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ABOUT THE MAGNETICAL CHARACTERISTICS OF THE SYNCHRONOUS MOTOR, PROPOSED IN ACTIVATING THE CONVEYORS FROM THE LIGNITE MINE SHAFTS

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ABSTRACT
In this paperwork, the authors present the results obtained by making a program in the Borland Pascal language, to obtain the partial magnetical characteristics, used to determine the excitation solenation at nominal duty of the synchronous motor with appearing polls and in the combined variant, proposed in activating the transport tools from the lignite mine-shafts. This is done in the purpose of implementing some new types of controllable activations mend to contribute at reducing the electrical power consumption of the tools mentioned above, according with the realizations obtained in this way by the countries with tradition and experience in the domain of the extraction, transporting and depositing the useful and sterile.

INTRODUCTION

For activating the large capacity belt conveyors from the mine shafts is proposed the synchronous motor with the rotor in the constructive combined variant, with longitudinal-transversal silencer completely made from Cu-Cu, with the following nominal data's: 777,4 kVA/630 kW, 6kV, 1000 rot/min. (fig. 1)

In the purpose of quick determining the magnetical characteristics, the program determines the main dimensions of the motor, the electrical and magnetical solicitations of the motor, the parameters of the notches and the windings, establishes the values of the magnetical tensions in different portions of the magnetical circuit (in the main inter-iron, in the teeth and in the ladle shank of the stator, in the big tooth of the rotor, in the area of the rotorical notches and in the inductors ladle shank)

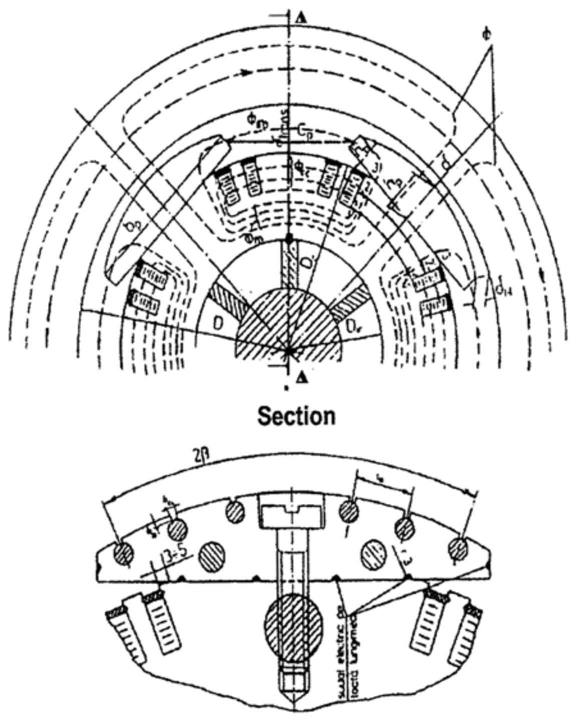


Figure 1. Synchronous motor with rotor in combined

Construction of magnetical characteristics and determination of solenation for nominal excitation of syncronous motor with rotor in combined constructive variant with nominal parameters: 777.4 kVA/630 kW; 6kV; 1000 rot/min and longitudinal-transversal complete dumping from Cu-Cu and Am-Cu

Table Nr:

$E = \frac{E}{U_{1NM}}$ / Relation	ur	0.55	0.70	0.85	$1(U_{1NM})$	$K_e(E_{NM})$	1.15	1.26	1.28	1.30
	V	1905.2	2424.8	2944.4	3464	3654	3983.6	4360.72	4433.92	4503.2
1	2	3	4	5	6	7	8	9	10	11
$\phi = \frac{E}{4K_B f K_{w1} W_{1ver}}$	Wb	0.042	0.053	0.065	0.076	0.080	0.087	0.096	0.097	0.099
$B_\delta = \frac{\phi_{0N}}{\alpha_i \tau l_i}$	T	0.420	0.534	0.648	0.763	0.805	0.877	0.960	0.976	0.992
$U_{m\delta} = \frac{2}{\mu_0} B_\delta K_c \delta$	A	4028.950	5127.755	6226.559	7325.364	7727.159	8424.168	9221.669	9376.466	9522.973
$B'_{dmax} = \frac{t l_{i1} B_\delta}{K_{Fe1} l_{Fe1} b_{dmin}}$	T	9.521	12.118	14.714	17.311	18.260	19.907	21.792	22.158	22.504
$B'_{dmed} = \frac{t l_{i1} B_\delta}{K_{Fe1} l_{Fe1} b_{dmed}}$	T	0.832	1.059	1.286	1.513	1.596	1.740	1.905	1.937	1.967
$B'_{dmin} = \frac{t l_{i1} B_\delta}{K_{Fe1} l_{Fe1} b_{dmax}}$	T	0.681	0.867	1.052	1.238	1.306	1.424	1.559	1.585	1.610

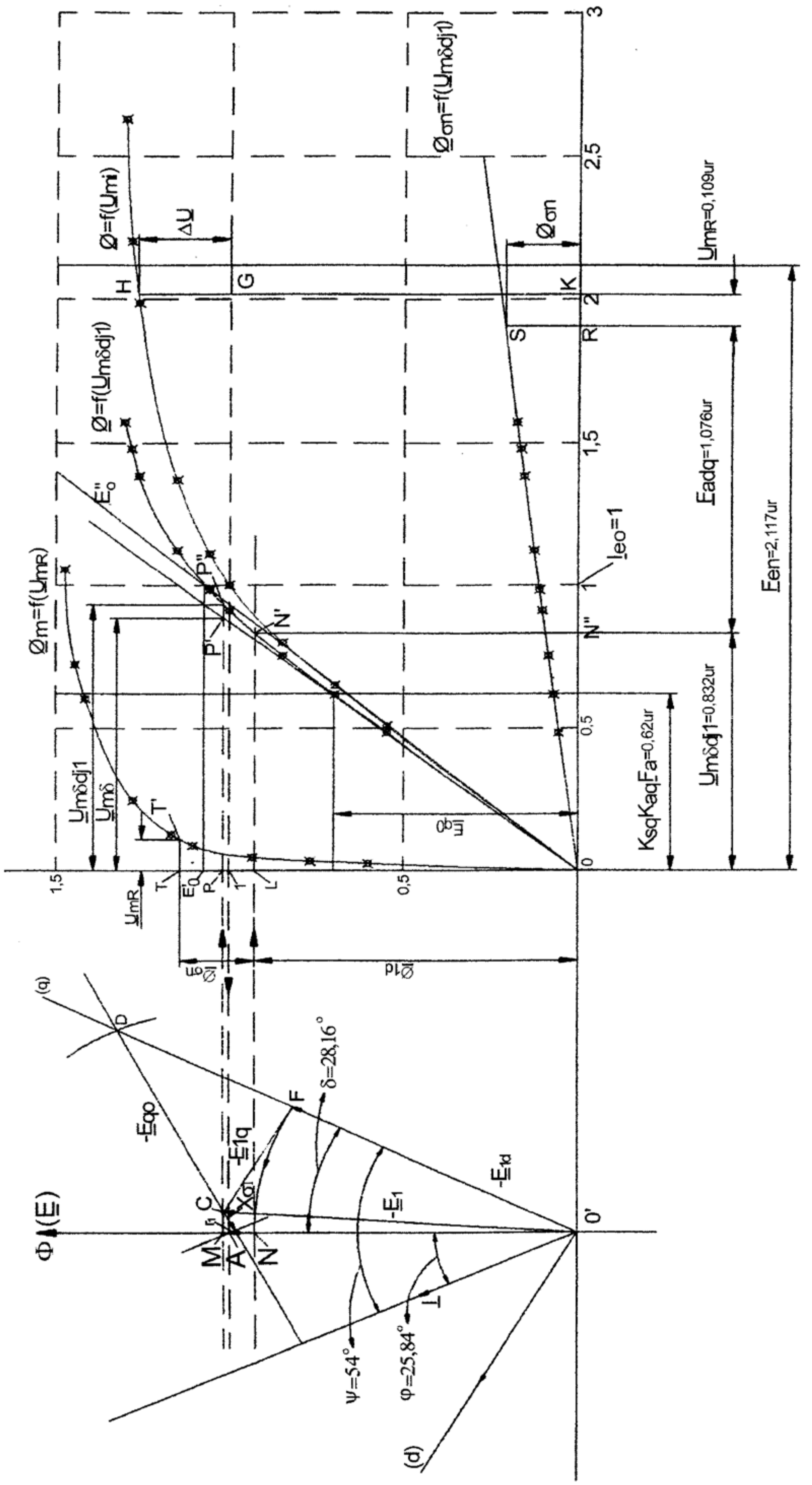
$$K_{d1} = \frac{b_{c1} l_i}{K_{Fe1} l_{Fe1} b_{dmax}} = 0.791 \qquad K_{d2} = \frac{b_{c1} l_i}{K_{Fe1} l_{Fe1} b_{dmed}} = 0.893 \qquad K_{d3} = \frac{b_{c1} l_i}{K_{Fe1} l_{Fe1} b_{dmin}} = 10.214$$

H_{dmax}	A/cm	2.250	5.025	15.500	90.000	140.000	170.000	760.000	880.000	1000.000
H_{dmed}	A/cm	2.000	3.400	6.000	20.000	35.000	95.000	150.000	200.000	250.000
H_{dmin}	A/cm	1.500	2.250	2.750	5.250	6.500	9.500	17.500	25.000	34.000
$H_{d1}=\frac{1}{6}\left[H_{dmax}+4H_{dmed}+H_{dmin}\right]$	A/cm	1.958	3.479	7.042	29.208	47.750	93.250	229.583	284.167	339.000
$U_{md1}=2h_{c1}H_{d1}$	A	18.408	32.704	66.192	274.558	448.850	876.550	2158.083	2671.167	3186.600
$B_{j1}=\frac{\phi}{2K_{Fei}l_{fei}h_{j1}}$	T	0.703	0.895	1.086	1.278	1.348	1.470	1.609	1.636	1.662
H_{j1}	A/cm	1.500	2.250	3.250	6.000	7.500	12.500	25.000	37.500	49.000
$U_{mj1}=\xi_1 L_{j1}H_{j1}$	A	38.745 0.630	56.272 0.610	77.285 0.580	118.080 0.480	138.375 0.450	194.750 0.380	328.000 0.320	476.625 0.310	602.700 0.300
$U_{m\delta dj1}=U_{m\delta}+U_{md1}+U_{mj1}$	A	4086.103	5216.731	6370.036	7718.002	8314.384	9495.468	11707.752	12524.257	13312.273
$\phi_{\sigma p}=\lambda_{\sigma p}U_{m\delta dj1}$	Wb	0.001	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004
$B_{dRmin}=\frac{\phi+\phi_{\sigma p}}{K_{Fe2}l_{Fe2c}b_{DRmax}}$	T	0.642	0.817	0.993	1.169	1.234	1.347	1.481	1.509	1.536
$U_{m\delta imb}=\frac{2}{\mu}B_{dRmin}\delta_{imb}$	A	153.317	195.149	237.008	279.093	294.602	321.676	353.653	360.309	366.626
$U_{m\delta dj1\delta imb}=U_{m\delta dj1}+U_{m\delta imb}$	A	4239.420	5411.881	6607.044	7997.095	8608.986	9817.145	12061.405	12884.567	13678.899
$\phi_{\sigma c}=\lambda_{\sigma c}U_{m\delta dj1\delta imb}$	Wb	0.003	0.004	0.004	0.005	0.006	0.006	0.008	0.008	0.009
$\phi_m=\phi+\phi_{\sigma p}+\phi_{\sigma c}$ $\sigma=\frac{\phi_m}{\phi}$	Wb	0.046 1.098	0.058 1.098	0.071 1.098	0.084 1.101	0.088 1.103	0.097 1.108	0.107 1.122	0.110 1.128	0.112 1.134
$\phi_\sigma=\phi_{\sigma c}+\phi_{\sigma p}$	Wb	0.004	0.005	0.006	0.008	0.008	0.009	0.012	0.012	0.013
$B_{dRmed}=\frac{\phi+\frac{1}{2}\phi_{\sigma c+}\phi_{\sigma p}}{K_{Fe2}l_{Fe2c}b_{DRmed}}$	T	0.763	0.971	1.180	1.390	1.468	1.606	1.772	1.809	1.844
$B_{dRmax}=\frac{\phi_m}{K_{Fe2}l_{Fe2c}b_{DRmin}}$	T	0.927	1.180	1.433	1.690	1.786	1.956	2.167	2.216	2.262

$$K_{dR\max} = \frac{\left(\alpha_p \frac{Z'_2}{2p} - N_D\right) b_{c2} l_i}{K_{Fe2}\left[\alpha_p \frac{Z'_2}{2p}\left(t_{r\min} - b_{c2}\right) + N_{D2} b_{c2}\right] l_{Fe2}} = 0.346 \qquad K_{dRmed} = \frac{\left(\alpha_p \frac{Z'_2}{2p} - N_D\right) b_{c2} l_i}{K_{Fe2}\left[\alpha_p \frac{Z'_2}{2p}\left(t_{Rmed} - b_{c2}\right) + N_{D2} b_{c2}\right] l_{Fe2}} = 0.287$$

$$K_{dR\min} = \frac{\left(\alpha_p \frac{Z'_2}{2p} - N_D\right) b_{c2} l_i}{K_{Fe2}\left[\alpha_p \frac{Z'_2}{2p}\left(t_{R\max} - b_{c2}\right) + N_{D2} b_{c2}\right] l_{Fe2}} = 0.245$$

1	2	3	4	5	6	7	8	9	10	11
H_{dRmin}	A/cm	1.500	2.000	2.400	4.500	6.500	8.600	19.000	25.000	27.500
H_{dRmed}	A/cm	1.750	2.500	4.500	10.500	19.500	50.000	100.000	140.000	190.000
H_{dRmax}	A/cm	2.250	4.750	9.750	86.000	125.000	280.000	950.000	1000.000	1600.000
$H_{dR} = \frac{1}{6}(H_{dR\max} + 4H_{dRmed} + H_{dR\min})$	A/cm	1.792	2.792	5.025	22.083	34.917	81.433	228.167	264.167	397.917
$U_{mdR}=2h_{c2} H_{dR}$	A	23.292	36.292	65.325	287.083	453.917	1058.633	2966.167	3434.167	5172.917
$B_{j2} = \frac{\phi_m}{2l_{Fe2}k_{Fe2}h_{j2}}$	T	0.743	0.945	1.149	1.355	1.432	1.568	1.737	1.776	1.813
H_{j2}	A/cm	1.850	2.500	4.750	9.500	18.500	40.000	100.000	130.000	190.000
$U_{mj2} = L_{j2}H_{j2}$	A	33.419	45.160	85.805	171.609	334.187	722.566	1806.416	2348.341	3432.190
$U_{mR} = U_{mdR} + U_{mj2} + U_{m\delta imb}$	A	210.027	276.601	388.138	737.786	1082.706	2102.876	5126.235	6142.816	8971.733
$\sum U_{mi} = U_{mR} + U_{m\delta dj1}$	A	4296.131	5493.333	6758.174	8455.788	9397.090	11598.344	16833.988	18667.074	22284.006
$\underline{\phi} = \phi / \phi_{oN}$	ur	0.550	0.700	0.850	1.000	1.055	1.150	1.259	1.280	1.300
$\underline{\phi}_m = \phi_m / \phi_{oN}$	ur	0.604	0.769	0.934	1.101	1.164	1.275	1.412	1.444	1.474
$\underline{\phi}_\sigma = \phi_\sigma / \phi_{oN}$	ur	0.054	0.069	0.084	0.101	0.109	0.125	0.153	0.164	0.174
$\sum \underline{U}_{mi} = \sum U_{mi} / U_{m0N}$	ur	0.508	0.650	0.799	1.000	1.111	1.372	1.991	2.208	2.635
$\underline{U}_{m\delta dj1} = U_{m\delta dj1} / U_{m0N}$	ur	0.483	0.617	0.753	0.913	0.983	1.123	1.385	1.481	1.574
$\underline{U}_{mR} = U_{mR} / U_{m0N}$	ur	0.025	0.033	0.046	0.087	0.128	0.249	0.606	0.726	1.061



Øm=f(UmR)
Ø=f(Umi)
Ø=f(Umδdj1)
Øσm=f(Umδdj1)
Øσm
ΔU
H
G
K
S
R
Eadq=1,076ur
Een=2,117ur
UmR=0,109ur
Umδdj1=0,832ur
KsqKaqFa=0,62ur
Ieo=1
Umδdj1
Umδ
UmR
Øld
δ=28,16°
ψ=54°
φ=25,84°
Φ(E)
-Eqo
-E1q
-E1d
-E1
D
F
C
M
A
(q)
(d)
0'
I
0
0,5
1
1,5
2
2,5
3

Figure 2

THE CONSTRUCTION OF THE MAGNETICAL CHARACTERISTICS AND DETERMINING THE SOLENATION EXCITATION AT NOMINAL DUTY

Based on the data's obtained in table 1 by the conceived program, for different values of the electro-motor tension (0,55 ; 0,70 ; 0,80 ; 1 ; 1,05 ; 1,15 ; 1,26 ; 1,28 ; 1,3) U_{1nm} , is determined the values of the flux (Φ) and also the magnetical tensions and is built:

– the magnetization characteristic at running on empty Φ = f $(\sum U_{mi})$ or E = f (I_e);

– partial magnetical characteristics;

– Φ = f ($U_{m\delta dJ1}$) – of the stator;

– Φ = f (U_{mR}) – of the rotor;

– Φ_σ = f ($U_{m\delta dJ1}$) – of the magnetical flux of slipping between polls.

All these magnetical characteristics (functioning unloaded and partial for motor, in u.r.) are traced by a special program in figure 2, and serve at determining the excitation solenation at nominal duty thru the method of the partial magnetical characteristics, which remembers the demagnetized effect of the inducted reaction, using the following operations:

– construction of fazorial diagrams for resulting t.e.m. E_1, in u.r. for motor regimes (and if $r_1 << x_{\sigma 1}$, this value is neglecting);

– determining of saturation rapport corresponding of following relations: $$\frac{\underline{U}'_{m\delta dj1}}{\underline{U}'_{m\delta}} = \frac{\overline{PP''}}{\overline{PP'}} \qquad (1)$$

– determining of coefficients k_{sd}, k_{sq}, k_1 like mathematical functions of saturation, resulted before, from variation of inter-iron, for δ_M/δ=1,5..2,5;

– establishing transversal solenation with magnetical saturation influence, according to following relations:

$$k_{sq} k_{aq} \underline{F}_a = k_{sq} k_{aq} \frac{F_a}{U_{m0N}} \text{ [u.r.]} \qquad (2)$$

where:

$$F_a = 0.9m \frac{W_1 K_{w1}}{p} I_{1NM} \text{ [A]} \qquad (3)$$

$$U_{m0N} = \sum U_{mi} \text{ for } \underline{U}_{1NM} \qquad (4)$$

– establishing fictive t.e.m. $\underline{E}_{q0} = \overline{CD}$ corresponding of solenation $k_{sq} k_{aq} \underline{F}_a$ from partial magnetical characteristic of stator, $\phi = f(\underline{U}_{m\delta dj1})$;

– determining of transversal direction (q), the line $\overline{OD'}$, which guiding t.e.m. $\underline{E}_{1d} = \overline{O'F}$;

– determining rotor magnetical tension (t.m.) corresponding of resulting t.e.m., $U_{m\delta dj1} = \overline{ON''}$ [u.r.]

– establishing ψ angle from fazorial diagram and "effective" rotor reaction solenation, $\overline{N''R} = \underline{F}'_{adq}$ for δ_M/δ=1,5..2,5;

– determining of dispersion flux $\underline{\Phi}_\sigma = \overline{RS}$ [u.r.] and rotor magnetical tension $\underline{U}_{mR} = \overline{TT'}$ [u.r.], resulting rotor solenation for nominal duty $\overline{OK} = \underline{F}'_{eN}$ [u.r.];

For looseness work, due to digressions from magnetization curves or little modify at constructive dimensions, sue to increasing obtained value with approx.4-6%, resulting:

$$\underline{F}_{eN} = (1{,}04 \div 1{,}06) \cdot \underline{F}'_{eN} \text{ [u.r.]} \qquad (5)$$

respectivelly:

$$F_{eN} = \underline{F}_{eN} \cdot U_{m0N} \text{ [A]} \qquad (6)$$

CONCLUSIONS

The presented method have the great advantage because allow to use modern technique of calculation and, in this way, could be known permanently the variation of excitation solenation, respectively the excitation circuit could be dimensioned optimally.

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