Harmonic Pollution in the Electric Networks by the Electric Arc Furnaces. Experimental Results

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Abstract: - The 3-phase electric arc furnaces represent one of the important generators of harmonic currents, reactive power and unbalanced conditions in the electrical power supply networks. This paper presents a study concerning the parameters of quality of electrical energy at 3-phase electric arc furnace.

Key-Words: - Electric arc furnace, energy quality, harmonics

1. Introduction

The electric arc furnace produces strong disturbing effects featured by non-symmetries of currents and voltages, harmonics, flickers, voltage drops and over-voltages. The paper presents qualitative indicators of quality of electrical energy [1], [2], [3], [4], [5] and results of measurements with specialized equipment to a 100t electric arc furnace.

2. Analysis of energy quality

The parameters of quantitative analysis of this quality:
-the pondered partial harmonic distortion for current:

$$THD_P = \sqrt{\sum_{14}^{40} n \left(\frac{I_n}{I(1)} \right)^2} \quad (1)$$

- the total harmonic distortion:

$$THD_I = \sqrt{\sum_{n=2}^{N}\left(\frac{I_n}{I_{(1)}}\right)^2} \qquad THD_U = \sqrt{\sum_{n=2}^{N}\left(\frac{U_n}{U_{(1)}}\right)^2} \tag{2}$$

- the power factor:

$$K_P = \frac{P}{S} = \frac{P}{\sqrt{P^2 + Q^2 + D^2}} \tag{3}$$

- the reactive factor:

$$\rho = \frac{Q}{P} \tag{4}$$

- the deforming factor:

$$\sigma = \frac{D}{\sqrt{P^2 + Q^2}} \tag{5}$$

where P is active power, S is apparent power, Q is reactive power and D is deforming power. Values are using digital systems based on data acquisition systems [6], [7]. It's been used an multifunctional power quality analyzer METREL (Fig. 1)

Fig.1 Measurement equipment METREL.

3. Results of measurements in the electric installation of arc furnace

The electrical power networks are presented in Fig. 2.

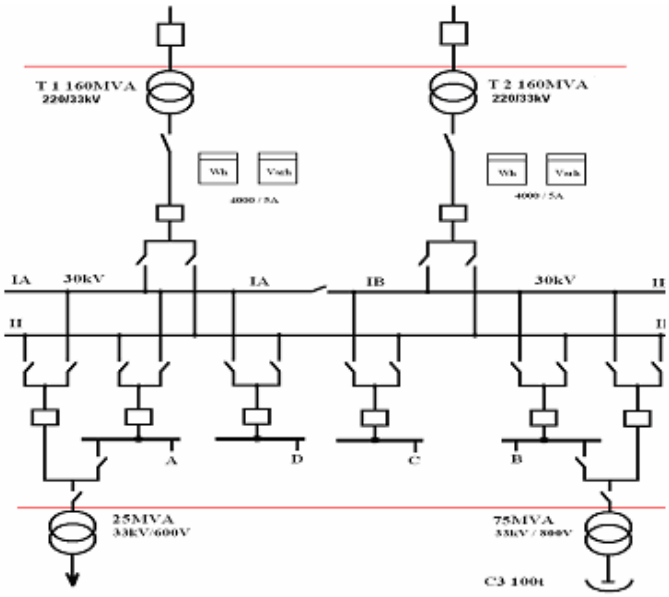
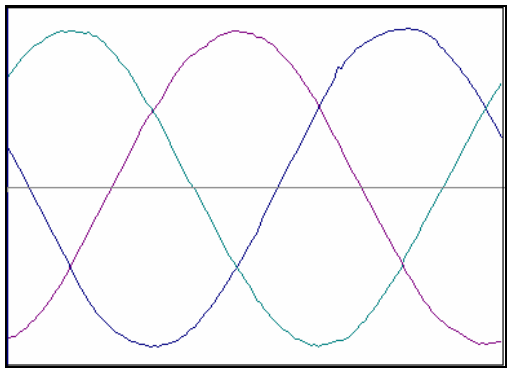
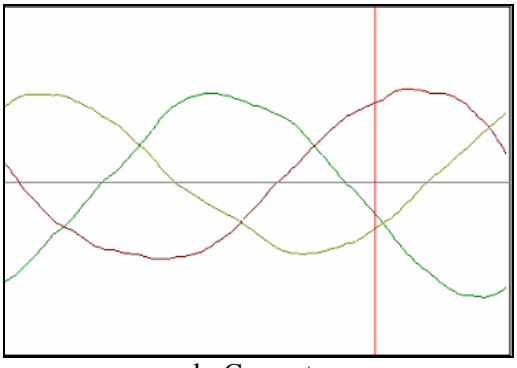


Fig.2. Electrical power supply networks

As regard to the wave forms of the voltages (Fig.3.a) and currents (Fig.3.b) on the 30kV voltage supply line in the melting phase is found a strong distortion of these (Fig.4.a and Fig.4.b).

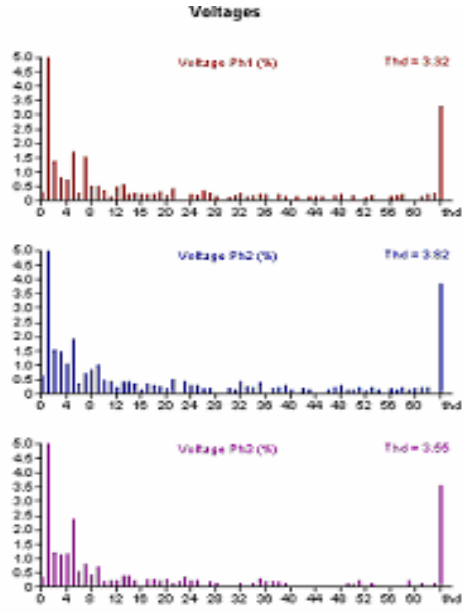


a. Voltages

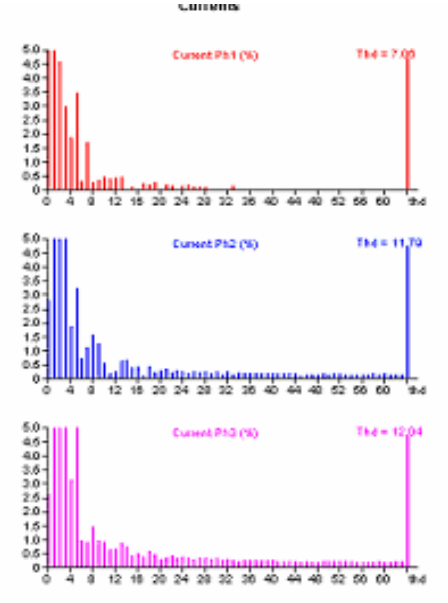


b. Currents

Fig.3. Wave forms in the melting phase.



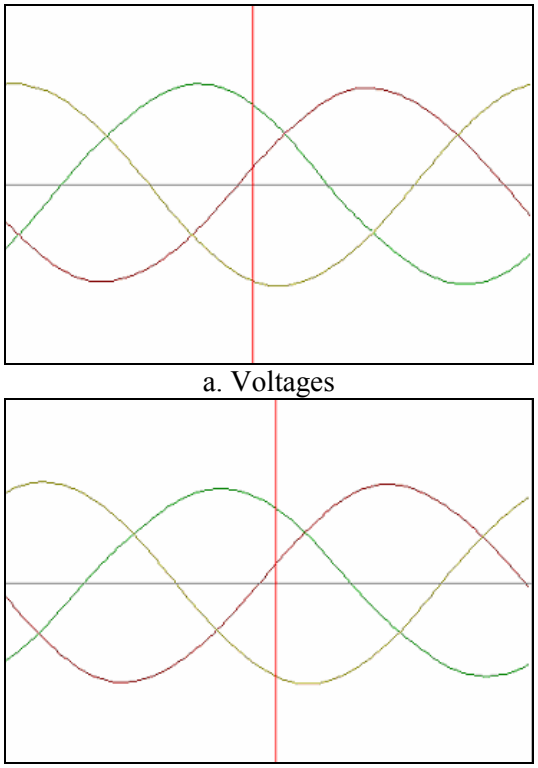
a. Voltages



b. Currents

Fig.4. Total harmonic distortion in the melting phase

In the phase of the electric arc stable burning (Fig.5.a and Fig.5.b), that appears towards the final of the heat's making, is found that the distortion that appear in the currents and voltages wave form are more reduced (Fig.6.a and Fig.6.b).



a. Voltages

b. Currents

Fig.5. Wave forms in the arc stable phase

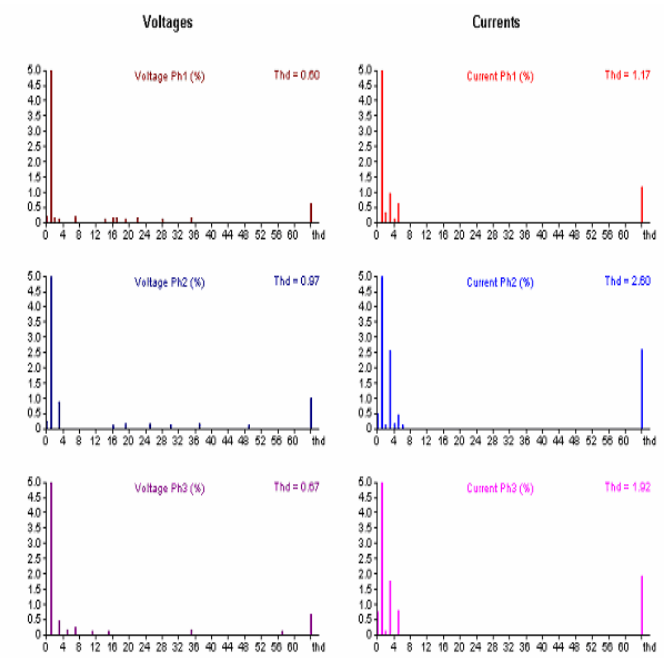


Fig.6. Total harmonic distortion in the arc stable phase

In this phase, the amplitude of the three phase currents and voltages are closer as value, fact which shows that the load impedance is more balanced. One can reach to the conclusion that the deformation of the current and voltage waves is smaller in the stable burning phase also by the fact that the distorting power is smaller in this phase, in conditions where the apparent, active and reactive power is higher.

As regard the voltage on the 30kV line, in the melting phase one can observe the presence of the important harmonics while in the oxidation phase is found practically only the presence of the fundamental. In the current's case, the important values of harmonics demonstrate that in this phase the current is strongly deformed.

In the Fig.7 are presented the variation form of powers measured values presented on the heat time. In the first period, corresponding to the melting phase, the apparent power is smaller. The electrodes are more lifted-up, in order to ensure protection against breaking and this determining a smaller value current. In the stable phase the apparent power is approximately constant and higher than in the melting phase. The variation of the voltage, as well as of the arc current, is reflected partially in the variation of active and reactive powers during the heat. The THD_U and THD_I (Fig.8) are higher in the melting phase than in the stable burning phase, bat the reactive power is higher in the stable phase than in the melting phase. The power

factor value (Fig.9) is higher in the stable arc phase and lower during the melting phase.

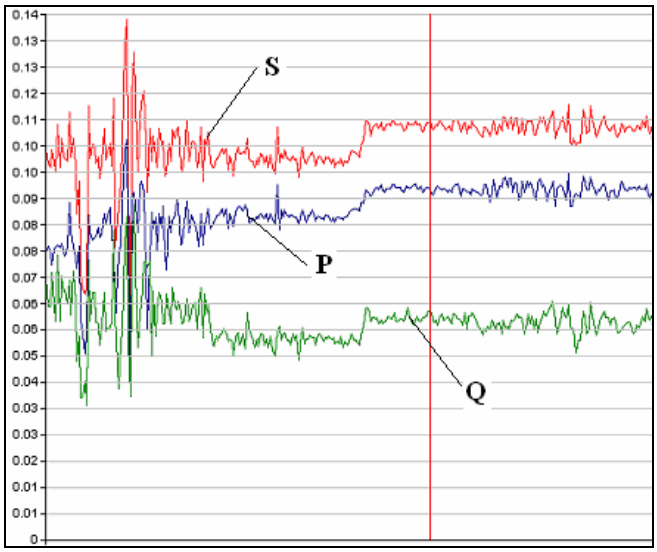


Fig.7.Powers variations

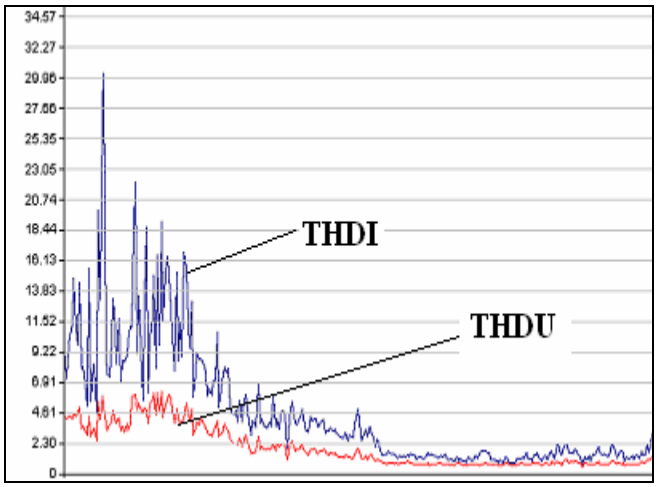


Fig.8. Variation of THD_I and THD_U

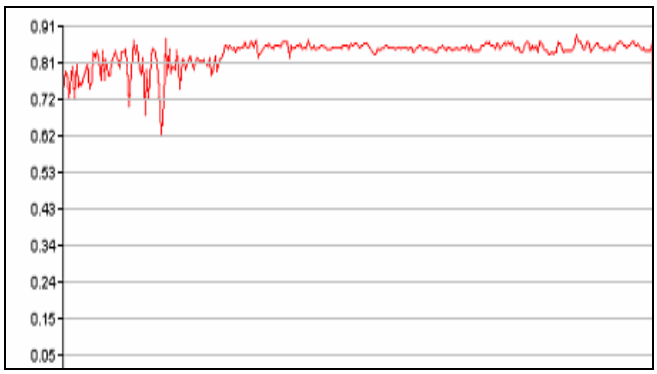


Fig.9. Variation of power factor

For this reason results that on the 30 kV line the currents wave is more distorted than the voltages wave. Following the measurements, were obtained values for THDI within 1-21% for current and 1-6% for voltage. Comparing these values with the standard [11], [12], results that the furnace is not matched in the national and international standards.

4. Conclusion

Following the analysis of the measurements results was obtained important conclusions: in the medium voltage supply line the current wave is more distorted than the voltage and the technological phase at the heat process has an influence on the electrical values.

Comparing the values of THD_I and THD_U with the standards results that the installation does not matched in the international standards. It is necessary the absorbing filters for the harmonic currents.

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