CONSIDERATIONS ON THE ENERGETIC EFFECTS OF THE UNBALANCED AND DISTORTING REGIME

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SUMMARY

The quantitative assessment of the energetic effects for the functioning of the three-phased electric networks in an unbalanced regime, a distorting regime or a combined unbalanced and distorting regime, is made by use of some specific indicators.
The present article aims at establishing such specific indicators for the functioning of the three-phased electric networks, others than those regulated by the in force normative documents.
By an analysis of the calculus relations of the specific indicators we can establish elimination or reduction measures for the energetic effects determined by the electric networks functioning in the unbalanced regime, distorting regime or the combined unbalanced and distorting regime.

1.INTRODUCTION

The definition relation, for the three-phased electric networks, of the medium power factor in sinusoidal regime under symmetric systems of powers and voltages $K_p = f\,(W_a, W_r)$, allows us to evaluate:
- The efficiency of the electric energy distribution service in comparison to the active and reactive energy circulations for the electric networks.

- The supplying (use) service efficiency of the electric energy for a customer, emphasizing the comparison between the realized and the neutral power factor, respectively the value of the reactive electric energy consumed by this.
Really, the functioning regimes that are registered are of the unbalanced or distorting type or, mostly, of the combined unbalanced and distorting regime. In such cases, the calculus relation of the power factor above mentioned, can no longer provide correct information on the functioning regime efficiency, its application in the relation supplier -customer being inequitable.
We must remember that for the functioning of the three-phased electric networks, the following main energetic effects occur:
- Active power supplementary losses due to the residual and asymmetry powers
- Influences on the electric energy measurement systems as a result of the asymmetry and/or distorting powers circulation, and of course on the administration and price of the electric energy service.
The present article aims at establishing some specific indicators, others than those regulated by the in force normative documents, for the quantitative assessment of the energetic effects for the three-phased electric networks functioning in an unbalanced regime, a distorting regime or a combined unbalanced and distorting regime.
Thus, the weight factor coefficient for powers allows a value establishment of the asymmetry and distorting active powers, in comparison to the symmetry or fundamental harmonic powers.
The losses factor allows the determination of the power and electric energy total losses in the electric network with an unbalanced and/or deformed functioning regime.
The global power factor allows the determination of the power factor real value when functioning in an unbalanced and/or distorting regime and establishes a relation between the active powers circulated in the electric network and the apparent power useful for the functioning of the electric receivers, of fundamental symmetry or harmonic.
The calculus relations analysis of the specific indicators allows us to establish the elimination or the reduction measures of the energetic effects for the electric networks functioning in the mentioned regimes.

2. THE ELECTRIC NETWORKS OF DISTRIBUTION IN AN UNBALANCED REGIME

2.1 The powers balance

When applying Tellegen's theorem, the definition regarding the conservation of the sequential powers in an electric system functioning in asymmetric regime makes possible to formulate the balance relations for each active and reactive power. We will mark with P_G, Q_G the powers absorbed by the passive elements of the electric network, and we will mark with P_L, Q_L the powers absorbed by the passive elements of the electric network, and P_R, Q_R the powers absorbed by the unbalanced electric receivers. Taking into account the fact that the powers discharged by the infinite power system are only symmetry powers, we can write the following balance relations, in an electric system formed by the source, the electric network and the asymmetric receiver:

$$P_{sG} = P_{sL} + P_{sR} \qquad Q_{sG} = Q_{sL} + Q_{sR} \qquad (1)$$
$$0 = P_{nL} + P_{nR} \qquad 0 = Q_{nL} + Q_{nR}$$

where we marked with the s index the symmetry powers and respectively the asymmetry powers.
The above relations can also be written as follows, if we take into consideration that the zero and the negative sequence powers are asymmetry powers:

$$P_G^+ = P_L^+ + P_R^+ \qquad Q_G^+ = Q_L^+ + Q_R^+$$
$$0 = P_L^- + P_L^0 + P_R^- + P_R^0 \qquad 0 = Q_L^- + Q_L^0 + Q_R^- + Q_R^0 \tag{2}$$

These relations are thus interpreted as that the conditions for having equilibrated electric networks elements (power lines, power transformers, etc); the only elements “generating” asymmetric active and reactive power are the unbalanced receivers.
In other words, the unbalanced receivers receive from the system a bigger symmetry power (of positive sequence) than that necessary to their functioning, and the difference is given in the network elements and the equilibrated receivers under the form of the asymmetry powers (of zero and negative sequence).
If we consider only the active power losses, which are usually of interest, we can write the (2) relations on the three sequences according to [2]:

$$P_R^+ = P_G^+ - P_L^+ = P_G^+ - 3R_{0F} \cdot l \cdot I^{+2}$$
$$P_R^- + P_R^0 = P_L^- + P_L^0 \tag{3}$$

The last relation in the (3) expression can be written according to the electric network of distribution type (RED) as follows:
- for RED of j.t. with four conductors:

$$P_R^- + P_R^0 = -3R_{OF} \cdot l \cdot I^{-2} - 3R_{oF} \cdot l \cdot I^{02} - 9R_{oN} \cdot l \cdot I^{02} \tag{4}$$

- for RED with three conductors:

$$P_R^- + P_R^0 = -3R_{OF} \cdot l \cdot I^{-2} \tag{5}$$

where R_{OF} and R_{ON} represent the specific resistance of the phase conductors, respectively of the null conductors for the power line;
I^+, I^-, I^0 – the effective values of the positive, negative and zero symmetric components;
l - the length of the power line.
So, these asymmetry powers produced by the unbalanced receiver represent the supplementary power losses in the electric network; these asymmetry powers mean supplementary charges of the source with active and reactive symmetry powers [4].
From the above relation follows that the active and reactive powers given (produced) by the receiving elements (passive elements) have the minus sign, rule which is specific to the receiving kinks. In order to emphasize the supplementary power losses, in the powers balance relations we did not consider the existence of another (equilibrated) receiver connected to the electric system.

2.2. Characteristic indicators in an unbalanced regime

The asymmetry degree assessment or the unbalance for the functioning of an electric network, must allow the evaluation of such a regime influences, both on the electric energy quality and on the technical and economical electric network functioning performances. Being based on dissymmetry and asymmetry factors, then named negative and zero asymmetry factors for voltage and power, defined in [PE 143/94], and expressed in absolute values under the form,

$$k_{nU}^- = \frac{U^-}{U^+}; \quad k_{nI}^- = \frac{I^-}{I^+}; \quad k_{nU}^0 = \frac{U^0}{U^+}; \quad k_{nI}^0 = \frac{I^0}{I^+}, \tag{6}$$

we can define the following indicators that characterize the three-phase electric networks functioning in a unbalanced regime and which can give an evaluation on the energetic effects of this regime on the network elements:

- the losses coefficient for the reactive and active asymmetry is defined as the relation between the asymmetry powers and the symmetry power sum, corresponding to the two types of powers: $k_{Pn} = \frac{P_{nL}}{P_s} = \frac{P_L^{\,-} + P_L^{\,0}}{P^+}$; $k_{Qn} = \frac{Q_{nL}}{Q_s} = \frac{Q_L^{\,-} + Q_L^{\,0}}{Q^+}$ (7)

or,

$$k_{Pn} = k_{nU}^- \cdot k_{nI}^- \cdot \frac{\cos\varphi^-}{\cos\varphi^+} + k_{nU}^0 \cdot k_{nI}^0 \cdot \frac{\cos\varphi^0}{\cos\varphi^+}$$

$$k_{Qn} = k_{nU}^- \cdot k_{nI}^- \cdot \frac{\sin\varphi^-}{\sin\varphi^+} + k_{nU}^0 \cdot k_{nI}^0 \cdot \frac{\sin\varphi^0}{\sin\varphi^+} \quad (8)$$

where we marked:

P_S, Q_S – the symmetry powers corresponding to the active and reactive powers of P^+ and Q^+ positive sequence;

P_n, Q_n – the active and reactive asymmetry powers, compound of the powers of negative and zero sequence sum for each type of power;

φ^+, φ^-, φ^0 - the phase difference angles corresponds to the impedances of positive, negative and zero sequence calculus.

Though, usually $P_n < 0$, $Q_n < 0$, as powers generated by the unbalanced receivers, and $P^+ > 0$, $Q^+ > 0$, and the values of the above named coefficients will have the minus sign, are of interest for the absolute values of the above coefficients.

- The asymmetry factor for the active power losses is defined as the relation between the total active power losses in a unbalanced regime because of the charge and the active power losses in a symmetric regime , thus:

- for RED of j.t. with four conductors: $k_{n\Delta P} = \frac{P_{sL} + P_{nL}}{P_{sL}} = 1 + k_{nI}^{-2} + k_{nI}^{02} + 3\frac{R_{ON}}{R_{OF}} \cdot k_{nI}^{02}$ (9)

- for RED with three conductors: $k_{n\Delta P} = \frac{P_{sL} + P_{nL}}{P_{sL}} = 1 + k_{nI}^{-2}$ (10)

For the networks with nominal powers of minimum 110 kW who's neutral is effectively tied to the earth, the asymmetry factor is written under the form: $k_{n\Delta P} = 1 + k_{nI}^{-2} + k_{nI}^{02}$ (11)

Knowing the negative and zero asymmetry factors for the powers, as well as electric network features, we can determine the active power losses in a regime unbalanced by charge, according to the active power losses corresponding to the positive sequence compound.

- The global factor of the powers asymmetry defines the power factor in a unbalanced regime as the relation between the symmetry and asymmetry active powers sum received and given by the unbalanced receiver and the apparent symmetry power:

$$k_{nP} = \frac{P}{S_s} = \frac{P_{sR} + P_{nR}}{S_s} = \frac{P_R^{\,+} + P_R^{\,-} + P_R^{\,0}}{S^+} = \cos\varphi^+ + \frac{P_R^- + P_R^0}{S^+} \quad (12)$$

Taking into consideration the calculus relations for the sequential powers, the above expression can be written according to the asymmetry factors for voltages and powers as follows: $k_{nP} = \cos\varphi^+ + k_{nU}^- \cdot k_{nI}^- \cdot \cos\varphi^- + k_{nU}^0 \cdot k_{nI}^0$ (13)

In case of RED of j.t. with four conductors and the neutral tied to the earth and

$$k_{nP} = \cos\varphi^{+} + k_{nU}^{-} \cdot k_{nI}^{-} \tag{14}$$

In case of medium power RED with the isolated or compensated neutral.

The above relations realize a connection between the cosine power factor φ^{+}, under which the symmetry power necessary to the functioning of the receivers and the asymmetry factors for the active power, respectively the asymmetry factors for power and current are absorbed. As usually, the asymmetry powers symbol is negative, the value of the global asymmetry factor of the k_{nP} powers will be less than the value of the power factor in cosine φ^{+} symmetric functioning regime.

3. THE ELECTRIC NETWORKS OF DISTRIBUTION IN A DISTORTING REGIME

3.1. The powers balance

Taking into consideration the powers conserving theorem, for a system of non-sinusoidal parameters, in all insulated networks the instant active and reactive powers will be separately conserved on each harmonic compound. In an electric system formed by the source (generator), electric network (power lines, power transformers) and user (distorting electric receiver) we can write the following balance relations, taking into account that the source discharges powers only on the fundamental harmonic:

$$P_{G1} = P_{L1} + P_{R1} \qquad Q_{G1} = Q_{L1} + Q_{R1}$$

$$0 = P_{dL} + P_{dR} \qquad 0 = Q_{dL} + Q_{dR} \tag{15}$$

where: P_{G1}, Q_{G1} – the active and reactive powers discharged in the electric network by the source on the harmonicm= 1;

P_{L1}, Q_{L1}- the active and reactive powers absorbed by the elements of the electric network elements on the harmonic m=1, which represents the active and reactive power losses in these elements;

P_{R1}, Q_{R1}- the powers absorbed on the fundamental harmonic by the distorting receiver;

P_{dL}, P_{dR}, Q_{dL}, Q_{dR}- the active and reactive powers received by the electric network, respectively given by the distorting receiver on each superior harmonic m>1.

The total sum of the active and reactive powers received or given on the superior harmonics can be defined as a distorting residue of the active and respectively reactive power, for each element of the electric system taken into consideration, we can write the following relations:

$$P_{dL} = \sum_{\substack{m \\ m\neq 1}} P_{Lm}; \quad P_{dR} = \sum_{\substack{m \\ m\neq 1}} P_{Rm}; \quad Q_{dL} = \sum_{\substack{m \\ m\neq 1}} Q_{Lm}; \quad Q_{dR} = \sum_{\substack{m \\ m\neq 1}} Q_{Rm}; \tag{16}$$

After analyzing relations (15) and (16) we can observe that the deformed receiver absorbs a greater power than necessary to him on the superior harmonic, and the difference is given to the linear elements under the form of residual powers distorting on the m>1 harmonic; the total sum for the distorting residue of the corresponding powers to the m>1 harmonic order, represents the supplementary power losses in the passive elements of the electric system. Taking into consideration the relations of the active power losses according to [2], relations (15) can be written for the active powers as follows:

$$P_{dR} = -P_{dL}$$

$$P_{R1} = P_{G1} - P_{L1} = P_{G1} - 3R_{OF} \cdot l \cdot I_1^2 \tag{17}$$

The last above relation is thus written for:

- the j.t. electric networks of distribution with four conductors:

$$P_{dR} = -3R_{OF} \cdot l \cdot \sum_{\substack{m \\ m\neq 1}} I_m^2 + 9R_{ON} \cdot l \cdot \sum_{3m} I_m^2 \tag{18}$$

- the electric networks of distribution with three conductors:

$$P_{dR} = -3R_{OF} \cdot l \cdot \sum_{\substack{m \\ m \neq 1}} I_m^2 \tag{19}$$

where: I_m – the effective values of the harmonic currents of m order in a regime equilibrated by the charge, the null conductor is only crossed by the harmonic currents of three and three multiple.

From the above relations, follows that the distorting receiver gives and the electric system receives active (and reactive) power on the superior harmonics which represent supplementary power losses.

Note: a) in the balance relations of the power we did not consider the existence of another (linear)receiver connected to the electric system taken into consideration.

b) in the calculus relations of the active power losses, we did not take into consideration the resistance variation according to frequency.

3.2. The characteristic indicators in a deforming regime

The distortion level introduced by a distorting receiver is evaluated through the distortion coefficient or THD (Total Harmonic Distortion). This indicator allows us to establish the distortion degree of a non-sinusoidal harmonic parameter, being a quality indicator of the electric energy, but does not allow us to assess the distorting regime effects on the technical and economical performances in the electric networks functioning.

In order to appreciate the influences of a distorting regime or of the periodical, non-sinusoidal parameters system on the performances in the electric networks functioning, we use weight factor coefficients for voltages and powers $\gamma_{U_m} = \dfrac{U_m}{U_1}$; $\gamma_{I_m} = \dfrac{I_m}{I_1}$ (20)

where : U_m, I_m and I_1, U_1 – represent the effective values of the m harmonic voltages and powers and respectively for the fundamental harmonic.

To evaluate the energetic effects on the distribution relation when functioning in a distorting regime the following indicators can be defined:

- The losses coefficients for the harmonic powers are defined as a relation between the active or reactive power value corresponding to the m order harmonic and the active or reactive power value corresponding to the fundamental harmonic:

$$k_{P_m} = \frac{P_m}{P_1} = \gamma_{U_m} \cdot \gamma_{I_m} \cdot \frac{\cos\varphi_m}{\cos\varphi_1}; \qquad k_{Q_m} = \frac{Q_m}{Q_1} = \gamma_{U_m} \cdot \gamma_{I_m} \cdot \frac{\cos\varphi_m}{\cos\varphi_1} \tag{21}$$

If we take into consideration the powers sum for all the m>1 order harmonics, we can define a weight factor global coefficient for the active and reactive powers:

$$k_{P_d} = \frac{\sum_{\substack{m \\ m\neq 1}} P_m}{P_1} = \sum_{\substack{m \\ m\neq 1}} \gamma_{U_m} \cdot \gamma_{I_m} \cdot \frac{\cos\varphi_m}{\cos\varphi_1}; \quad k_{Q_d} = \frac{\sum_{\substack{m \\ m\neq 1}} Q_m}{Q_1} = \sum_{\substack{m \\ m\neq 1}} \gamma_{U_m} \cdot \gamma_{I_m} \cdot \frac{\cos\varphi_m}{\cos\varphi_1} \tag{22}$$

where, $\sum_{\substack{m \\ m\neq 1}} P_m$ and $\sum_{\substack{m \\ m\neq 1}} Q_m$ represent the distorting waste of the active and reactive power.

- The distorting factor for the active power losses is defined as the relation between the active power losses in a distorting regime and the active power losses in a sinusoidal regime (corresponding to the fundamental harmonic), thus:

- for the j.t. RED four conductors: $$k_{d\Delta P} = \frac{P_{L1} + P_{dL}}{P_{L1}} = 1 + \sum_{\substack{m \\ m \neq 1}} \left(\gamma_{I_m}\right)^2 + 3\frac{R_{ON}}{R_{OF}} \cdot \sum_{3m} \left(\gamma_{3m}\right)^2 \quad (23)$$

- for RED with three conductors: $$k_{d\Delta P} = \frac{P_{L1} + P_{dL}}{P_{L1}} = 1 + \sum_{\substack{m \\ m \neq 1}} \left(\gamma_{I_m}\right)^2 \quad (24)$$

The values of these relations are bigger than one as all the parameters in the above relations are positive as absolute values, thus resulting that in a distorting regime supplementary active power losses occur.

- The distortion global factor for powers defines the power factor in a distorting regime as the relation between the active power circulating in the electric network and the apparent power corresponding to the fundamental harmonic:

$$k_{dP} = \frac{P_R}{S_1} = \frac{\sum_m P_m}{S_1} = \frac{P_{R1}}{S_1} + \frac{\sum_{\substack{m \\ m \neq 1}} P_m}{S_1} = \cos\varphi_1 + k_{dP_m} \quad (25)$$

where: k_{dPm} – represents the distortion factor for the distorting residue of the active powers, which is expressed with the relation $k_{dP_m} = \sum_{\substack{m \\ m \neq 1}} \gamma_{U_m} \cdot \gamma_{I_m} \cdot \cos\varphi_m$.

If we are to consider that the distorting receivers are the ones giving powers in the electric network on the m>1 superior harmonics, and their sign is negative, follows a reduction of the distorting global factor value for the powers in comparison to the power factor value corresponding to a sinusoidal system.

4. ELECTRIC NETWORKS OF DISTRIBUTION IN A DISTORTED AND UNBALANCED REGIME

4.1. Powers balance

The analysis of the combined, distorted and unbalanced regime has at the foundation the recording theories mentioned before; considering the same scheme of the electric system consisting of source (generator), electric network and user (unbalanced and distorted user), it is possible to write the following power balance relations:

$$\begin{aligned} P_{G1}^{+} &= P_{L1}^{+} + P_{R1}^{+} & \qquad Q_{G1}^{+} &= Q_{L1}^{+} + Q_{R1}^{+} \\ 0 &= P_{ndL} + P_{ndR} & \qquad 0 &= P_{ndL} + P_{ndR} \end{aligned} \quad (26)$$

where: P_{G1}^{+}, Q_{G1}^{+} – of the active and reactive powers discharged by the source on the fundamental positive compound;

P_{L1}^{+}, Q_{L1}^{+}– of the active and reactive powers absorbed by the electric network on the fundamental positive compound, which represents the power losses in the electric network;

P_{R1}^{+}, Q_{R1}^{+}–of the powers absorbed on the m = 1 harmonic positive compound by the unbalanced and distorted receiver;

P_{ndL}, P_{ndR}, Q_{ndL}, Q_{ndR} – the active and reactive powers received by the electric network and given by the asymmetric and non-linear receiver on each sequential compound of each m>1 superior harmonic.

The balance relations for the active powers are then written as follows:

$$P_{R1}^{+} = P_{G1}^{+} - P_{L1}^{+} = P_{G1}^{+} - 3R_{OF} \cdot l \cdot I_1^{+2}$$

$$P_{ndR}=-P_{ndL}=-P^{+}_{ndL}-P^{-}_{ndL}-P^{0}_{ndL}=-\sum_{\substack{m\\ m\neq 1}}P^{+}_{Lm}-\sum_{m}P^{-}_{Lm}-\sum_{m}P^{0}_{Lm} \tag{27}$$

Taking into account the active power losses expression under an asymmetric and non-sinusoidal current system, the last relation in (27) can be thus written for:

- the j.t. electric networks of distribution with four conductors:

$$P_{ndR}=-3R_{OF}\cdot l\cdot(\sum_{\substack{m\\ m\neq 1}}I^{+2}_{m}+\sum_{m}I^{-2}_{m}+\sum_{m}I^{02}_{m})+9R_{ON}\cdot l\sum_{3m}I^{02}_{m} \tag{28}$$

- the electric networks of distribution with three conductors:

$$P_{ndR}=-3R_{OF}\cdot l(\sum_{\substack{m\\ m\neq 1}}I^{+2}_{m}+\sum_{m}I^{-2}_{m}) \tag{29}$$

After analyzing the balance relations of the active and reactive powers the result is that the unbalanced and distorted receiver absorbs symmetry power on the m=1 harmonic positive compound and gives in the electric system asymmetry powers on the zero and negative sequence compound of all the harmonics and distorting residueal powers on the positive sequence compounds of the m≠1 harmonics. The power transmitted in the electric network by the asymmetric and non-linear receiver, represents supplementary active powers losses according to relation (28) or (29).

NOTE: a) in the balance relations of the powers we did not consider the existence of another receiver (linear or symmetric) connected to the electric system considered.

b) in the calculus relations of the active power losses we did not take into consideration the resistances variations with the frequency.

4.2. Characteristic indicators in a distorting and unbalanced regime

The negative and zero asymmetry coefficients for all the m order harmonics, as well as the weight factor coefficients for the harmonic parameters, are defined similarly to those presented in relations (6) and (20). The evaluation of the energetic effects for the electric network functioning in a distorting and unbalanced regime can be made by defining the following indicators:

- The weight factor coefficient for the active and reactive powers represents the relation between the powers discharged in the electric system by the asymmetric and non-linear receiver on each sequential positive compound of the m order harmonics and the corresponding sequence powers of the fundamental harmonic,

- for the active powers: $$k_{P_{nd}}=\frac{P_{nd}}{P^{+}_{1}}=\frac{P^{+}_{nd}+P^{-}_{nd}+P^{0}_{nd}}{P^{+}_{1}}=\frac{\sum_{\substack{m\\ m\neq 1}}P^{+}_{m}+\sum_{m}P^{-}_{m}+\sum_{m}P^{0}_{m}}{P^{+}_{1}} \tag{30}$$

or, $$k_{P_{nd}}=\sum_{\substack{m\\ m\neq 1}}\gamma^{+}_{U_m}\cdot\gamma^{+}_{I_m}\cdot\frac{\cos\varphi^{+}_{m}}{\cos\varphi_{1}}+\sum_{m}k^{-}_{mU_m}\cdot k^{-}_{nI_m}\cdot\frac{\cos\varphi^{-}_{m}}{\cos\varphi_{1}}+\sum_{m}k^{0}_{nU_m}\cdot k^{0}_{nI_m}\frac{\cos\varphi^{0}_{m}}{\cos\varphi_{1}}$$

- for the reactive powers: $$k_{Q_{nd}}=\frac{Q_{nd}}{Q^{+}_{1}}=\frac{Q^{+}_{nd}+Q^{-}_{nd}+Q^{0}_{nd}}{Q^{+}_{1}}=\frac{\sum_{\substack{m\\ m\neq 1}}Q^{+}_{m}+\sum_{m}Q^{-}_{m}+\sum_{m}Q^{0}_{m}}{Q^{+}_{1}} \tag{31}$$

or, $$k_{Q_{nd}}=\sum_{\substack{m\\ m\neq 1}}\gamma^{+}_{U_m}\cdot\gamma^{+}_{I_m}\cdot\frac{\sin\varphi^{+}_{m}}{\sin\varphi_{1}}+\sum_{m}k^{-}_{mU_m}\cdot k^{-}_{nI_m}\cdot\frac{\sin\varphi^{-}_{m}}{\sin\varphi_{1}}+\sum_{m}k^{0}_{nU_m}\cdot k^{0}_{nI_m}\frac{\sin\varphi^{0}_{m}}{\sin\varphi_{1}}$$

where: φ_1 and φ_m^+ represent the phase difference between the tension and power harmonics of one order and respectively m of positive sequence;
φ_m^-, φ_m^0 - the phase difference angle for the m order harmonics of zero and negative sequence.
- The distortion and asymmetry factor for the active power losses represent the relation between the total active power losses in a unbalanced and distorting regime in the electric network elements and the active power losses corresponding to the positive compound of the m=1 harmonic for:
- the j.t. electric networks of distribution with four conductors:

$$k_{nd\Delta P} = \frac{P_{L1}^+ + P_{ndL}}{P_{L1}^+} = 1 + \sum_{\substack{m \\ m\neq 1}} \gamma_{I_m}^2 + \sum_m k_{n\ I_m}^{-2} + \sum_m k_{n\ I_m}^{02} + 3\frac{R_{ON}}{R_{OF}} \sum_m k_{nI_m}^{02} \quad (32)$$

- the electric networks of distribution with three conductors:

$$k_{nd\Delta P} = \frac{P_{L1}^+ + P_{ndL}}{P_{L1}^+} = 1 + \sum_{\substack{m \\ m\neq 1}} \gamma_{I_m}^2 + \sum_m k_{nI_m}^{-2} \quad (33)$$

We can notice that the value of this factor of the active power losses has a supra-unitary value being according to the absolute values of the weight factor coefficient for the m>1 power harmonics, as well as to the absolute values of the zero and negative asymmetry coefficients.
- *The global factor of distortion and asymmetry for the powers* is defined as the relation between the sequential power sum of m harmonic, absorbed and discharged by the distorting and unbalanced receiver and the apparent power of positive sequence of the fundamental harmonic:

$$k_{ndP} = \frac{P_R}{S_1^+} = \frac{\sum_m P_m^+ + \sum_m P_m^- + \sum_m P_m^0}{S_1^+} \quad (34)$$

or,

$$k_{ndP} = \cos\varphi_1 + \sum_{\substack{m \\ m\neq 1}} \gamma_{U_m}^+ \cdot \gamma_{I_m}^+ \cos\varphi_m + \sum_m k_{nU_m}^- \cdot k_{nI_m}^- \cdot \cos\varphi_m^- + \sum_m k_{nU_m}^0 \cdot k_{nI_m}^0 \cdot \cos\varphi_m^0 \quad (35)$$

After the analysis of the above relation we can notice that the distortion and asymmetry global factor for the powers is mainly compound by the following factors (coefficients):
- The symmetry power factor of positive sequence corresponding to the fundamental harmonics, sequence and respectively harmonic on which is given in the electric system the power useful to the electric receivers;
- The product of the weight factor coefficient for voltagrs and currents corresponding to the distorting active powers of m>0 harmonic;
- The product of the zero and negative asymmetry coefficients for voltages and currents, corresponding to the asymmetry active powers on each m harmonic.
We should mention that the value of the asymmetry and distortion global factor is reduced by negative values of the active powers given in the electric system by the asymmetric and non-linear receiver.

5. CONCLUSIONS

The evaluation of the energetic efficiency regarding the supplying of electric power for the users can be made by determining the weight factor coefficient of the powers, the factor for the active power losses and the global power factor corresponding to the functioning regime registered: unbalanced, distorting or combined, as described in the present study.

One should observe that from the relations by which we can determine the mentioned indicators corresponding to the combined unbalanced and distorting regime, relations (30), (32), (33), (34) and (35), we can deduce the indicators that are similar to the particular analyzed regimes, the unbalanced and the distorting regime.
After analyzing the calculus relations of the indicators characterizing the functioning of the unbalanced regime and especially of the global factor powers asymmetry, results the measures of elimination or diminishing the energetic effects specific for this regime:
- the compensation of reactive power use on the component of positive sequence Q^+, therefore obtaining cos φ_1=1;
- balancing the receptor load on each phase at the user therefore the active powers of asymmetry to be zero, which would correspond to the asymmetry factors for currents and voltages equal to zero.
The improvement of the energetic performances in case of functioning in a distorting regime, is a result of relations (22), (23) or (24) and (25) by insuring the following measures:
- compensating the reactive power use on the fundamental harmonic, thus as to get cosine….;
- filtering the superior harmonics on each compound separately if possible, or at least on those which present the greater weight factor,
Eliminating or reducing the energetic effects produced when functioning in a combined regime, both unbalanced and distorting, imposes the cumulative realization of the above measures. More than this, for all the analyzed regimes we recommend a reduction of power losses in the four conductors electric networks, to modify their constructive characteristics, which is realizing the relation R_{ON}/R_{OF}=1 in order to increase the null conductor section.
The abnormal regimes analyzed also influence the measuring systems of the electric energy, especially induction meters, which do not allow registering the circulations of asymmetry and/or waste distorting powers, leading to incorrect registering of the electric powers and wrong prices of the reactive electric power. As realizing another measuring system for electric energy is not possible, a periodical analysis (monthly, yearly) of the users functioning regime is necessary, aiming at a correct administration and cost evaluation of the electric power by:
- establishing the distortion level of the tension and current waves, respectively of the unbalance degree for voltage and current;
- determining the previous specified indicators, especially of the global power factor and the power factor for active power, corresponding to the functioning regime;
- establishing the measures that are the supplier's responsibility and the user's responsibility for eliminating or reducing the electric network of distribution effects and of the other users connected to the same network.

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