PARAMETERS OF A PILOT COGENERATION PANT

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REZUMAT. Conceptul de cogenerarea este bine cunoscut, care realizează cu mijloace foarte eficiente generare de căldura şi energie electrică în acelaşi timp, de la aceeaşi sursă de energie. Folosind caldura generată de arderea combustibililor fosili, care în mod normal ar fi fost irosită în procesul de generare a energiei electrice, se poate tripla, sau chiar cvadrupla eficienţa de producere de energie convenţională. Pentru a măsura parametrii termodinamici, iar ulterior să se calculeze randamentul total al centralei de cogenerare, este necesar să existe aparate de măsurare de înaltă precizie şi echipamente de automatizare. În acest studiu, a fost integrat programul de grafică LabView 8.5 şi placa de achizitie NI-6224 PCI de la National Instruments.

Cuvinte cheie: energie electrică, generarea de energie electrică, LabView

ABSTRACT. The Cogeneration concept is well known that with highly efficient means of generating heat and electric power at the same time from the same energy ressource. Displacing fossil fuel combustion with heat that would normally be wasted in the process of power generation, it reaches efficiencies that can triple, or even quadruple, conventional power generation. In order to measure the thermodynamic parameters, and later on calculate the total efficiency of the cogeneration plant it is necessary to have high precision measuring and automation equipment. In this study, it was integrated LabView 8.5 graphical program and NI-6224 PCI acquisition board from National Instruments.

Keywords: electric power, power generation, LabView

1. INTRODUCTION

This paper presents a data acquisitions program and intelligent control of a pilot cogeneration plant, build in the Multifunctional Lab, at the University “POLITHENICA” form Timişoara. The primary mover of the cogeneration plant is a reciprocating internal combustion engine powered by diesel and biofuel. The engine has one cylinder air cooled, with the capacity of 406 cc equipped with direct injection system at 150 bar. The maximum power 6.5 kW is obtained at 3600 rpm. Due to the main purpose that this engine is designed for (producing electricity at 220 V and 50 Hz) the engine is obliged by the electric generator to work at 3000 rpm (50 Hz). At this operating condition the output of the engine is 5.5 kW, the total electric power of the cogeneration plant. For the data acquisition of the thermodynamic parameters and intelligent control of the cogeneration plant, the National Instruments graphical platform was employed. The program code that reads controls and saves data in real time from the sensors was written in LabView 8.5.

2. INTELIGENT CONTROL SYSTEM OF THE COGENERATION PLANT

The Intelligent Control System of the cogeneration plant (figure 1) is divided in three major components:

-Thermodynamic parameters
-Primary mover control
-Data acquisition software

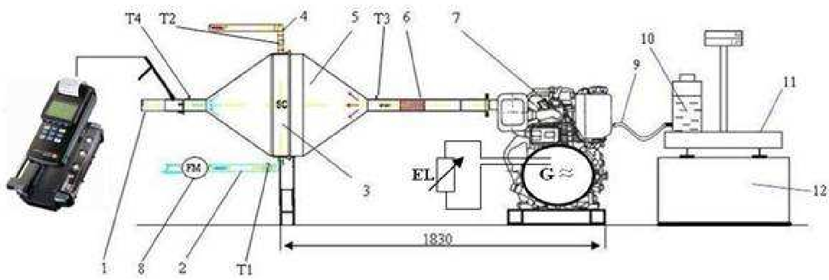

Figure 1. *Pilot Cogeneration Plant.* [1]

In figure 1 is presented the pilot cogeneration plant and its components, form the Multifunctional Lab at the University "POLITEHNICA" from Timişoara:

1-Exhaust gases outlet; 2-Water (cold) inlet; 3-Heat exchanger; 4-Water (hot) outlet;5-Heat exchanger framework; 6- Metal vibration absorber; 7-Diesel engine; 8-Water flow meter; 9-Fuel delivery pipe; 10-Additional fuel tank; 11- Digital weightier; Digital weightier holder; G – electric generator coupled directly on the engine shaft; EL – Electric load;
T1, T2 - Thermocouple K type 0 – 200 °C (water);
T3, T4 - Thermocouple K type 0 – 400 °C (gases)

A. THERMODYNAMIC PARAMETRS

The thermodynamic parameters necessary to record on a cogeneration plant are temperatures. In order to record temperatures, with a high precision in real time, thermocouples ware placed in specific points to record values that later on are used to calculate the total efficiency of the cogeneration plant. Taking into consideration the characteristics of the sensors, the most appropriate selection is are the K type thermocouples.

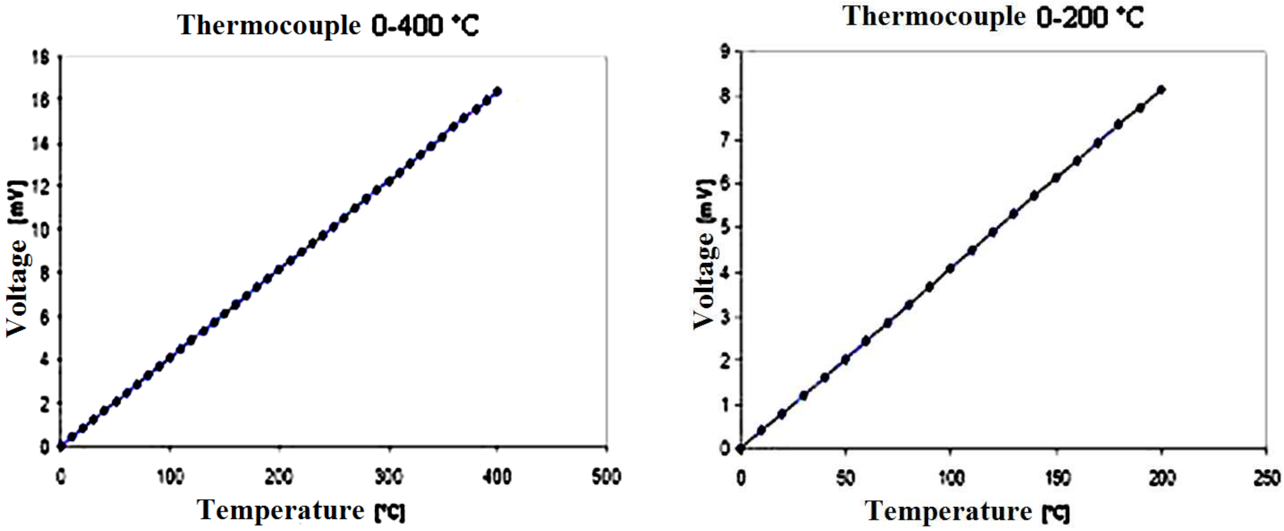

Figure 2. *Thermocouple characteristics.* [1]

Figure 2 presents the characteristics of the K type thermocouple, for two different ranges. On the cogeneration plant are mounted four thermocouples. Two thermocouples measure the exhaust gas temperatures, before and after the heat exchanger, in the range 0 - 400 °C. The amount of heat recovered by the water that passes though the heat exchanger is measured also by two thermocouples that are mounted on the water route that enters and exits the heat exchanger. At this point the measurements are taken with thermocouples that have a measuring range from 0 to 200 °C. An additional two thermocouples ware mounted to measure (in the range of 0 – 400 °C) the cylinder engine temperature and the ambient temperature, that are necessary for the final calculation, and for the cogeneration plant control.

The major disadvantage of these sensors is the output. The K type thermocouple has an output from -6.458 - 54.886 mV, that is corresponding to -270 to 1370 °C [2]. The temperature ranges at the cogeneration plant is operating are maximum 350 °C for the exhaust gases and 80 °C for the water in the heat exchanger. Taking into the characteristics and the output table, the voltage given by the thermocouples is rather small, and interferences may appear during the tests.

Reducing interference and, read the accurate value of the thermocouple, between the sensors and the acquisition board Pixsys ATR 243 ABC (figure 3) analogical digital converters ware placed. The analogical digital converter filters, amplifies and laniaries the signal from the thermocouples, converting it form mV to V, on the 0 – 10V scale. Among this key function, the converter has the possibility to be programmed, to open and close a SSR relay, creating in this way a small autoimmunization o a process.

Figure 3. *Analogical -Digital converter Pixsys ATR 243 ABC.* [1]

After the signal from the thermocouples is amplified and filtered, is transmitted to the acquisition board. The acquisition board employed in the Intelligent Controlled System of the cogeneration plant is a PCI 6224 M Series form National Instruments (figure 4).

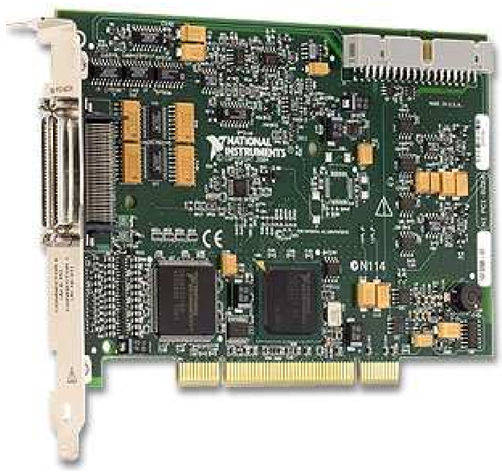

Figure 4. *Data acquisition board NI-PCI 6224 M*

The National Instruments PCI-6224 is a data acquisition (DAQ) board optimized for cost-sensitive applications. Also consider the high-speed M Series devices for 5X faster sampling rates or the high-accuracy M Series devices for 4X resolution and superior measurement. The M Series devices incorporate advanced features such as the NI-STC 2 system controller, NI-PGIA 2 programmable amplifier, and NI-MCal calibration technology to increase performance and accuracy [4].

The PCI 6224 is a data acquisition board that interacts with the sensors trough a connector block. The SCB-68 is a shielded, noise rejecting I/O connector block for interfacing I/O signals to plug-in DAQ devices with 68-pin connectors. Combined with the shielded cables, the SCB-68 (figure 5) provides rugged, very low-noise signal termination [4].

Figure 5. *Block connector SCB - 68*

The connector bloc also has a solid case, enabling resistance to shock, that can be experienced at this kind of measurements.

Following the recommendations given by the producer, in order to have precise measurements, the connector block was grounded to the building.

In figure 6 can be visualize the setup scheme for the data acquisition of the thermodynamic parameters, where :

C1 – C6 are the analogical digital converters Pixsys ATR 243 ABC also presented during tests in figure 3; T1-T6 thermocouples described above;

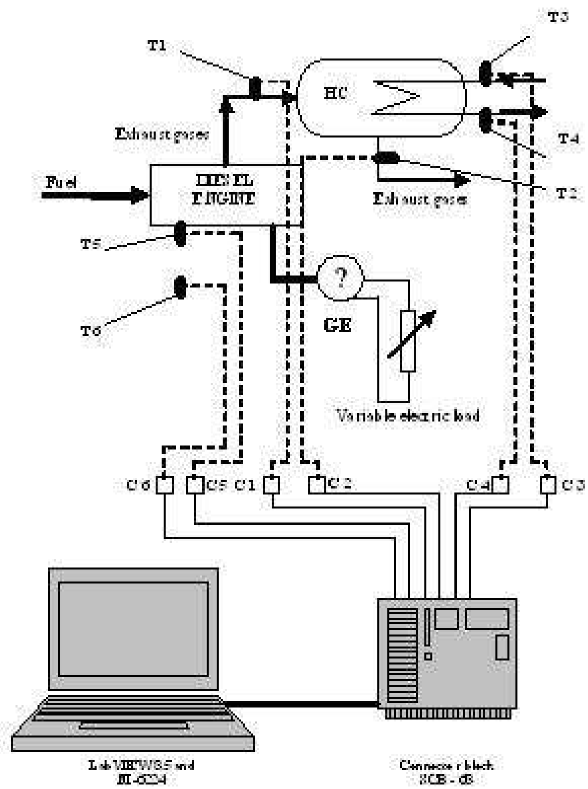

Figure 6. *Scheme of the thermodinamical parameters aqcusition*

B. PRIMARY MOVER CONTROL

The primary mover of the cogeneration plant, is an electric generation that initial it was operated manually. In order to start the engine, first the START lever must be turned on, by sliding it to the right. The function of the START lever is release or stop fuel to the injection pump, resulting starting and stopping the engine when the operator desires. When the START lever was enabled, it locks mechanically, to the STOP lever. When the STOP lever is pressed then the spring attached to the START lever resets the lever at the initial position (fuel closed), stopping the engine.

To the levers are attached actuators that operate at 12 V. The voltage is supplied by the battery that is incorporated as a part in the electric generator system. The automation of the primary mover includes 5V/ 5A analogical digital relays, which are connected to the data acquisition board and actuators. The commands of the relays are given by the program built in the graphical software. The same logic was implemented for the engine start. The former ignition key was replaced by a 5V/200A analogical digital relay, also connected DAQ board and driven by the labview program.

C. DATA ACUISITION SOFTWARE

The data acquisition software was developed in the graphical environment of the National Instruments Labview 8.5, based on a logic used in other research [5], [6], [7] has logic scheme presented in figure 7.

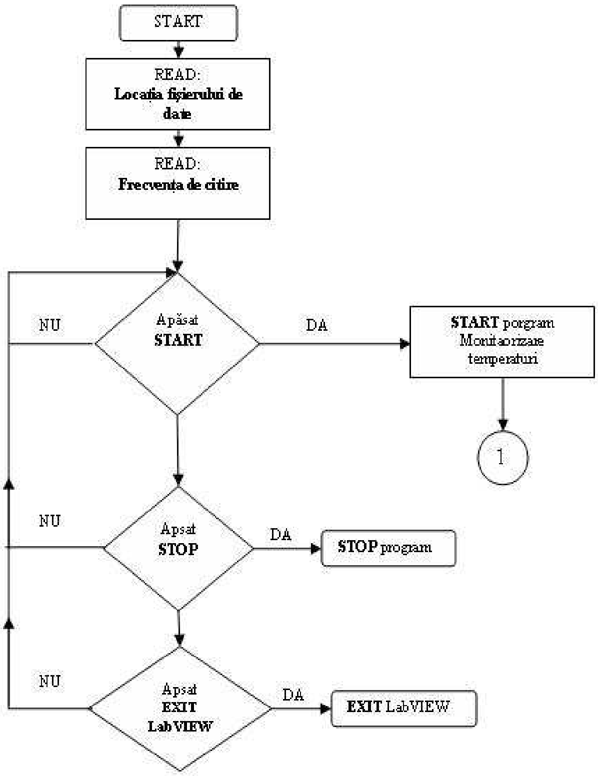

Figure 7. *Main menu logic scheme*

The software has a first interface (figure 8) where several fields are mandatory to be completed by the operator. The first field that must be completed is the location of the final file. The name of the file would be succeeded by the *.txt extension, due to the fact that LabView will write the final file on the hard drive in the hexa format, thus enabling the possibility of reading the values with almost any editor. Another field that must be completed is the time duration of the data acquisition for the parameters.

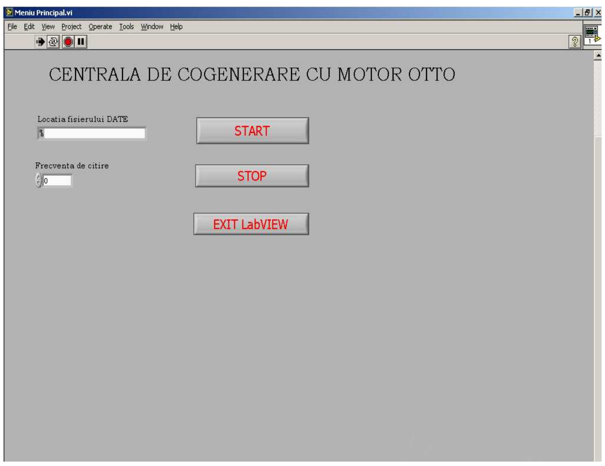

Figure 8. *Main menu interface*

After these fields are introduced, the START button will enable the software to start measuring (figure 9).

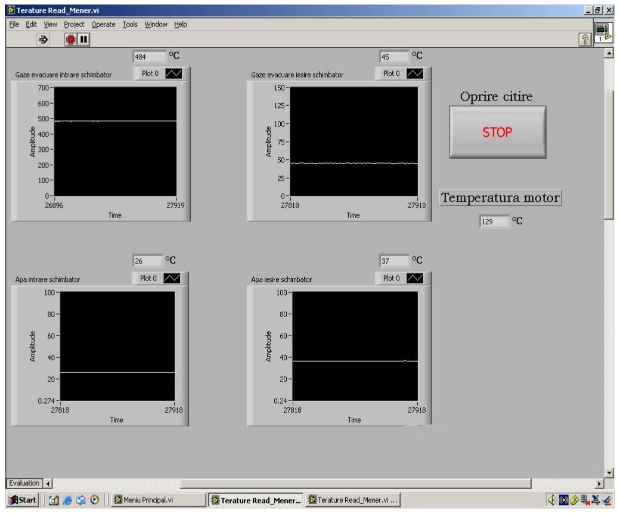

Figure 9. *Measurement interface*

In this phase the software is recording the data form the sensors. The logic of the measurement software presented in figure 10, will record the data with the maximum capacity of the DAQ board divided by the number of channels until the time settled in the first step, then the program will average the values and after the final values are saved in the final file.

In this way with this software it can be recorded values that define a high dynamic process such as cogeneration with reciprocating internal combustion engine.

The final file (figure 11) will be closed when the button STOP is pressed. In the software a safety measure was introduced. When the data acquisition is started, in parallel the software build also a backup file, in a specific location, known by the operator.

With the final file saved the data processing can take place with any data software that can analyze the data.

D. CONCLUSIONS

The National Instruments data acquisition platform is a very compact and wide range application, enabling even a non programmer experience operator to develop successful and validated software regarding data acquisition.

One other major advantage is that the National Instruments Labview graphical programming software has the functionality to perform data acquisition and process control in the same time and in some circumstances in real time.

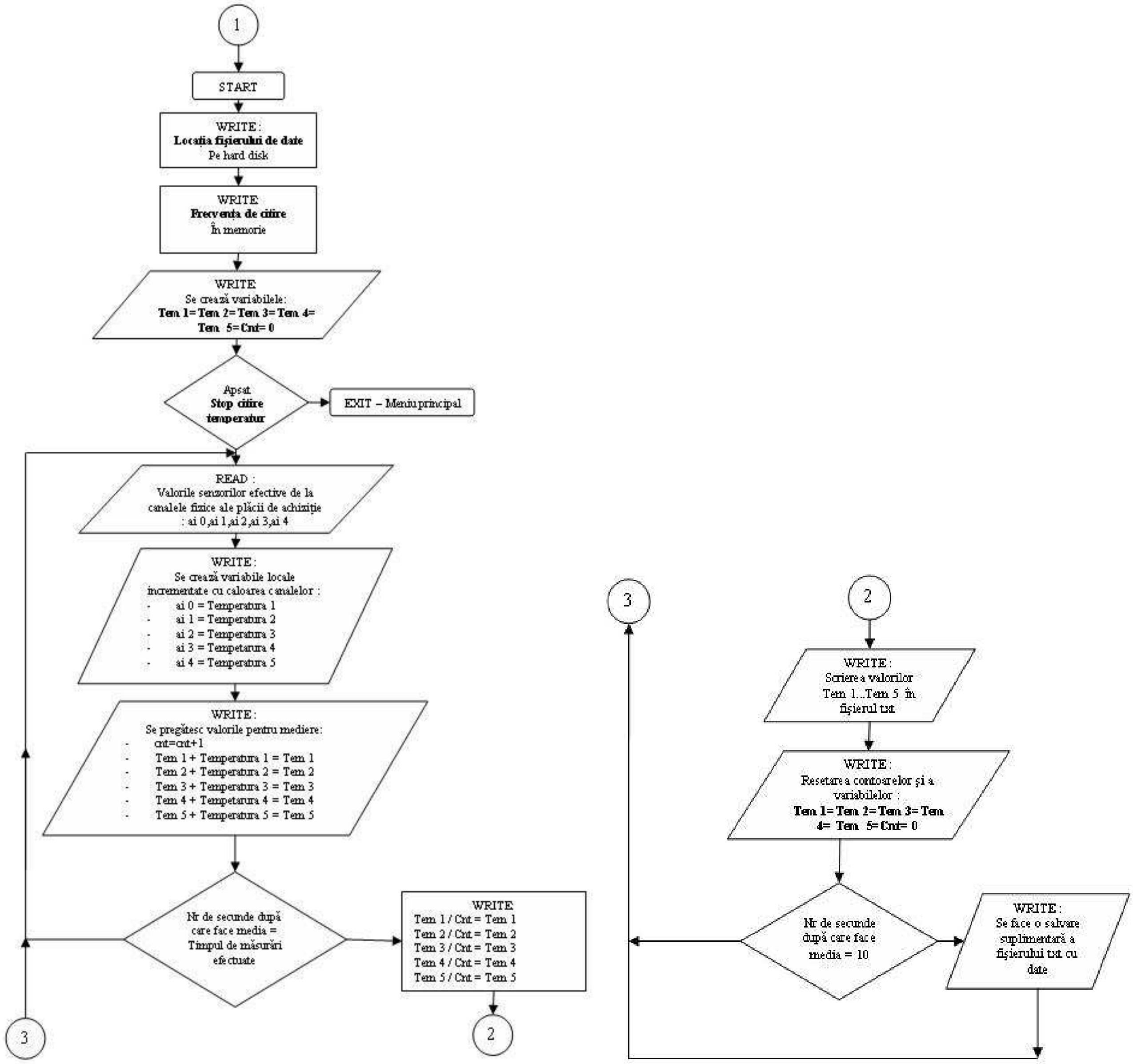

Figure 10. *Logic scheme of the data acquisition software*

Timp	Gaze int SC[°C]	Gaze ies SC[°C]	Temp Motor[°C]	Apa int SC[°C]	Apa ies SC[°C]
10:44:59	178.970	29.219	83.304	27.360	26.620
10:45:09	188.051	29.564	86.046	27.393	26.496
10:45:19	194.177	29.796	87.656	27.408	26.549
10:45:29	200.132	30.007	89.184	27.338	26.587
10:45:39	205.886	30.181	90.554	27.317	26.650
10:45:49	211.559	30.390	91.826	27.346	26.682
10:45:59	216.874	30.672	92.853	27.371	26.690
10:46:09	221.909	30.872	93.937	27.384	26.815
10:46:19	226.778	31.078	94.989	27.317	26.874
10:46:29	231.571	31.220	95.760	27.269	26.973
10:46:39	236.398	31.465	96.482	27.333	27.118
10:46:49	241.075	31.575	97.181	27.377	27.191
10:46:59	245.742	31.752	97.998	27.395	27.243
10:47:09	250.270	31.858	98.518	27.367	27.349
10:47:19	254.477	32.008	99.121	27.376	27.423
10:47:29	258.259	32.151	99.607	27.304	27.567
10:47:39	261.943	32.198	100.152	27.317	27.606
10:47:49	265.228	32.269	100.556	27.340	27.596

Figure 11. *Final data file*

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