PROGRAMMING AND VISUALIZING THE CHEMICAL ANALYSIS PARAMETERS OF THE WATER STEAM CYCLE

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Abstract: After a presentation of the process of water treatment in a thermal power plant (TPP), we present an application of a supervisory control and data acquisition system (SCADA). In fact, almost all critical industrial infrastructures and processes are managed remotely from central control rooms, using computers and communications networks. Thus, the architecture of the supervisory system and the different steps of the application of the SCADA system on the process of water treatment have been presented. Our contribution in this work consists in programming and visualizing new parameters of the chemical analysis (pH and conductivity) of the water - steam cycle to the SCADA system. The achieved supervision application is going to facilitate the work of both laboratory and instrumentation agents of the process of water treatment in the TPP.

Key words: Water treatment, thermal power plant, water - steam cycle, SCADA.

1. Introduction

History of the industrial development is constructed in collaboration with water. This natural source united a whole exceptional of physical and chemical properties. It can play the role of a solvent, of a thermal fluid or simply of an easy manipulated liquid. It is why water is implied in most industrial manufactures [1-3].

In fact, the electricity production in a thermal power plant (TPP) is based on a set of energies transformations using water as support of energy. This water must have a noble quality to guarantee the installation security and to improve production groups' performances. It is therefore necessary to apply a rigorous treatment of the raw water and a stern control of its quality.

The process of the electricity production in the TPP of Radès (near to Tunis, Tunisia) is essentially based on the water distributed by the SONEDE (National Water Distribution Utility of Tunisia). This water generally contains dissolved mineral salts and organic matters. The presence of these elements can generate problems bound to the furring, the corrosion and the different facilities contamination notably the furnace, the steam-powered turbine and water or steam circuits.

In order to assure the quality of water required in the water-steam cycle of the TPP of Radès, a water treatment process is necessary. Indeed, water passes by the filtration chain then introduced in the inverse osmosis station and thereafter in the demineralization station.

The objective of this article is the rehabilitation of the instrumentation of the chemical analysis (pH, NaCl) of the water-steam cycle of a TPP. An example of a SCADA system of the TPP of Radès is presented. The last section presents the interests of the supervision of the chemical analysis parameters on the SCADA system of the TPP.

2. Presentation of the process of water treatment

The water of the SONEDE used in the TPP of Radès is unfit to the feeding of furnaces. It contains matters suspended and in various solutions in nature and in quantity of salts and gases dissolved.

A matter suspended is constituted of the sand, of colloidal clays, insoluble mineral salts and of organic matters (products of animal and plant deterioration). These bodies give a certain coloration to water (turbidity) that requires a clarification treatment. This undesirable foulness can drive to the serious damages. Among which we mention notably: corrosion and furring (or encrustations) [4-7].

In order to avoid these problems, it is necessary to:

- Eliminate gases (CO_2, O_2, N_2) of water by physical degassing or chemical degassing by injection of oxygen reduction as N_2H_4…
- Use of a destitute water of mineral salts for example water done demineralization with a conductivity ($\sigma < 0.2$ µS/cm) and a content in silica $SiO_2 < 30$ ppb.
- Work with a sufficiently basic pH ($8.5 < pH < 9.5$)

Considering that the water of the SONEDE contains an elevated rate in dissolved salts and in matter suspended, it is indispensable to adopt a stage of pretreatment to assure the good working of the inverse osmosis installation and to protect modules against risks of usuries, corrosion and especially membrane calmative.

The pretreatment is constituted of two filtration chains each including a sand filter and an active coal filter. Thereafter, we present the two stations of the TPP: inverse osmosis and demineralization.

2.1- Inverse osmosis station

The control of the water quality is an important task to maintain the efficiency and the sure and continuous working of the power station [8-11]. To guarantee the best water quality at the level of the water steam circuit, the TPP of Radès arranges an inverse osmosis station that permits to eliminate the majority of salts dissolved in the raw water before being treated in a demineralization station (Fig.1). This stage serves to minimize risks of failing by corrosion of the turbine or the loss of the efficiency and the power.

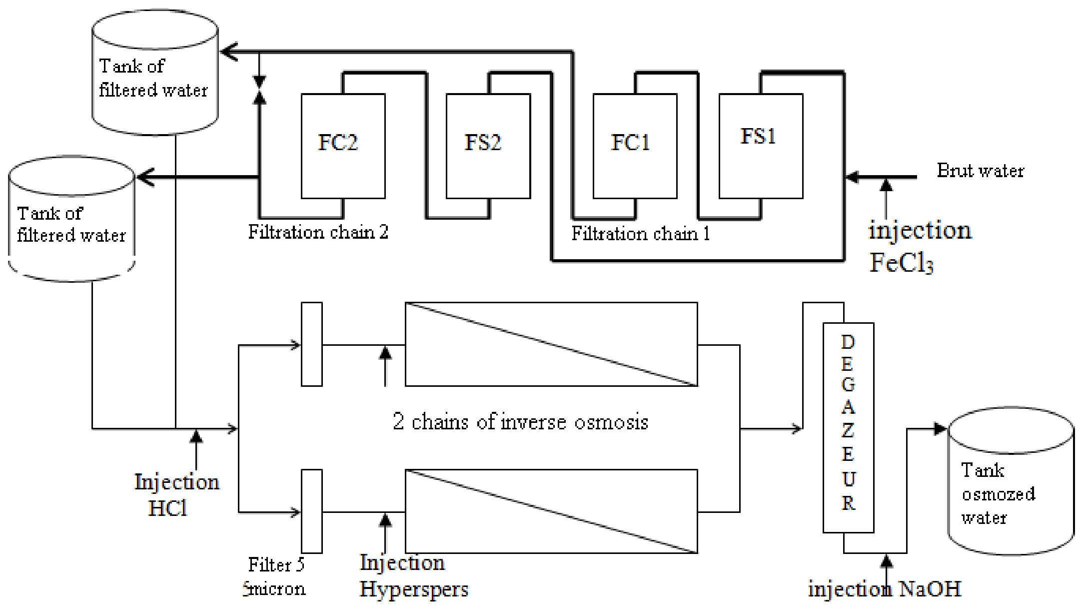

Fig.1. Functional diagram of the inverse osmosis station of the TPP.

Legend:

FS1: Sand filter of the filtration chain 1.
FC1: Active coals filter of the filtration chain 1.
FS2: Sand filter of the filtration chain 2.
FC2: Active coals filter of the filtration chain 2.

The bold lines present the water circuit in the two filtration chains and the light lines present the water circuit in the two inverse osmosis chains.

2.2- Demineralization station

The basic principle of the ion exchange consists in withdrawing ions (remaining salts that are lower to 8%) in solution in water is to recover an ion of value, either to eliminate a harmful or bothersome ion for the ulterior utilization of water.

The exchange of ions is a process which ions with a certain load contents in a solution are eliminated of this solution, and replaced in the same way by an equivalent quantity of other ions load gave out by the strong but the opposite load ions are not affected.

In the demineralization chain, osmosis water passes by the following stages:

- a weak cationic exchanger (CF1);
- a strong cationic exchanger (CF2);
- a weak anionic exchanger (AF1);
- a degasser;
- a strong anionic exchanger (AF2);
- a strong cationic exchanger (CF3);
- a strong anionic exchanger (AF3).

After the demineralization, the water must have a lower conductivity of 0.2 µS/cm, a pH between 6.5 and 7.5; silica < 30 ppb.

Figure 2 presents the cycle of the water treatment in the demineralization station.

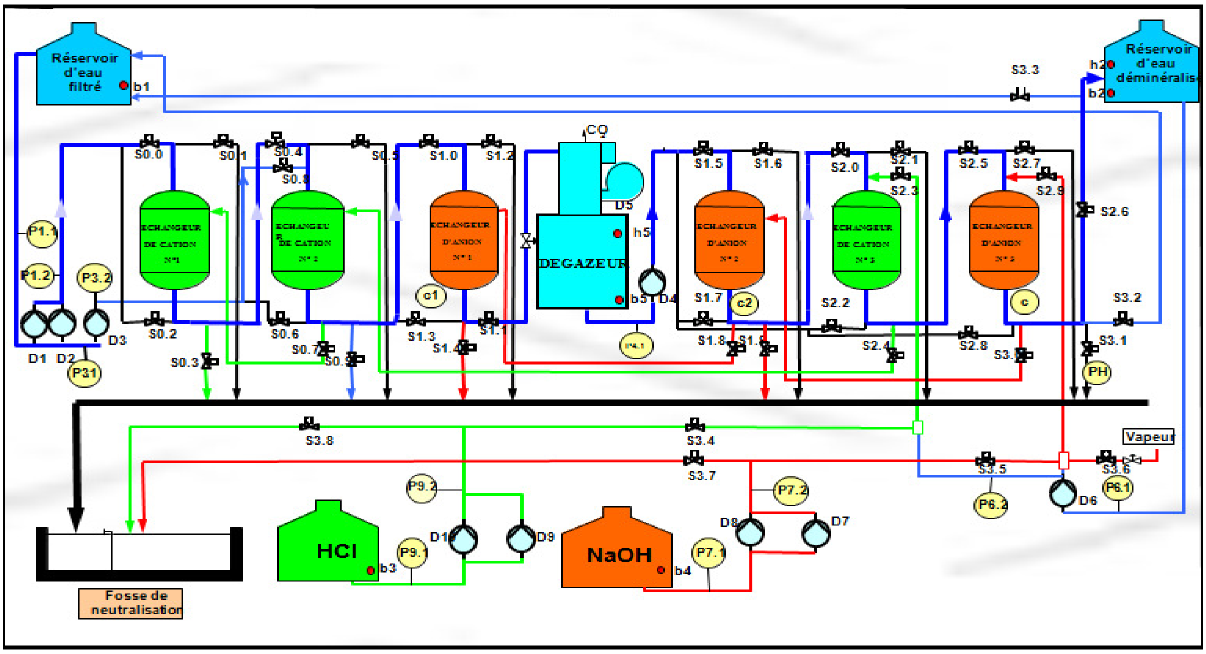

Fig.2. Demineralization station of the TPP.

3. Chemical Analysis of the water in a TPP

After a presentation of the process of the water treatment in the TPP of Radès, we present in this part a general survey of the water analysis particularly for the two parameters pH and conductivity.

3.1- pH measurement

The pH is a measure of the acidity or basicity of a solution. Pure water is said to be neutral, with a pH close to 7.0 at 25 °C (77 °F).

A basic solution is characterized by the presence of hydroxides ions OH^- formed by loss of an H proton by a molecule of water. If an aqueous solution contains more OH^- ions than the pure water, it is basic and its pH is superior to 7.

Neutral water contains the same quantity, in very weak proportion, of ions $H3O^+$ and OH^-. In fact, in water and in all aqueous solution occurs a limited transformation of water, whose chemical equation is the following: $2H_2O = H_3O^+ + OH^-$.

The pH meter used in the TPP of Radès is constituted of a measure probe and a transmitter. It permits to measure the degree of acidity or alkalinity of an aqueous solution. This pH meter is provided of a case joined to a probe. The probe is constituted of two electrodes soaking in the aqueous solution which one wants to measure the pH.

The electronic case is joined to the probe that displays the value of the pH. This case is a mill voltmeter that measures the tension between the two electrodes of the probe and that will be converted in pH by the calculator.

This case is an instrument of panel-support; it permits the display both the pH and the temperature (Fig. 3). It can be permutable for the reading of the pH for the mv/ORP (potential redox); it possesses two exits and two relay contact freely programmable as the limit controller; it has two analogical exits with a galvanic insulation of 0/(4) to 20 mA or 0/(2) to 10v freely configurable as value of pH, of redox or the temperature; it also possesses two logical entrances for the control of its working.

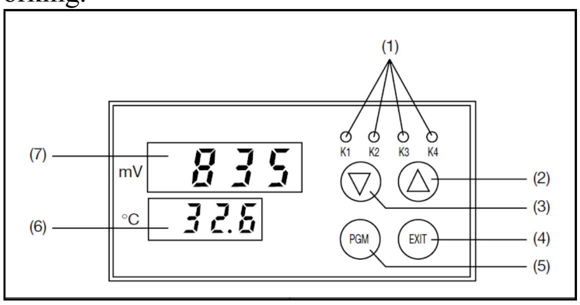

Fig.3. Indications / commands of the pH meter.

(1) Indicators of statues for productions 1 to 4.
(2) Increment key to change parameters or manual operation of the relay K2.
(3) Decrease key to change parameters or manual operation of the relay K1.
(4) Exit key to leave the levels.
(5) PGM key for the selection of parameters and the confirmation of entrances.
(6) Display with 4 numbers for the temperature.
(7) Indication of the value of the process with 4 numbers (pH, redox tension).

(3)+(5) CAL: introduction of the electrode calibration (1 point or 2 points)
(2)+(4) Entrance of the manual operation.

3.2- Conductivity measurement

The conductivity measures the capacity of water to drive the current between two electrodes. Indeed, most matters dissolved in water are electrically loaded ions. The measure of the conductivity permits to appreciate the quantity of salts dissolved in water. The conductivity is expressed in µS/cm or ms/cm according to the quality of water.

The conductivity meter used in the TPP of Radès (model 8531) is composed of a detector and a converter. The detector provides a proportional electric current to the conductivity of the solution by one electrode of the cell constant $0.05cm^{-1}$ or $5cm^{-1}$ according to the measure. The electrode possesses a thermistor permitting to correct the conductivity in relation to the temperature of reference.

The converter gets conductivity converts in terms of temperature of reference of the electric current detected by the electrode and the value of resistance thermistance, and indicates the conductivity on an indicator. It also provides an exit signal of 4 to 20mA for the transmission. A cell is based on the temperature characteristics of the NaCl solution.
Table 1 shows some values of the conductivity measure in the TPP.

Tab.1. Some values of the conductivity measure.

Acquisition parameters	Measure (µs/cm)	Output signal
Water of the boiler	9 (0-50)	4-20 mA
Overheated steam	0,10 (0-1)	4-20 mA
Saturated steam	0.065	4-20 mA
Cleared water	0.18	4-20 mA
Output pump (condenser)	0.39	4-20 mA
Filter	0.032	4-20 mA
Brut water	1200	4-20mA

4. Interfacing of the chemical analysis signals with the SCADA system

Supervision consists of commanding a process and supervising its working. To achieve this goal, the supervisory system of a process must collect, supervise and record important sources of data linked to the process, to detect the possible loss of functions and alert the human operator [12-16].

The main objective of a supervisory system is to give the means to the human operator to control and to command a highly automated process. So, the supervision of industrial processes includes a set of tasks aimed at controlling a process and supervising its operation [17-21].

The SCADA term (supervisory control and data acquisition) refers to a system that collects data coming from different sensors of an industrial or other process, these sensors can beings installed in the same site or distant (several Km), the introverted data are treated by an unit called processor power station (CPU, PCU, PC...), results are sent in real time to the Men / Machine interfacing that can be a computer with its peripherals.

The SCADA system of the TPP of Radès orders and classifies all data for [22-24]:

- Instantaneous impression.
- Visualization on screen using data tables and tabular diagrams.
- Registration of instantaneous exchanges of numeric and analogical data.
- Instantaneous calculation for example corrections of gas debits, direct middle specific consumption, middle values.
- Storage of the analogical information of the process.
- Calculation of outputs and losses of the process.
- Surveillance of the SOE signals (entrances rapid contact 1ms)
- Interfacing interactive Men / Machine for the surveillance of the system and the conduct of processes (tabular, curves view of alarm).

The objective of the SCADA system is to collect data instantaneously (ON LINE) of their sites and to transform them in numeric data. This centralized supervision allows operators, since the room of control of the TPP, to control facilities in their domain of exploitation and the different types of incidents.

The SCADA system of the TPP of Radès is equipped of 3 networks of communication [25]:

- Field bus, 5 Mbits, permitting to do exchanges of the numeric data of the entrance card / exits (FBM) toward the central system (CP) via modules of communication (FCM);
- Node bus, 10 Mbits, permitting to do exchanges of the numeric data of the central system (CP) via modules of communication (DNBT) toward the Men/Machine interfacing (workstations);
- Ethernet TCP/IP, 100 Mbits, permitting to do exchanges of files between workstations of the Men/Machine interfacing. It avoids so the overcharge of the Nodebus network.

Figure 5 presents the different links between the CP60, FCM and FBM blocks.

In order to remedy to the absence of indication, of follow-up and of storage of the chemical characteristics of the water of the furnace, it is necessary to achieve an interfacing between the chemical sensors (pH meter and conductivity meter) and the stations of surveillance of the control room of the TPP.

The interfacing of the signals of the pH and the conductivity of the ball furnace is assured by a data configuration of both analogical and numeric signals and requires a unique code for every entrance which must be programmed in the data base system.

Figure 5 presents the display of the sampling room containing the chemical analysis parameters of the water-steam cycle of the TPP.

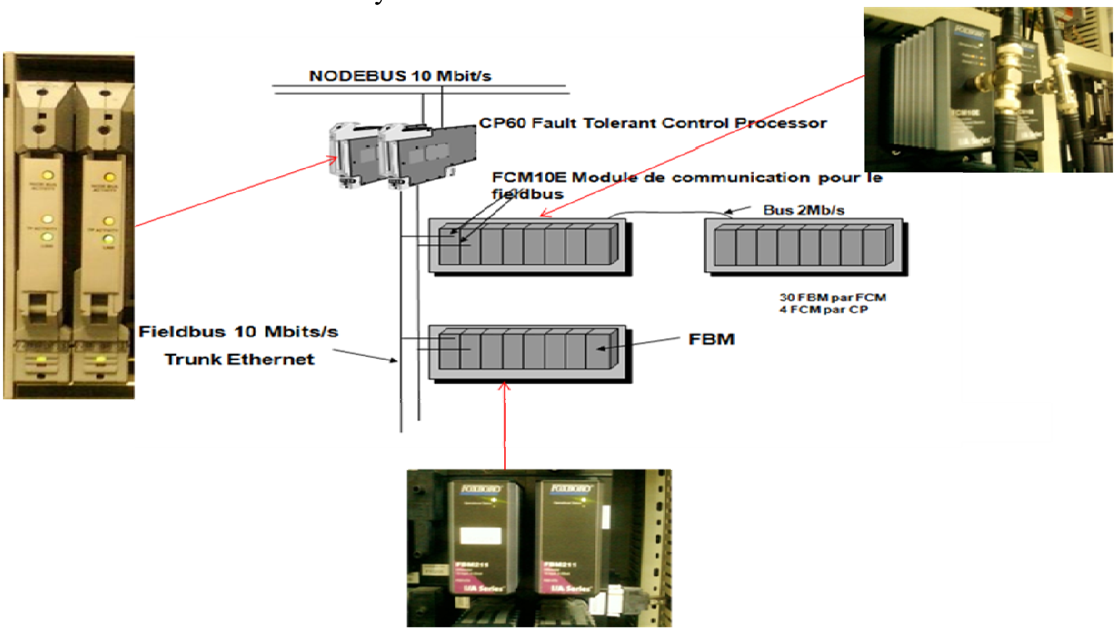

Fig.4. The CP60/FCM/ FBM links.

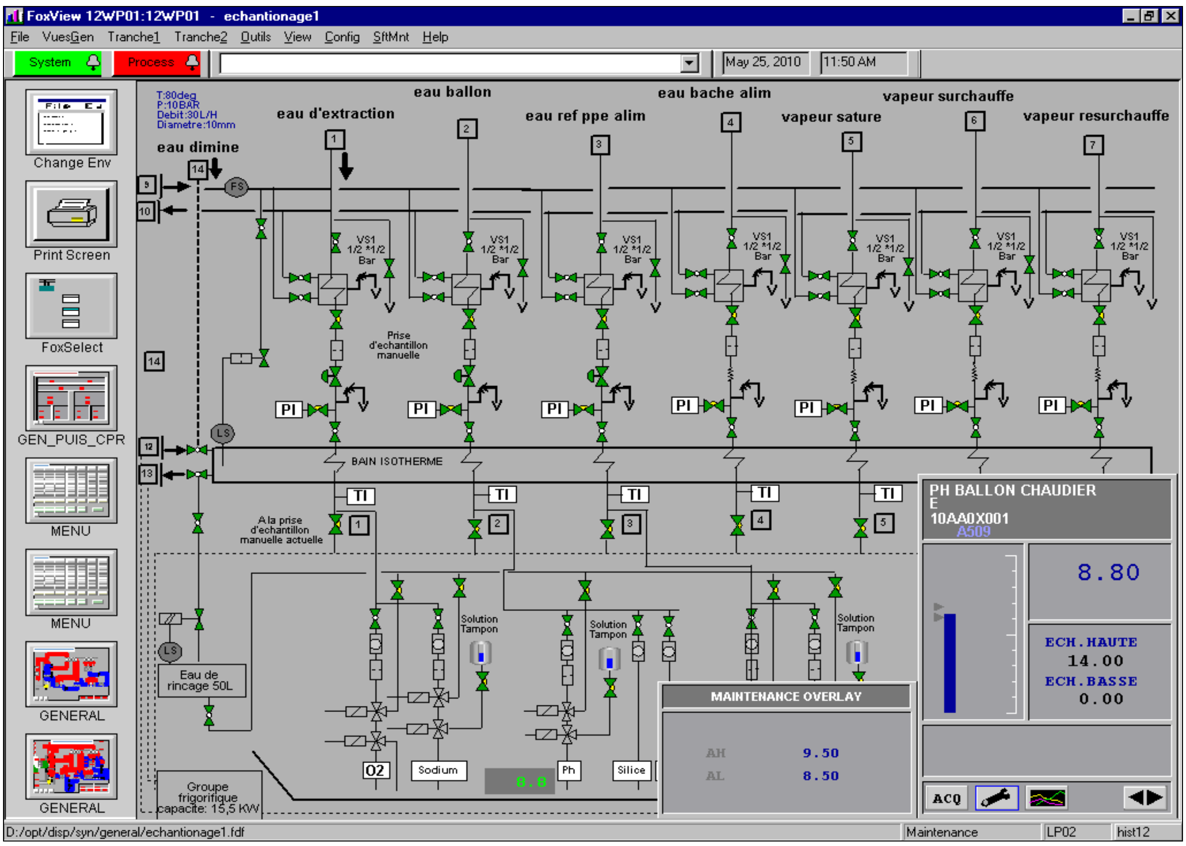

Fig.5. Display of the chemical analysis parameters.

This application is declined in six stages:
Stage 1: Choosing the site of the signal (FBM module).
Stage 2: Programming both AIN and CIN blocks for the supervision of the signals pH (4 to 20 mA) and conductivity (alarm).
Stage 3: Testing both AIN and CIN blocks by injection of current and by short circuit.
Stage 4: Passing the cable between the sampling room and the SCADA room.
Stage 5: Connecting the signals in the two modules 10FBM215 and 10FBM325.
Stage 6: Conceiving a new tabular for the general vision of the sampling room.
The last stage of this application of interfacing consists in improving the tabular pH meter and conductivity meter.

5. Conclusion

SCADA systems are used to control and monitor physical processes, examples of which are transmission of electricity, transportation of gas and oil in pipelines, water distribution, traffic lights, and other systems used as the basis of modern society.

In this paper, we presented an application of the SCADA system on a thermal power plant. This application consists in interfacing the chemical analysis parameters of water – steam cycle to the SCADA system.

In fact, the SCADA system gathers information, transfers the information back to the central site, alerting the home station and carrying out necessary analysis and control, and displaying the information in a logical and organized fashion.

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