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Full Length Research Paper

Supervision of a counting system of the natural gas of a thermal power plant

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After a presentation of the functionality of a supervisory system for complex processes, we present the concepts of a supervisory control and data acquisition (SCADA) system. An application of supervision of a counting system of the natural gas (NG) of a thermal power plant (TPP) in Tunisia was realized. The paper briefly discusses the different steps of this application and some advantages of SCADA systems used in TPPs.

Key words: Supervision, thermal power plant, counting system, natural gas, SCADA.

INTRODUCTION

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 (Lambert et al., 1999; Poon, 1989).

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 (Bailey et al., 2003; Wiles, 2008).
SCADA (supervisory control and data acquisition) systems are widely used in industry for supervisory control and data acquisition of industrial processes. The process can be industrial, infrastructure or facility.

The objective of this paper is to show interests of the use of a SCADA system for upgrading the counting system of natural gas (NG) of a thermal power plant (TPP). An example of a SCADA system of a TPP is presented. The next section briefly describes the characteristics of the SCADA system and the problems linked to its design. Next, the interests of the application of the SCADA system are developed. The last section presents a discussion about some advantages of the application presented.

PRESENTATION OF SCADA SYSTEMS

SCADA system is used to observe and supervise the shop floor equipments in various industrial automation applications. SCADA software, working on DOS and UNIX operating systems used in the 1980s, was an alarm-based program, which has a fairly simple visual interface (Ozdemir et al., 2006).

The SCADA system usually consists of the following subsystems (Ralstona et al., 2007): 1. A Man-Machine Interface (MMI) is the apparatus which presents process data to a human operator. Through this, the human operator, monitors and controls the process. 2. A supervisory system, acquiring data on the process and sending commands to the process. 3. Remote Terminal Units (RTUs) connecting to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory system. 4. Communication infrastructure connecting the supervisory system to the RTUs.

In fact, most control actions are performed automatically by RTU or by programmable logic controllers (PLC). Host control functions are usually restricted to basic overriding or supervisory level intervention (Horng, 2002). For example, a PLC may control the flow of cooling water through the part of an industrial process, but the SCADA system may allow operators to change the set points for the flow and enable alarm conditions, such as loss of flow and high temperature, to be displayed and recorded. The feedback control loop passes through the RTU or PLC, while the SCADA system monitors the overall performance of the loop (Avlonitis et al., 2004).

With the advances of electronic and software technologies, the supervisory control and data acquisition systems are widely used in industrial plant automation. It provides an efficient tool to monitor and control equipment in manufacturing processes on-line (Aydogmus, 2008; Patel et al., 2004). The SCADA automation system always includes several functions, e.g signal sensing, control, human machine interface, management and networking.

CASE STUDY OF A SCADA SYSTEM OF A TPP

History of civilization and the progress in science and technology are closely associated with the growth of power consumption. A direct consequence of the developing heat power engineering based on combustion of carbon-containing fuel and of the growing amount of electric power produced is the increasing consumption of fuel-energy resources.

Economic growth is the most important driver of energy demand. Total final consumption of electricity has been shown in many countries to be correlated with economic activity. The other reasons for increase of electricity demand are high birth rates, higher living standards, industrialization and young populations. Like in the other developing countries, in Turkey, the demand for energy and electricity is growing rapidly due to the social and economic development and increase of the population of the country (Ozturk et al., 2007).

Tunisia was the first Mediterranean Partners to sign an Association Agreement with the EU in July, 1998. The Agreement came into force on 1 March, 1998 (European Commission, 2009). Tunisia insists on supply with a minimized cost and seeks the reconstitution of reserves, the control of energy demand and the establishment of a framework favourable to foreign investments.

The Société Tunisienne de l'Electricite et du Gaz (S.T.E.G) is a vertically integrated monopoly for power and gas. It is responsible for power transmission, distribution and gas distribution. The monopoly of power generation has been abolished and the first IPP is a reality. The transmission and distribution losses of the Tunisian electricity grid are about 12% of the power generated (Rapport, 2008).

The CO_2 emissions from power plants in Tunisia were approximately 1 million tones in 1996 (World Energy Council, 2009). Utilization of renewable technologies is in the development phase. Tunisia signed the UNFCCC during the Earth Summit held in Rio de Janeiro in June 1992, ratified it in July, 1993 and entered it into force in March, 1994.

Gas production and consumption will be the most significant aspect of the future MPs energy development. Tunisia views gas generation as providing an outlet for its domestic production.

During the last few years, the S.T.E.G has evolved in a difficult international conjuncture characterized by the increasing of the hydrocarbon's prices. In spite of this economic situation, the S.T.E.G has deployed many efforts in different domains of its activity that enabled it to record some remarkable results. This is why the growth of 4.8% of the national production of electricity in 2007 enabled S.T.E.G to answer to the country evolution demand under the best conditions of continuity and security (Rapport, 2008).

Among the units of electricity production of the S.T.E.G, we present an example of a TPP such as the Centre de Production de l'Electricité de Radès (C.P.E.R) that consists of a system producing the electricity while using dry water steam to drag the alternator in rotation. This steam is generated in a furnace that transforms the chemical energy of the fuel (NG, heavy fuel-oil) in calorific energy.

In fact, Thermal (or fossil fuel) power plants (TPP) are the major polluters of man's environment, discharging into the atmosphere the basic product of carbon fuel combustion, CO_2 (Vitaly et al., 2008).

A TPP is a power plant in which the prime mover is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser. The greatest variation in the design of TPPs is due to the different fuel sources. Some prefer to use the term energy center because such facilities convert forms of heat energy into electrical energy (Figure 1).

In TPPs, mechanical power is produced by a heat engine which transforms thermal energy, often from combustion of a fuel, into rotational energy. Most TPPs produce steam, and these are sometimes called steam power plants. TPPs are classified by the type of fuel and prime mover installed.

The electric efficiency of a conventional TPP, considered as saleable energy produced at the plant busbars compared with the heating value of the fuel consumed, is typically 33 to 48% efficient, limited as all heat engines are by the laws of thermodynamics. The rest of the energy must leave the plant in the form of heat.

Since the efficiency of the plant is fundamentally limited by the ratio of the absolute temperatures of the steam at turbine input and output, efficiency improvements require the use of higher temperature and therefore higher pressure of steam.

Most of the TPPs operational controls are automatic. However, at times, manual intervention may be required. Thus, the plant is provided with monitors and alarm systems that alert the plant operators when certain operating paracounters are seriously deviating from their normal range.

The architecture of a SCADA system of a TPP is presented in Figure 2. The stations belong to a superior network Ethernet (10 Mb/s). Principally, this network helps to exchange files between the stations and avoid the overload of the Node bus network. In fact, the SCADA

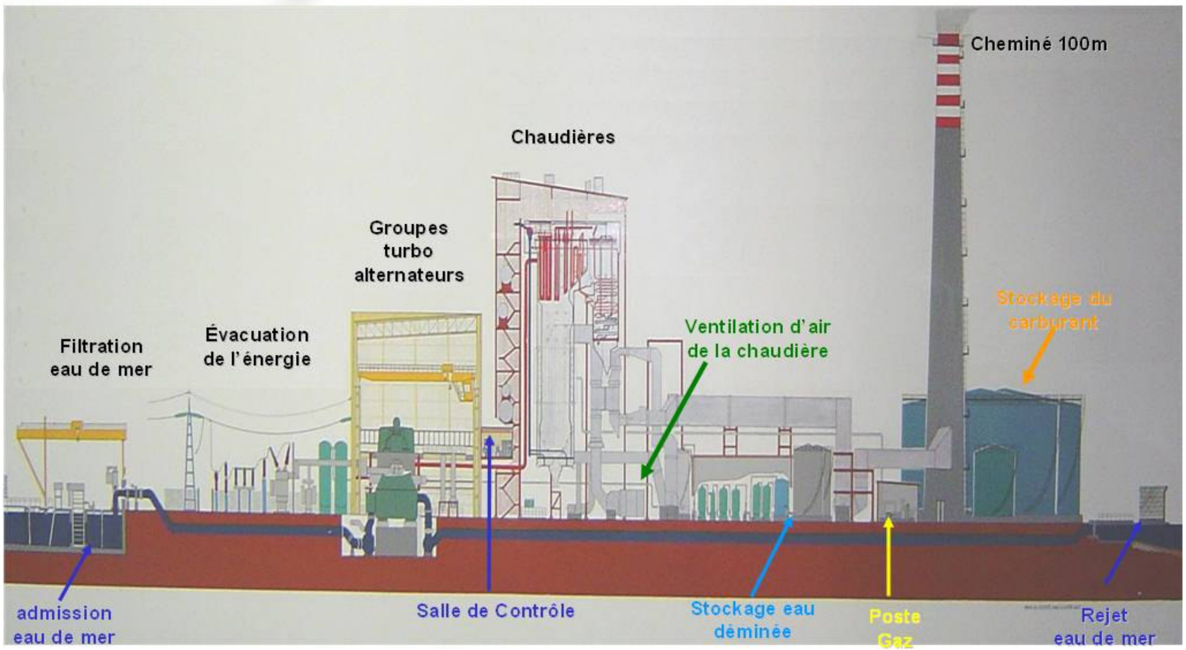

Figure 1. Constitution of a thermal power plant

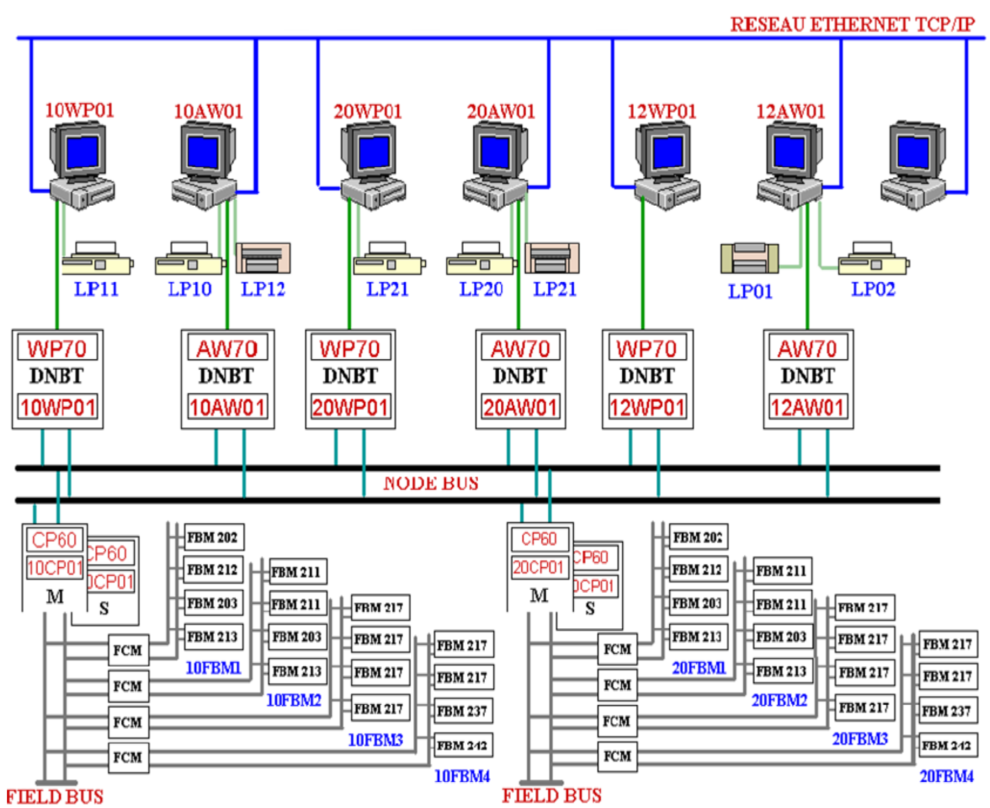

Figure 2. Architecture of a SCADA system of a TPP. Legend: I/A, Intelligent / Automation; FBM, Field bus modules; FCM, Field Bus Communication Module; AW, Application work station; WP, Work station Processor; CP60, Control Process60; DNBT, Dual Node bus.

system is composed of modules that exchange information through the communication network. There exist three levels in the SCADA system: acquisition; treatment and Men/Machine Interface.

APPLICATION OF A COUNTING SYSTEM OF NG

The different generation sources in the Tunisian electrical system are: hydroelectric, co-generation, renewable (biomass, solar and wind), NG thermal power and others including diesel, oil and coal. The decision to invest in power generation projects, especially in NG thermal power generation, involves a series of issues and challenges. In fact, the real need for thermal power capacity is determined by the combination of energy supply and demand curves.

Presentation of the natural gas of a TPP

NG is the fastest growing primary energy source in the world. It is more used than fuels and coal in the TPPs (Lochner et al., 2009; Eugenio et al., 2007 and Hamedi et al., 2009). It is more manageable and it presents dangers and a bigger explosion risks. The exploitation of the NG requires a structure of equipments, instruments and an automatic control.

One of the main features of the utilization of the NG in a TPP is constituted by the importance of volume clear soups. The research of precision in the measured volumes of gas became then as much for the supplier as for the consumer a necessity. The first interest of the precise numbering of gas is the control of invoicing. The second interest, own to the TPP, is the establishment of the complete economic control of the power plant. The third interest is to have a picture of the load produced currently and the important debits are in general measured by the volumetric counters.

The C.P.E.R is nourished in NG from the Tunisian network of distribution. In fact, the gas undergoes several operations of preparation (Figure 3) before being introduced in the steam generator, it must be filtered, rehash, relaxed and counted.

The pressure of the NG nourishing burners and lighters vary according to the rate of combustion from 1.5 to 2.2 bars, gas arrives to the C.P.E.R at a pressure understood to be between 15 and 20 bars. It is therefore necessary to loosen it in order to have a neighboring pressure of 4 bars before the regulating floodgate. A second distinct détente for each generator of steam adjusting the pressure of the order of 2 bars has the uphill of the regulating floodgate of debit of NG.

The détente of gas can induced, according to types of regulator and the conception of détente stations or noises

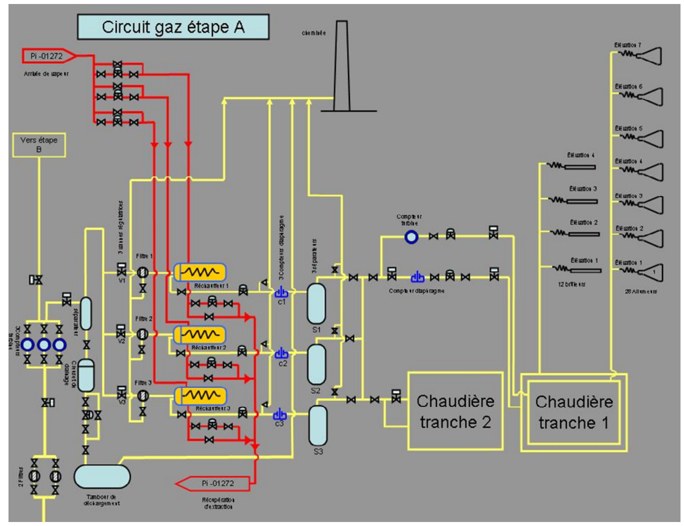

Figure 3. Display of the NG of a TPP.

that are transmitted and amplified sometimes by pipelines which can reach some inadmissible levels for the man and for the good holding of the material. In critical cases, one decreases the importance of this phenomenon while immediately choking noises in mufflers room after regulators. A regulation of the arrival of the calorific flux (fluid of heating) is necessary in order to maintain a temperature understood to be between 15 and 20°C after détente. This temperature corresponds to the one of the numbering. A separator, placed in head of the station, assures a first elimination of foulness which can be transported by the NG and generally, the separator is slim of a decantation pot. Filters assure the final operation. These filters have an important role in beginning of exploitation. Dusts and oxide of iron contents in pipelines of gas are progressively driven toward the primary détente station.

All the time, in facilities where gas circulates with fast speed, these filters remain indispensable to the fact that there is the continuous release of oxides that could damage regulators and burners.

Floodgates of security are used in facilities to multiple lines, they are placed upstream of every regulator and they serve to isolate the line of détente in case of defect. The floodgate of security is ordered by the pressure of the gas of the circuit downstream, therefore the closing of this floodgate depends solely on the order of pressure of declenchment of the floodgate and must take into consideration of the influence of losses of load and the possible state of the regulator according to the debit of NG.

Interfacing and configuration to SCADA system

The objective of the SCADA system of the C.P.E.R is to collect data instantaneously of their sites, transform in signals and numeric impulse and to send them through the network

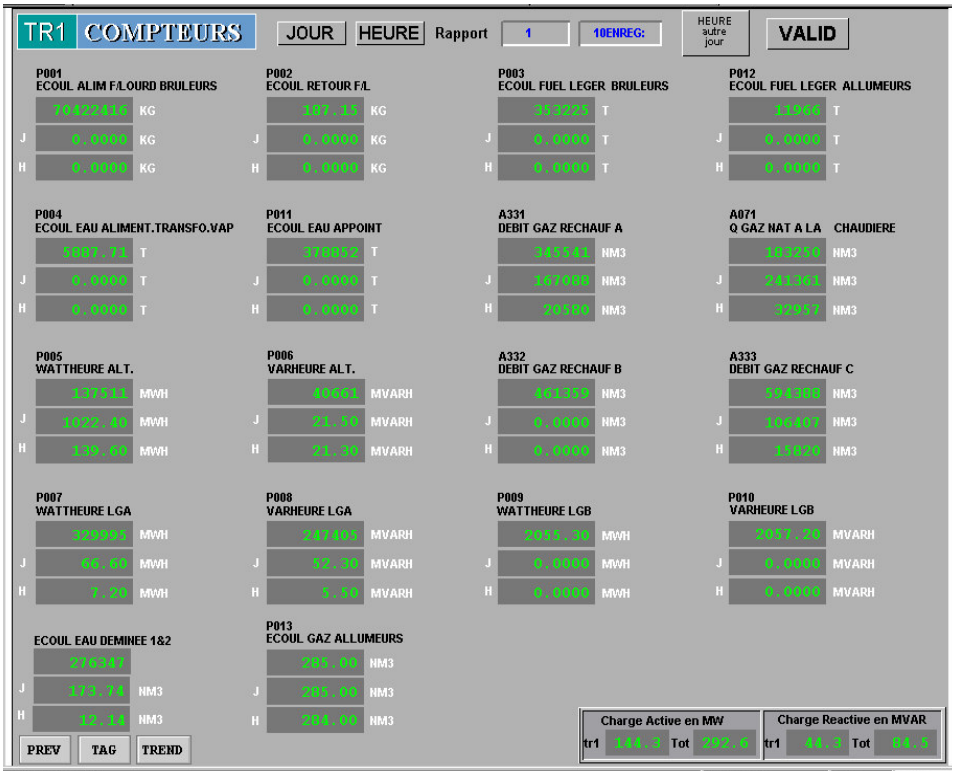

Figure 4. Creating the counter of the NG.

of communication toward the main and secondary stations. Indeed, the received data by the SCADA system only present 20% of the existing data totally.

In this part, we present the different stages of our application related to the interfacing and the configuration of the counting system of the NG to SCADA system: 1. Branching of counters gas lighter to the SCADA system; 2. Programming of the general counting of the gas lighter; 3. Configuration of a new tabular circuit of the NG containing the new information.

We chose the Input/output map, the programming and the necessary block. This operation is achieved by the algorithms standard called blocks provided by Foxboro.
The proposed solution is to make the counting of impulses by the SCADA system and to program blocks of hourly and daily numbering. These impulses are given out by the generator of meter impulses to the turbine.

The meter-turbine of gas lighters is installed 7.5 m at steam level, the distance between this one and the SCADA system is appraised to 160 m and the work of branching are done during the minor revision of the power station. After these works of branching, we programmed the different blocks of counting of the volume gas lighters; an algorithm of numbering of the volume NG has been adopted . Indeed, the block AIN permits the reading of the value of the entrance of the module FBM. The block ACCUM achieves the integration and delivers to OUT exit a quantity. The block COST permits to pilot one of the exits of the module FBM. Finally, the block MATH permits to achieve some arithmetic operations in definite chain in a program.

For the stage of configuration, we used the software ICC (Integrated Control Configuration). This software enables us to create and configure programs residing in the CP60.
For the stage of different block programming (AIN, ACCUM, etc.), we identified the label, the compound and the address of the signal.

The interfacing helps in improving the counters and to conceive a new tabular form of the circuit NG containing the new counters of gas lighters by the use of the software Fox Draw (Figure 4).

We proceeded in the following manner: creation of the meter gas lighter; test of meter working; configuration of the different alarm display; configuration of the meter overlay and the test of the meter overlay. The new tabular form is elaborated by the use of the software Fox-draw containing the new counters of the NG (Figure 5).

Conclusion

A supervisory system must take into account the physiolo-

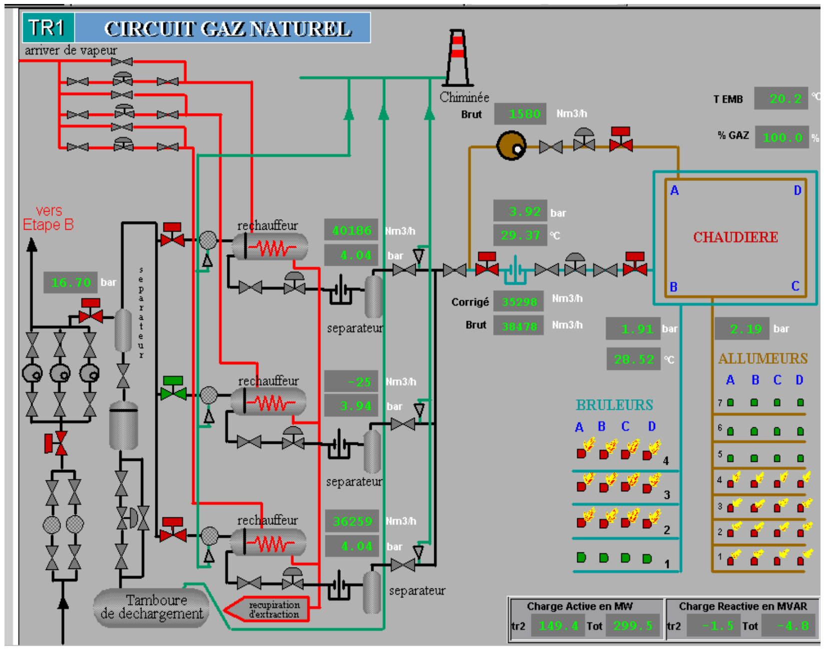

Figure 5. New tabular of the NG

gical and cognitive features of the supervisory operator because an inadequacy between the supplied information and the operator's information requirement is dangerous. So, to be more efficient, the design of a supervisory system should be human centered.

An application of supervision of a counting system of the natural gas of a thermal power plant was presented. This application permits the branching of counters of the natural gas of a thermal power plant to a SCADA system on one hand and requires the programming and the configuration of the counting system, on the other hand.

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