THE ARC FURNACES – A SOURCE OF DEFORMED STATE

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Abstract. *An arc furnace is an unbalanced, nonlinear and time variant load that produces unbalance, harmonics and interharmonics related with flicker effect. This paper presents the analysis of harmonics from the arc furnaces. We make some experimental determinations at the distribution substation "Radiatoare" Suceava, in the supply bay of S.C. ROMUPS S.A.. In this moment operate the IHF 3/A arc furnaces.*

Keywords: *arc furnace, harmonics, virtual instrument, quality indices, data acquisition.*

Introduction

The electric arc furnaces [1] are used for melting and refining metals, mainly iron in the steel production. Now days, arc furnaces are designed for very large power input ratings and due to the nature of both, the electric arc and the meltdown process, these devices can cause large power quality problems on the electrical net, mainly harmonics, interharmonics, flicker, and voltage imbalances.
The voltage-current characteristic of the arc is non-linear, what can cause harmonic currents. These currents, when circulating by the electric net, can produce harmonic voltages, which can affect other users. The beginning [2] of the meltdown process is the most critical part of the cycle in terms of disturbances.

Method description

We make some experimental determinations at the distribution substation "Radiatoare" Suceava, in the supply bay of S.C. ROMUPS S.A.. In this moment operate the IHF 3/A arc furnaces.
This is the three-phase direct arc furnace, with cylindrical shell. The arc furnace is supply with 200 V from the 2000 KVA transformer. This transformer is supply from the 6 KV substation of S.C. ROMUPS Suceava.
The data acquisition for the voltage and the current we make with the digital oscilloscope – TDS 310 from Tektronix, differential probe (for voltage) - MX9000 and Hall probe (for current). Fig. 1 presents the connecting of the measurement systems.

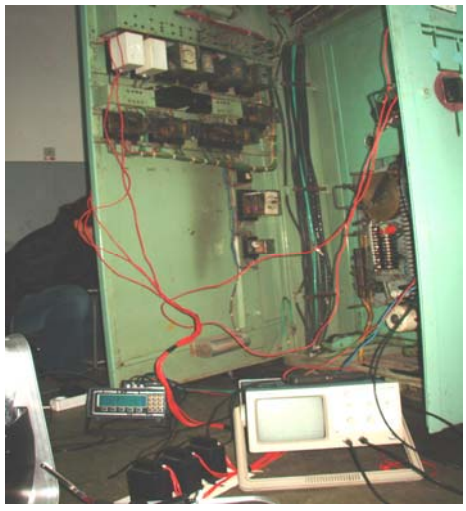

Fig. 1 - The connecting of the measurement systems

We transfer the date in the PC with the help of WaveStar 23 program.
It may be save these dates both text format and graph format. The dates in the text format are readied with LabVIEW [3]. We present a virtual instrument, in LabVIEW 7 Express, for the analysis of deforming state at the arc furnaces, in the last part of the paper.

For the validation of the results obtained with the VI we use the VIP SYSTEM 3 etalon (harmonics and energy analyzer).

Virtual instrument

The following time is one hour. In this time we acquisition the data. We select 60 measurement windows. Each window have the width equal with 200 ms. Therefore the real measurement time is 1200 ms. Because the current from the arc furnace is more deformed than voltage, we analyse just current data.

The VI permits to:

- take the dates from the text file
- obtain the amplitudes and phases spectrum for deformed signal
- save the date, after the FFT application, in EXCEL files, for the analysis
- extract 40 current harmonics both RMS values and percent of fundamental
- calculate the quality indices for the deforming state

One portion of front panel for the designed virtual instrument is shown in Fig. 2.

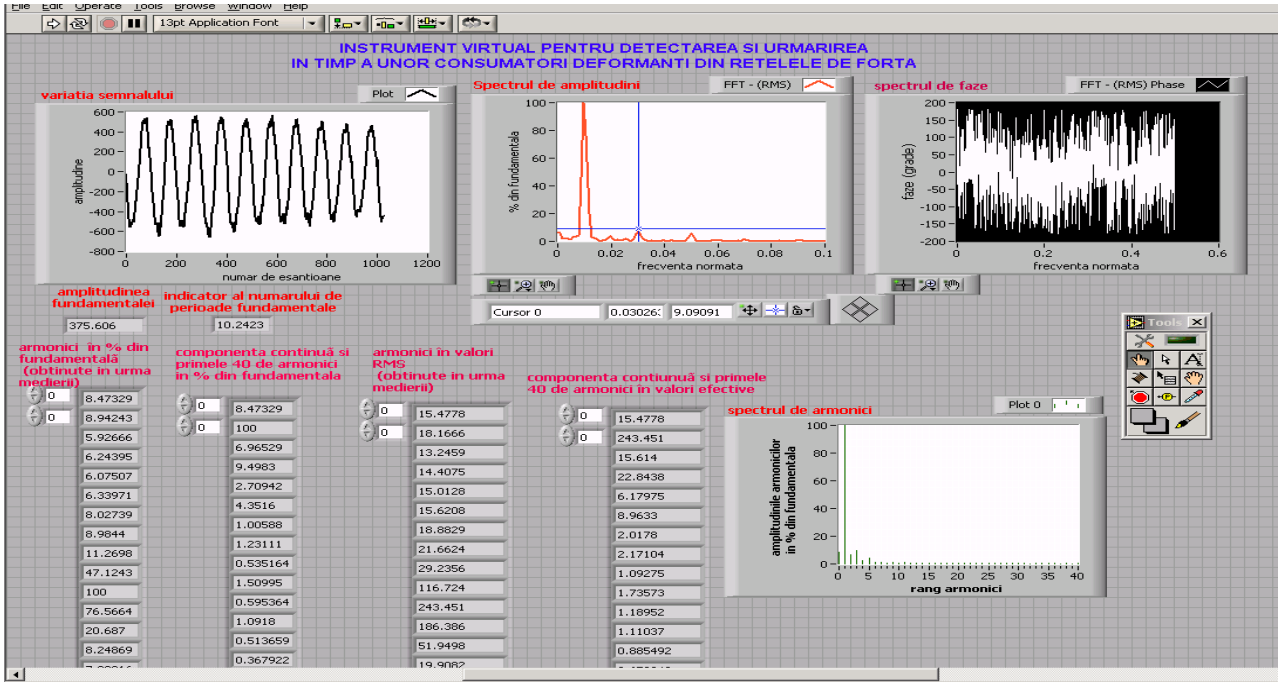

Fig.2 Front panel of virtual instrument – part 1

As it can be seen in Fig.2, the deformed signal can be visualized in the graphic windows – variation of signal. The last waveform that can be seen in this diagram is the electric current of the arc furnace, from the last measurement window. The indicator "spectrum of amplitudes" shows the amplitudes of current harmonics, which depend by normalized frequencies. The continuous component and the current harmonics, for every measurement window,

The VI read a text file, where the data from measurement windows are structured on the columns.

could be read with the help of array and table indicators from the front panel (Fig. 3). The part 3 of the front panel (Fig.4) contains: indicators for RMS, mean and maximally values of the deformed signal, the indicators of deforming state (the form factor, the harmonic distortion, the crest factor, the total harmonic distortion etc) which are result after programme running.

With the help of the control element we select the standardized value of THDI.

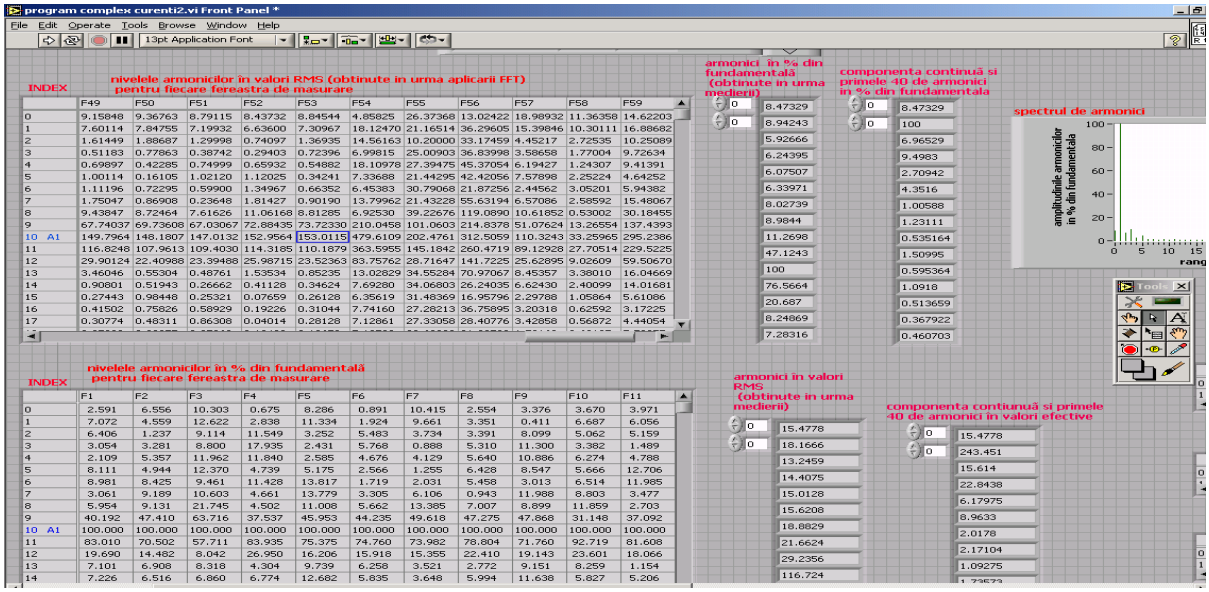

Fig.3 Front panel of virtual instrument – part 2

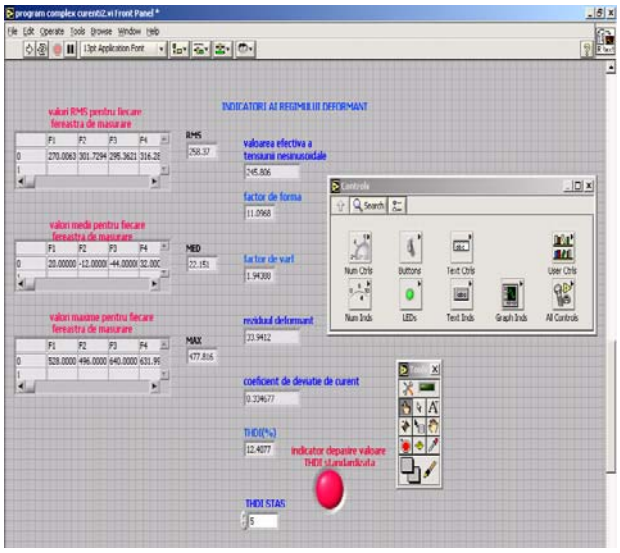

Fig.4 Front panel of virtual instrument – part 3

With the help of the control element we select the standardized value of THDI. This value is compare with the THDI obtained with the programme. We can see on the front panel the button for the signalling overshoot of the standardized value.

Figure 5 shows the diagram window for the harmonics amplitudes calculation both RMS values and percent values.

Fig. 6 illustrates the calculus block of the deforming state indicators. The input is the harmonic spectrum of current from the arc furnace.

This block gives to the output RMS value of the deformed signal and the indicators of deforming state. With the help of build array structure we extract 40 harmonics and continuous component by the amplitudes spectrum, after FFT application. THDI obtained is compare with the standardized value.

The level of current harmonics are calculate with the programme illustrates in fig. 7.

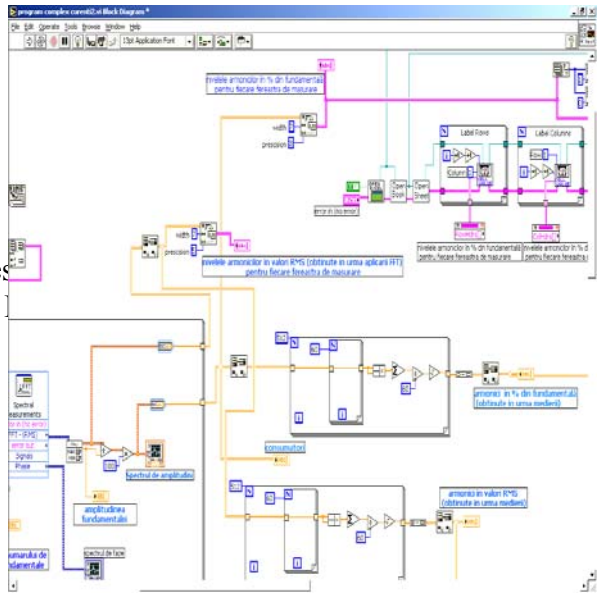

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Fig.5 Diagram window – part 1

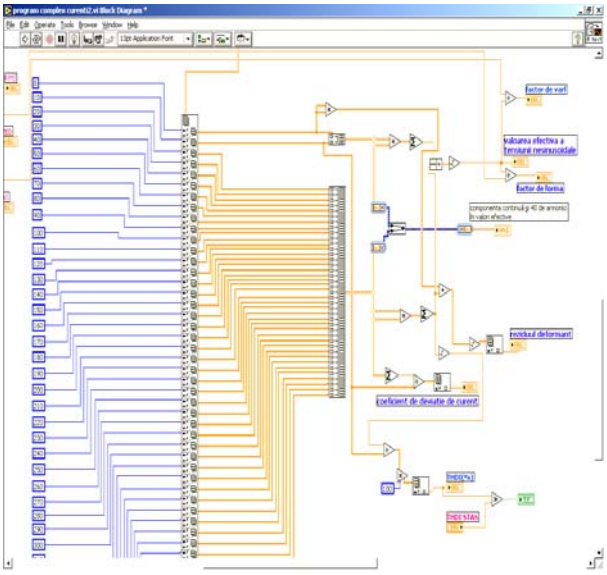

Fig.6 Diagram window – part 2

In table 1 is present the current harmonics spectrum from the arc furnace, which are obtained with the help of programme.

Table 1 – the harmonic spectrum of the current from the arc furnace

Harmonic range	2	3	4	5	7	9	11	13
In/I1 (%)	6.9	9.4	2.7	4.3	1.2	1.5	1	0.3

We compare these values with the values obtained with VIP SYSTEM 3 etalon and we can say that they are approximately equal.

We can see in this spectrum the even harmonics. It can be observed that the 3rd harmonics is highest. The harmonics amplitudes decrease with the harmonics range increase. THDI for the arc furnace is higher than the standardized value.

Therefore the 2nd, 3rd and 5th harmonics are higher than the values given by PE 143/2001 [4].

The form factor and the crest factor are also higher than the values for the sinusoidal state.

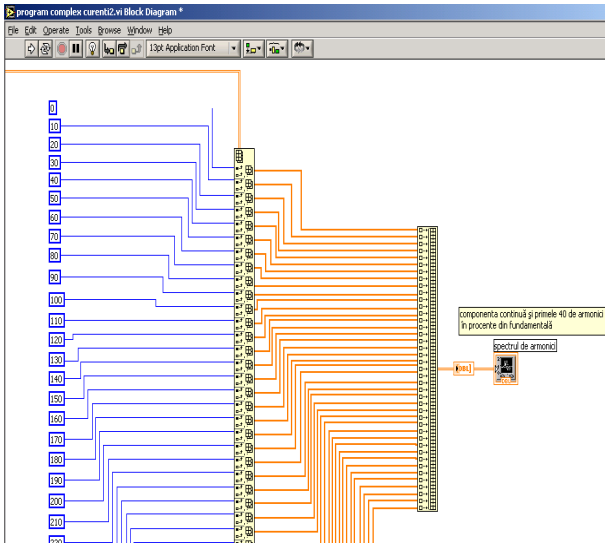

Fig.7 Diagram window – part 3

Conclusions

An instrument for deforming state analysis of arc furnace was designed.

The proposed instrument can determine up to the 40rd harmonic of current and provides important indices, such as rms value of harmonics, harmonic distortion, crest factor, total harmonic distortion.

The instrument can be use to evaluate waveform distortion. Numerical and graphical results are available in real-time.

All the indicators of the deforming state for the IHF 3/A arc furnace are above the standardized values.

References

[1] Anxo, M.P.A., Perez, M.D., An Improved Time Domain Arc Furnace Model for Harmonic Analysis, IEEE Transactions On Power Delivery, Vol. 19, No.1, January 2004

[2] Beites, L.,F., Mayordomo, J.,G., ş.a., Harmonics, Interharmonics and Unbalances of Arc Furnaces: A new frequeny domain approach, IEEE Transactions On Power Delivery, Vol. 16, No.4, October, 2001Analog Device

[3] LabVIEW, Databook, 1996

[4] Normativul PE 143/2001