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Lukman Ahmed Omeiza, Lecturer; Dr, Salawudeen Ahmed Tijjani, Lecturer
Department of Electrical Engineering Federal Polytechnic Bida Nigeria,
Department of Electrical/Electronic Engineering Ahmadu Bello University Zaria Nigeria

IMPROVING THE EFFECTIVENESS OF GEREGU ELECTRICAL POWER NETWORK

The aim of the study was to evaluate the possible ways of increasing the efficiency of Geregu Electrical Power Network.

Keywords: power station, electrical energy, power network, efficiency.

Increasing the efficiency of Geregu Electrical Power Network was researched by employing the method of mathematical calculation of preliminary data of design, to help find out the exact point of power division and in order to know the working condition of voltages during operation. This will help decide which point needs voltage regulation most in order to increase performance. The electrical power network was constructed by defunct USSR. Calculations was made base on information obtain from the name plate data of various component at the electrical power network (Transformers and transmissions lines). The normal working modes were established and the analysis of the index mode was made, the point of power division was found. Measures were purpose for increasing the effectiveness of the electric power station and minimizing cost base on the result of mathematical calculation of primary data of design. The obtained skills and knowledge can be applied to improve any electrical power network in the world.

The modern level of civilization development is characterized by an increased consumption of all kinds of energy. These bring about fast exhaustion of organic and nuclear fuel resources, continuous growth of energy resources cost, deterioration of environment were electrical power network are located. Hence careful treatment of all kinds of energy is evidently necessary. In this electrical power network research, decisions are laid to provide the reasonable compromise between cost of electrical network itself and its operation costs to preserve a reliable and uninterrupted supply of power to it consumers. Installation of transformers with minimally possible steel capacity losses were recommended [5, 6, 8], the best operation modes of electrical network chosen on the basis of electric power losses minimization [2, 5, 10].

During operation modes, parameters of electrical units can differ from the designed ones [8, 10]. The reason for these deviations can be traced to the initial information about electrical loadings, which is insufficient for the designing, change of consumer structure in load nodes while in service and deviation from the design recommendations [3, 4, 5].

The description and analysis of Geregu electrical power network is done below with the help of the schematic diagrams and tables. The information about consumers is taken from the company and tabulated on table 1. The transformers used are TRDN-25000, TDN-16000, with rated secondary voltage and maximum loads [11]. All the initial data about transmission lines and transformers are taken from the catalogue [12, 13], current which is alternative current, has industrial frequency of 50 Hz [7]. Rated high voltage of the network is 110 kV. Substations are lowering, with ratio 110/10 and 110/6 kV [1, 2, 11]. The network carries distributive function and industrial by the nature of consumers. Network works on voltage 110kV so it is with isolated neutral [1].

The calculation of the electrical network maximum mode is necessary for the determination of power flows in its elements and voltage values in load connection nodes [3, 10]. The mode calculation is fulfilled by the method under a voltage specified at the beginning of the transmission line (on the power supply) taking into account following assumptions [11]:

- maximum loads of all nodes are supposed to coincide with time of their appearing [2, 7];
- At zero iteration the voltage in all nodes of the network are identical and equal to the rated value $U_{r\,V}$ [10].

Then capacity losses in transformers are calculated. They are necessary for determining the calculated loads, and also for estimating the efficiency of the measures to decrease power losses in the transformers. Thus, it is necessary to find separately losses in steel [1,2,5].

$$\Delta P_{ST} = n_T \cdot \Delta P_X, \qquad 2*25= 50 \quad = 0{,}05\text{MVA}$$

$$\Delta Q_{ST} = n_T \cdot \frac{I_X}{100} \cdot S_{NOM} \qquad 2 \ \cdot \frac{0.65}{100} \cdot 25 \ = 0{,}32 \ \text{MVA}$$

$$R_{T\,E} = \frac{R_T}{n_T}, \quad 2.53/2 = \ 1.265 \text{ ohms} \qquad\qquad X_{T\,E} = \frac{X_T}{n_T}. \ \ 55{,}54/2 = 27{,}77 \text{ ohms}$$

Table 1 – The calculation of power losses in the transformers

The name of the consumer	The type of transformer	n_T	S_{NOM}, MVA	S_M, MVA	K_l	ΔP_K, MVA	ΔP_X, MVA	I_X, %	U_K, %
1	2	3	4	5	6	7	8	9	10
A	TPDH-25000	2	25	29.12	0.58	120	25	0.7	10.5
B	TDH-16000	2	16	21.95	0.69	85	18	0.7	10.5
C	TDH-16000	2	16	18.37	0.57	85	18	0.7	10.5
D	TDH-16000	2	16	18.91	0.59	85	18	0.7	10.5
E	TPDH-16000	2	16	16.33	0.51	85	18	0.7	10.5

The name of the consumer	The type of transformer	$R_{T\,E}$, Ohm	$X_{T\,E}$, Ohm	ΔP_{ST}, MW	ΔP_{COP}, MW	ΔQ_{ST}, Mvar	ΔQ_{COP}, Mvar
11	12	13	14	15	16	17	18
A	TPDH	1.26	43.4	0.05	0.081	0.325	1.766
B	TDH	2.19	69.4	0.036	0.081	0.244	1.600
C	TDH	2.19	69.4	0.036	0.055	0.244	1.092
D	TDH	2.19	69.4	0.036	0.059	0.244	1.170
E	TPDH	2.19	69.4	0.036	0.044	0.224	0.874

Equivalent impedance values of the transmission lines are calculated according to the linear values of the active impedance (r_0) and reactance (x_0) [2, 13].

$$R_{TL} = \frac{r_O \cdot l}{n_{TL}}, \qquad X_{TL} = \frac{x_O \cdot l}{n_{TL}},$$

For the open section of the network the power flows are determined by the first Kirchhoff's law while moving from the terminal points to the supply source [1, 12].The pattern of the power flows is shown on the figure (i) Figure 2.4 - Preliminary distribution of powers on the trunk site. At first capacities on the head sites are defined for the closed site of the network [9]. For this purpose the circular network is cut on the power supply and it is represented as two-way feeding scheme with conterminous voltage on the value and direction on the supply sources. The calculation is fulfilled under the formulas [2]:

$$\underline{S}_{HS1} = \frac{\sum_{j=1}^{n} \underline{S}_{CAL\,J} \cdot \overset{*}{\underline{Z}}_{J-SS2}}{\overset{*}{\underline{Z}}_{SS1\text{-}SS2}},$$

Where $\underline{S}_{CAL\,J}$ is the calculated load of j-node;

$\overset{*}{\underline{Z}}_{j-SS1}, \overset{*}{\underline{Z}}_{j-SS2}$ are conjugate complexes of impedances from the connection node of j-load up to the first and second supply sources;

$\overset{*}{\underline{Z}}_{SS1\text{-}SS2}$ is conjugate complex of the total impedance between the supply source 1 and supply source 2.

The result of calculation is equal:

$$\frac{29.16 + j19.37(3.42 - j3.55 + 5.14 - j5.04) + 15.08 + j7.71(5.14 - j5.04)}{5.99 - j6.22 + 3.42 - j3.55 + 5.14 - j5.04} = 22.137 + j14.20$$

MVA

$$\underline{S}_{HS2} = \frac{\sum_{j=1}^{n} \underline{S}_{CAL\,J} \cdot \overset{*}{\underline{Z}}_{J-SS1}}{\overset{*}{\underline{Z}}_{SS1\text{-}SS2}},$$

$$\frac{15.08 + j7.71(3.42 - j3.55 + 5.99 - j6.22) + 29.16 + j19.37(5.99 - j6.22)}{5.99 - j6.22 + 3.42 - j3.55 + 5.14 - j5.04} = 22.113 + j12.88$$

MVA

The correctness of the calculations obtained is confirmed by performing of the power balance – the equation of the produced and consumed powers [2]:

$$\underline{S}_{HS1} + \underline{S}_{HS2} = \sum_{j=1}^{n} \underline{S}_{CAL\,J}.$$

22.137+j14.20+22.113+j12.88 = 44.25+j27.08 MVA

On the rest of the network sections power flows are found according to the first Kirchhoff's law for the connection nodes of the calculated load. The calculated values of capacities are pointed on the figure as for the trunk site.

The research analysis on Geregu electrical power network has shown the possible ways of increasing the effectiveness of any Electrical power network in the world. Transformers with minimum steel and copper losses should be installed, as this will help decrease power lose during maximum load operation as shown in our calculation. The installation of compensating device will help decreases the active power losses in the copper of transformers and in the transmission lines. The transformer of timber industry was changed from TPDH-25000 to TDH-16000, as the normal loading factor of transformer was found to exceed the standard acceptable working limit ($\mathbf{0.5} \leq \boldsymbol{K_l} \leq 0.75$). The point of power division in the network was established and illustrated on the figure 2.4, thereby confirming that the point 'D' will be the most remote area of electrical power network and voltage lost will be highest, voltage regulation is required at this substation for improve effectiveness of the electrical netwrk. Without regulation the desire voltage is provided only for consumers A, B, C and E. With regulation the desire voltage is provided for all consumers.

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