 2,1 |
| No load current, $I_0$ [A] | 28,5 | 34 |
| Reduced height of the rotor bar, $h'$ | 22.44 | |
| Losses in the iron, $P_{Fe}$ [kW] | 32,375 | 3,5 |

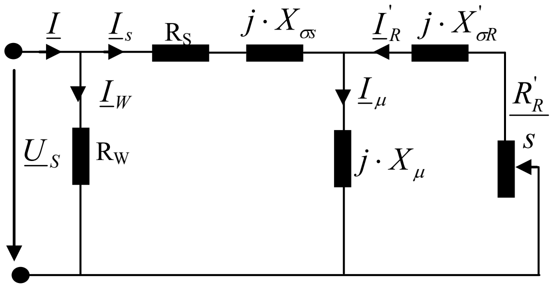



Fig. 4. Computation equivalent scheme for the asynchronous motor.

The parameters of the asynchronous machine equivalent scheme, which is shown in Figure 4, have been computed according to the following existing algorithms in the specialty literature [1], [2], [3].

$$U_{sn} = \frac{U_n}{\sqrt{3}}, \quad I_w = \frac{1}{3}\frac{P_{Fe}}{U_{sn}}, \quad R_w = \frac{U_{sn}}{I_w} \tag{1}$$

$$I_{sdn} = I_n \cos\varphi_n - I_w, \quad I_{sqn} = I_n \sin\varphi_n, \quad I_{sn} = \sqrt{I_{sdn}^2 + I_{sqn}^2} \tag{2}$$

$$R_{abn} = \frac{U_{sn} I_{sdn}}{I_{sn}^2}; \quad X_{abn} = \frac{U_{sn} I_{sqn}}{I_{sn}^2} \tag{3}$$

$$A = 1 - 2s_n(m_m - 1); \quad B = 2m_m \tag{4}$$

$$s_m = s_n \frac{B + \sqrt{B^2 - 4A}}{2A} \tag{5}$$

$$a_c = \frac{1}{s_m^2}; \quad b_c = \frac{1 + s_n^2 a_c - 2 s_n m_m \sqrt{a_c}}{s_n(m_m - 1)} \tag{6}$$

$$a = \frac{2\sqrt{a_c}}{b_c}; \quad b = \frac{2}{s_n b_c}; \quad c = \frac{R_{abn}}{X_{abn}} \tag{7}$$

$$q = \frac{ac\left(a^2 + b^2\right) + 2b^2}{a^2 b + b^2(1 + ac)}; \quad r = \frac{a^2 + b^2}{a^2 b + b^2(1 + ac)} \tag{8}$$

$$\sigma = 0.5\left(q + \sqrt{q^2 - 4r}\right) \tag{9}$$

$$m_s = \frac{1 - \sigma}{\sqrt{a^2\sigma^2 - 1}}; \quad m_R = \frac{2 m_s \sigma}{b_c} \tag{9'}$$

$$X_s = \frac{m_R^2 + s_n^2}{m_R^2 + s_n^2(1 - \sigma)} X_{abn}; \quad R_s = m_s X_s \tag{10}$$

$$X_\mu = \frac{X_s}{1.03}; \quad X'_R = \frac{X_\mu^2}{\sigma X_s}; \quad R'_R = m_R X'_R \tag{11}$$

$$X_s = X_{\sigma s} + X_\mu, \quad X'_R = X'_{\sigma R} + X_\mu \tag{12}$$

$$X_{\sigma s} = X_s - X_\mu, \quad X'_{\sigma R} = X'_R - X_\mu \tag{13}$$

For motors with high bars in the rotor in order to separate the components of resistance and the reactance of the rotor, the computation is continued by the following formulas:

$$K_c = \frac{1.5 p U_{sn}^2}{\omega R_s} b_c, \quad M_{en} = \frac{s_n K_c}{s_n^2 a_c + s_n b_c + 1} \tag{14}$$

$$R_{sc} = \frac{\omega m_p M_{en}}{3 p i_p^2 I_n^2} + R_s$$
$$X_{sc} = \sqrt{\frac{U_{sn}^2}{i_p^2 I_n^2} - R_{sc}^2} \tag{15}$$

$$m_{Rsc} = \frac{R_{sc} - R_s}{X_s - X_{sc}}$$
$$\sigma_s = \frac{X_\mu}{X_s} \tag{16}$$
$$\sigma_{Bsc} = \frac{X_{sc} - m_{Rsc}(R_{sc} - R_s)}{X_s}$$

$$\sigma_{Rsc} = \frac{1 - \sigma_{Bsc}}{\sigma_s}$$
$$X'_{Rsc} = \frac{X_\mu}{\sigma_{Rsc}} \tag{17}$$
$$R'_{Rsc} = m_{Rsc} X'_{Rsc}$$

$$k_{Rsc} = h'$$
$$k_{Xsc} = \frac{1.5}{h'} \tag{18}$$

$$R'_{RV} = \frac{R'_{Rsc} - R'_R}{k_{Rsc} - 1}$$
$$X'_{RV} = \frac{X'_{Rsc} - X'_R}{k_{Xsc} - 1} \tag{19}$$

$$R'_{RC} = R'_R - R'_{RV}$$
$$X'_{RC} = X'_R - X'_{RV} \tag{20}$$

TABLE II.
THE COMPUTED PARAMETERS OF THE COMPUTATION EQUIVALENT SCHEME FOR THE ASYNCHRONOUS MOTOR TO DRIVE A COAL MILL

| Parameter | Variant I | Variant II |
|---|---|---|
| | MIB 2-Ax 630L 150-4 | MIB-X 630L 150-4 |
| $I_W$ [A] | 3.115 | 3.368 |
| $R_W$ [Ω] | 1112 | 1029 |
| $I_{sdn}$ [A] | 137.935 | 138.592 |
| $I_{sqn}$ [A] | 64.264 | 64.679 |
| $I_{sn}$ [A] | 152.171 | 152.942 |
| $R_{abn}$ [Ω] | 20.635 | 20.525 |
| $X_{abn}$ [Ω] | 9.614 | 9.579 |
| $X_s$ [Ω] | 106.317 | 113.489 |
| $R_s$ [Ω] | 0.189 | 0.125 |
| $X_\mu$ [Ω] | 103.22 | 110.184 |
| $X_R'$ [Ω] | 105.462 | 112.499 |
| $R_R'$ [Ω] | 0.178 | 0.118 |
| $X_{\sigma s}$ [Ω] | 3.097 | 3.306 |
| $X_{\sigma R}'$ [Ω] | 2.242 | 2.316 |
| $R_{sc}$ [Ω] | 0.788 | 0.446 |
| $X_{sc}$ [Ω] | 4.589 | 3.803 |
| $X_{Rsc}'$ [Ω] | 104.731 | 110.682 |
| $R_{Rsc}'$ [Ω] | 0.616 | 0.323 |
| $R_{RV}'$ [Ω] | 0.02 | 0.009594 |
| $X_{RV}'$ [Ω] | 0.784 | 1.947 |
| $R_{RC}'$ [Ω] | 0.158 | 0.108 |
| $X_{RC}'$ [Ω] | 104.678 | 110.552 |

These parameters are summarized in Table II, where:

$I_W$ [A] - the corresponding current to the iron losses (occurring in resistance $R_W$);

$R_{RV}'$ [Ω] - the phase dispersion resistance corresponding to portions of the rotor winding comprised the inside of the magnetic core of the rotor, reported to the stator;

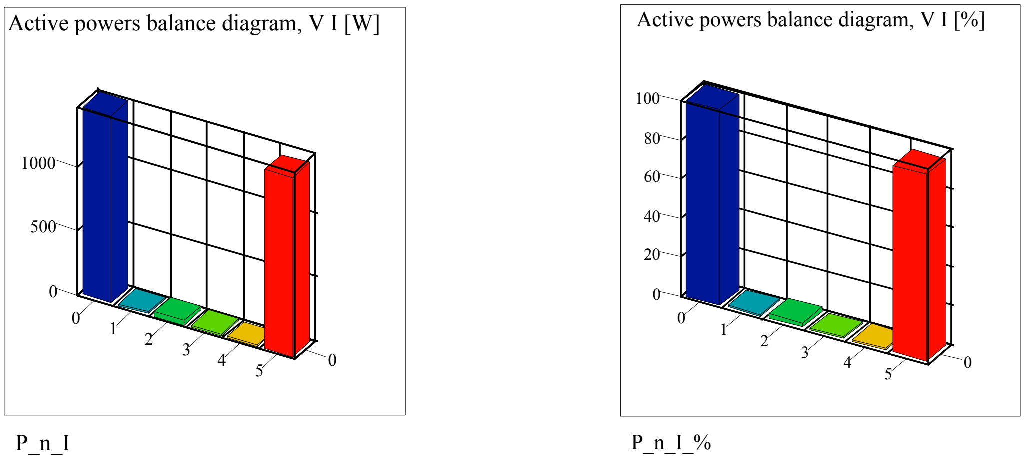
$X_{RV}'$ [Ω] - the phase dispersion reactance corresponding to portions of the rotor winding comprised the inside of the magnetic core of the rotor, reported to the stator;

$R_{RC}'$ [Ω] - the phase dispersion resistance corresponding to winding portions located outside of the rotor core (bar ends and shorting rings), reported to the stator;

$X_{RC}'$ [Ω] - the phase dispersion reactance corresponding to winding portions located outside of the rotor core (bar ends and shorting rings), reported to the stator. The computation of parameters of computing equivalent scheme was required to obtain then the main components of electric balance and energy indicators for the rated regime of asynchronous motor. The electric balance of active and reactive powers for the rated regime of the asynchronous motor to drive coal mill was then drawn up using a complete mathematic model (BEMAS) for the two constructive variants. The diagrams of active and reactive powers balance at the asynchronous motor, in absolute and percentage values have been represented for Variant I (Fig. 5, Fig. 7) and for Variant II (Fig. 6, Fig. 8). The energy indicators (efficiency and power factor) of the motors to drive coal mills have been also computed in the two constructive variants, the results being summarised in Table III. For all these computing algorithms, own conception computation programmes have been developed in version 7.0 Mathcad programming environment [4].

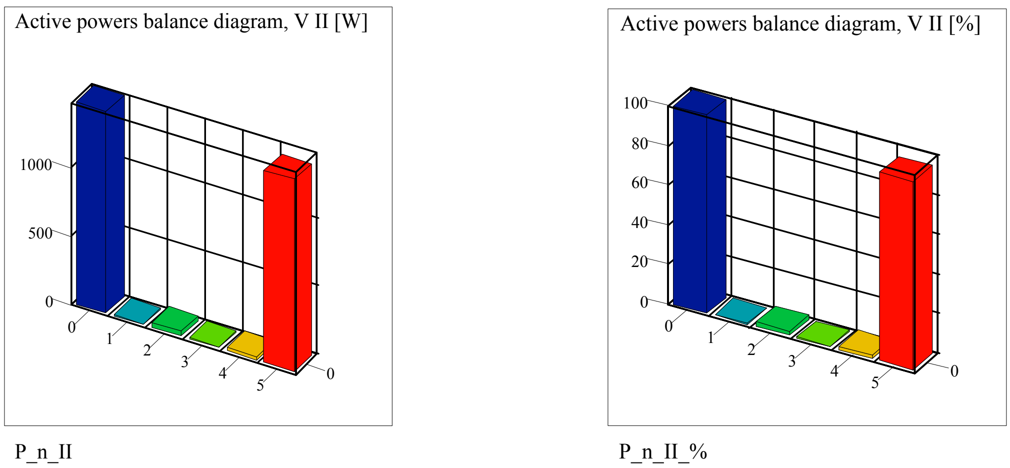
TABLE III.
COMPONENTS OF ELECTRIC BALANCE OF THE ASYNCHRONOUS MOTOR TO DRIVE A COAL MILL

| Name of the component | Variant I | Variant II |
|---|---|---|
| | MIB 2-Ax 630L 150-4 | MIB-X 630L 150-4 |
| Joule effect losses in the stator, $P_s$ [kW] | 13.146 | 8.769 |
| Iron losses, $P_{Fe}$ [kW] | 32.375 | 35 |
| Joule effect losses in the rotor, $P_R$ [kW] | 11.362 | 7.635 |
| Mechanical and ventilation losses, $P_{mv}$ [kW] | 8.919 | 23.86 |
| The absorbed active power, $P_{an}$ [kW] | 1466 | 1475 |
| Efficiency, $\eta_n$ | 0.955 | 0.949 |
| The reactive power covering stator dispersion, $Q_{\sigma s}$ [kVAr] | 215.101 | 231.947 |
| The reactive power covering rotor dispersion, $Q_{\sigma R}$ [kVAr] | 142.793 | 150.081 |
| The reactive power needed for machine magnetization, $Q_\mu$ [kVAr] | 309.921 | 290.101 |
| The absorbed reactive power, $Q_{an}$ [kVAr] | 667.816 | 672.129 |
| The apparent power, $S_{an}$ [kVA] | 1611 | 1621 |
| Power factor, cosφ | 0.91 | 0.91 |



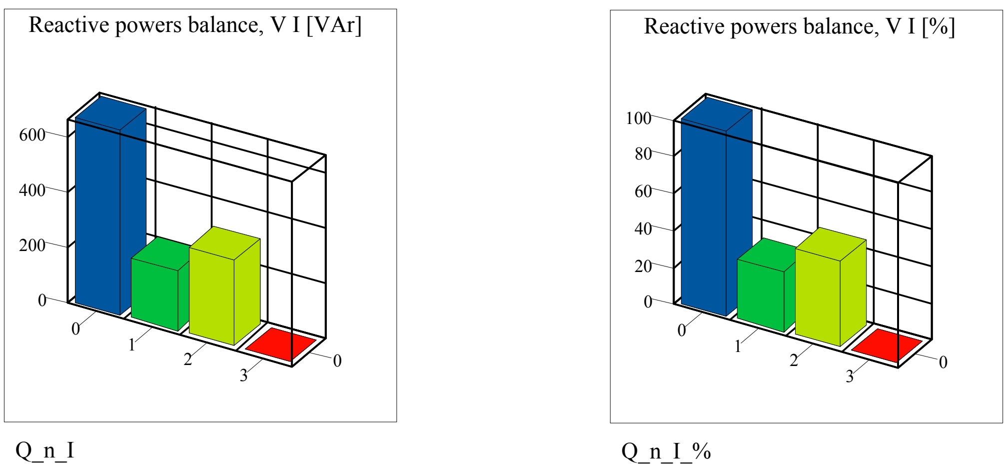

a) b)

Fig. 5. Diagram of active powers balance at the asynchronous motor, Variant I: a – absolute values; b – percentage values.



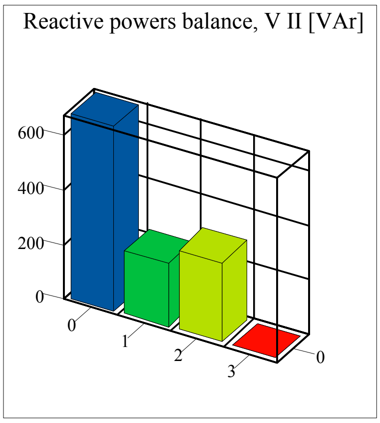

a) b)

Fig. 6. Diagram of active powers balance at the asynchronous motor, Variant II: a – absolute values; b – percentage values.

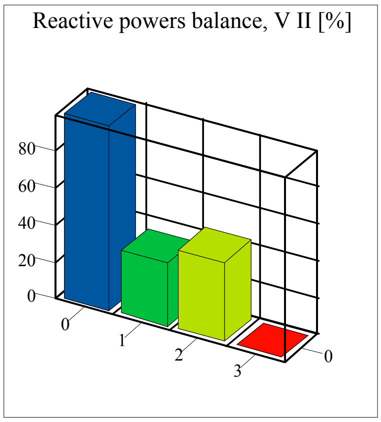



a) b)

Fig. 7. Diagram of reactive powers balance at the asynchronous motor, Variant I: a – absolute values; b – percentage values.




a)




b)

Fig. 8. Diagram of reactive powers balance at the asynchronous motor, Variant II: a – absolute values; b – percentage values.

where in Fig. 5 and Fig. 6:
0 - The absorbed active power, $P_{an}$
1 - The Joule effect losses in the stator, $P_S$
2 - The iron losses, $P_{Fe}$
3 - The Joule effect losses in the rotor, $P_R$
4 - The mechanical and ventilation losses, $P_{mv}$
5 - The output power, $P_n$
while in Fig. 7 and Fig. 8:
0 - The absorbed reactive power, $Q_{an}$
1 - The reactive power covering stator dispersion, $Q_{\sigma S}$
2 - The reactive power needed for machine magnetization, $Q_\mu$
3 - The reactive power covering rotor dispersion, $Q_{\sigma R}$

The active power components have resulted according to the following computation formulas:

$$P_s = \frac{3R_s U_s^2\left(R_R'^2 + s^2 X_R'^2\right)\cdot 10^{-3}}{s^2\left[R_s^2 X_R'^2 + \left(X_s X_R' - X_\mu^2\right)^2\right] + s2R_s R_R' X_\mu^2 + \left(R_s^2 + X_s^2\right)R_R'^2}$$
[kW] (21)

$$P_{Fe} = 3\frac{U_s^2 \cdot 10^{-3}}{R_W}[kW]$$
$$P_R = \frac{R_R'}{R_s}\cdot\frac{s^2 X_\mu^2}{R_R'^2 + s^2 X_R'^2}P_s \qquad (22)$$

In order to determine the mechanical and ventilation losses are used the relations from the rated regime data. Are computed with the relation (22) the Joule losses in the rotor winding ($P_{Rn}$) for the rated slip ($s_n$) with which are obtained:

$$P_{en} = \frac{P_{Rn}\left(1 - s_n\right)}{s_n}$$
$$P_{mv} = P_{en} - P_n \qquad (23)$$

Therefore the total active losses will be:
$$\Delta P_n = P_{sn} + P_{Fen} + P_{Rn} + P_{mvn} \qquad (24)$$

The absorbed active power and the efficiency are computed with the following relations:

$$P_{an} = P_n + \Delta P_n \qquad (25)$$

$$\eta_n = \frac{P_n}{P_{an}} \qquad (26)$$

The reactive power components are obtained thus:

$$Q_{\sigma s} = \frac{X_s - X_\mu}{R_s}P_s \qquad (27)$$

$$Q_{\sigma R} = \frac{X_R' - X_\mu}{X_s - X_\mu}\cdot\frac{s^2 X_R'^2}{R_R'^2 + s^2 X_R'^2}; Q_{\sigma R} = \frac{X_R' - X_\mu}{R_R'}\cdot P_R \qquad (28)$$

$$Q_\mu = \frac{X_\mu\left[R_R'^2 + s^2\left(X_R' - X_\mu\right)^2\right]}{\left(X_s - X_\mu\right)\left(R_R'^2 + s^2 X_R'^2\right)}Q_{\sigma s} \qquad (29)$$

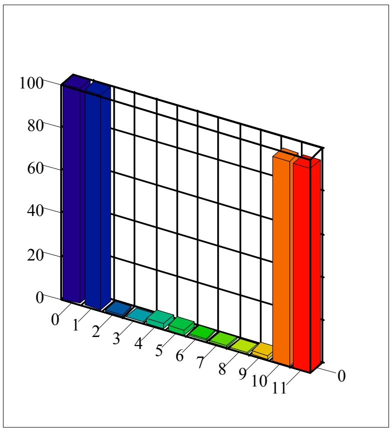
The absorbed reactive power results:

$$Q_{an} = Q_{\sigma s} + Q_{\sigma R} + Q_\mu \qquad (30)$$

The apparent power and the power factor result according to the relations:

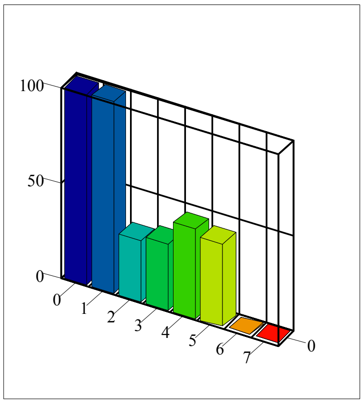
$$S_a = \sqrt{P_a^2 + Q_a^2}$$
$$\cos\varphi = P_a / S_a \qquad (31)$$

It was performed a suggestive *comparative analysis* [5], [6] of diagrams of active power balance in absolute and percentage values (obtained by reference to the absorbed active power for each constructive variants) (Fig. 9) and diagrams of reactive power balance in absolute and percentage values (obtained by reference to the absorbed reactive power for each constructive variants) (Fig. 10).




P_n_I_II_%

Fig. 9. Comparative diagram of active powers balance at asynchronous motor, Variant I and Variant II in percentage values.
0, 1 - The absorbed active power, $P_{an}$
2, 3 - The Joule effect losses in the stator, $P_S$
4, 5 - The iron losses, $P_{Fe}$
6, 7 - The Joule effect losses in the rotor, $P_R$
8, 9 - The mechanical and ventilation losses, $P_{mv}$
10, 11 - The output power, $P_n$




Q_n_I_II_%

Fig. 10. Comparative diagram of reactive powers balance at asynchronous motor, Variant I and Variant II in percentage values.
0, 1 - The absorbed reactive power, $Q_{an}$
2, 3 - The reactive power covering stator dispersion, $Q_{\sigma S}$
4, 5 - The reactive power needed for machine magnetization, $Q_\mu$
6, 7 - The reactive power covering rotor dispersion, $Q_{\sigma R}$

### B. *Opportunity analysis of the derated motors replacement*

In terms of energy, the main positive effects that are expected to replacing motors that operate in steady state derated with others having the rated power closer to those required by the driven mills are reducing power consumption and improving power factor [7], [8], [9], [10].

The results of the measurement processing of active power for the concerned regime, which were performed on five mills while operate, of the six available, were summarized in Table IV.

TABLE IV.
PERFORMED MEASUREMENTS AT THE MILLS ASSOCIATED TO BOILER NO. 5

| Parameter | Mill no. | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| $P_c$ [kW] | 833 | 858 | 828 | 939 | 843 | - |
| $\beta_P$ | 0.595 | 0.613 | 0.591 | 0.671 | 0.602 | - |
| $\eta$ | 0.939 | 0.941 | 0.939 | 0.945 | 0.940 | - |
| $\cos\varphi$ | 0.830 | 0.835 | 0.829 | 0.851 | 0.832 | - |
| $P_A$ [kW] | 833 | 858 | 828 | 939 | 843 | - |
| $P_a$ [kW] | 782.916 | 807.721 | 777.954 | 888.074 | 792.834 | - |
| $\Delta P$ [kW] | 50.083 | 50.278 | 50.045 | 50.925 | 50.165 | - |

TABLE V.
ANALYSIS OF THE OPPORTUNITY CHARACTERISTICS FOR THE REPLACEMENT OF DERATED MOTORS

| The name of characteristic | | Variant I (used for mills no. 1, 3, 5) | | | Variant II (used for mills no. 2, 4) | |
|---|---|---|---|---|---|---|
| | | MIB 2 500Y 120-4 | | | MIB-V 20X 180F 1900-12 | |
| Power, $P_{n1}$ [kW] | | 800 | | | 1000 | |
| Efficiency, $\eta_{n1}$ | | 0.93 | | | 0.945 | |
| Power factor, $\cos\varphi_{n1}$ | | 0.91 | | | 0.83 | |
| $\beta_{P1}$ | | Mill no. | | | | |
| | | 1 | 3 | 5 | 2 | 4 |
| | | 0.9786 | 0.9724 | 0.991 | 0.8077 | 0.8881 |
| $\Delta P_1$ [kW] | | 60.2151 | | | 58.2011 | |
| $P_{A1}$ [kW] | | 841.85 | 836.51 | 852.51 | 854.73 | 939.76 |
| $\delta P$ | [kW] | 10.13 | 10.17 | 10.05 | 7.922 | 7.275 |
| | [%] | 16.83 | 16.89 | 16.689 | 13.612 | 12.500 |
| $\Delta P_{ab}$ | [kW] | 8.845 | 8.509 | 9.509 | -3.268 | 0.761 |
| | [%] | 1.051 | 1.017 | 1.115 | -0.382 | 0.081 |

where $P_c$ [kW] represents the power consumed by the mill motor. The degree of loading with active power, $\beta_P$ is computed with the relation (32).

$$\beta_P = P_c / P_n \tag{32}$$

The efficiency $\eta$ and the power factor $\cos\varphi$ of steady state are computed with the relations (33), (34).

$$\eta \approx (\beta_P - A_\eta)/(B_\eta \cdot \beta_P) \tag{33}$$

$$\cos\varphi \approx \beta_P / (A_\varphi + B_\varphi \cdot \beta_P) \tag{34}$$

From the tables [1] are found the coefficients: $A_\eta=0.0313$; $B_\eta=1.008$; $A_\varphi=0.155$; $B_\varphi=0.944$. The absorbed active power, $P_A$ [kW] and the available active power to the shaft, $P_a$ [kW] in the considered regime are determined with the relations (35), (36):

$$P_A = \beta_P \cdot P_n \tag{35}$$

$$P_a = \eta \cdot P_A \tag{36}$$

Power active losses $\Delta P$ [kW] will be computed with the relation (37):

$$\Delta P = P_A - P_a \tag{37}$$

To analyse the opportunity of the derated motors replacement (justified because the loads are under 0.75, as can be seen from Table IV) also were used some relations for computation:

- The degree of loading with active power, $\beta_{P1}$:

$$\beta_{P1} = P_a / P_{n1} \tag{38}$$

- The active power losses, $\Delta P_1$ [kW]:

$$\Delta P_1 = [(1-\eta_1)/\eta_1] \cdot P_{n1} \tag{39}$$

- The absorbed active power, $P_{A1}$ [kW]:

$$P_{A1} = P_a / \eta_1 \tag{40}$$

- The difference between the active power losses, $\Delta P_1$ and the power active losses, $\Delta P$, $\delta P$ in [kW] and in [%]:

$$\delta P = \Delta P_1 - \Delta P \tag{41}$$

$$\delta P_{\%} = ((\Delta P_1 - \Delta P)/\Delta P) \cdot 100 \tag{42}$$

- The difference of absorbed power in [kW] and in [%], $\Delta P_{abs}$:

$$\Delta P_{ab} = \Delta P_{A1} - P_A \tag{43}$$

$$\Delta P_{ab\%} = ((\Delta P_{A1} - P_A)/P_{A1}) \cdot 100 \tag{44}$$

The computation results have been summarized in Table V.

## III. CONCLUSIONS

It was studied *the energy opportunity of the replacement of derated motors* of *the five mills which are in service*, with other motors having a rated power closer to the real load.

Thus it was found that new motors with the rated power of 800 kW (for coal mills no. 1, 3, 5) and 1000 kW (for coal mills no. 2, 4) will work in practice with rated efficiency, $\eta_{n1}$=0.93 and $\eta_{n2}$=0.945 respectively, but this is lower than the existing motor regime efficiency ($\eta$ = 0.952), resulting some active power losses.

So if the motor of 1400 kW is replaced with another one at 800 kW respectively 1000 kW, instead to obtain a reduction of power losses and absorbed power it results in a growth of these.

The coal mill no. 2 is an exception at this it is found however a sensible reduction of the absorbed power (– 0.382 %) as it can be seen from Table V.

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