Surveillance of pumps vibrations using a supervisory control and data acquisition system

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Abstract: In most industrial applications implying some rotating machines, the surveillance of vibrations occupies a major role in the setting of machine surveillance. Indeed, the surveillance of vibrations normally makes while combining measures of absolute vibrations of landings or we present an application of a supervisory control and data acquisition system (SCADA) to a system of vibratory surveillance of pumps in a thermal power plant. Thus, the functionality of a supervisory system for real time processes is presented. Then we present the concepts of a SCADA system. The paper briefly discusses the different steps of this application and some advantages of SCADA systems used in thermal power plants.

Keywords: Pump vibration, surveillance, thermal power plant, SCADA.

1. 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.

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 [1-3]. So, the supervision of industrial processes includes a set of tasks aimed at controlling a process and supervising its operation.

Supervisory control and data acquisition systems (SCADA) are widely used in industry for supervisory control and data acquisition of industrial processes. The process can be industrial, infrastructure or facility [4-6].

The objective of this paper is to show interests of the use of a SCADA system for the surveillance of pumps vibrations in a thermal power plant (TPP). An example of a SCADA system of the center of production of electricity of Rades is presented. The next section briefly describes the characteristics of systems of vibration surveillance in a TPP. 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.

2. SURVEILLANCE OF PUMPS VIBRATION

Systems of vibration surveillance are often equipped of measure chains for other complementary parameters, as the axial position, the crankiness, the differential dilation, the dynamic pressure, the speed of rotation and the temperature.

Among the new systems of measures [7-9], we mention notably IDS (system of icing detection) and AGMS (system of measure of the bore between the rotor and the stator) that complete a system of vibration surveillance efficiently, but that are also usable as of the autonomous specific systems.

The MMS system (System of Machine Surveillance) is the synthesis of the long experience of Vibro-Meter in the domain of the surveillance of machines [10] and its expertise to master technologies of vanguard as for the manufacture of the electronic of surveillance.

The instrument of vibration control measures the vibration all the time when machines (turbine of power plant, big dimension compressor, pump, blower…) are in service. When the supervised vibration reached the amplitude of vibration, that is adjusted in advance, the instrument gives out an exit of point of alarm contact to give a warning to the working of the machine or gives out an instruction to stop the working of the machine, avoiding so the danger and accidents before they occur.

The mechanical vibration that is developed in a machine is controlled by a sensor of vibration and is converted in electric signal and this signal is introduced in an amplifier of vibration. In this amplifier, a signal that is proportional to the speed of vibration and supervised by an instrument of vibration control, and convert in a signal that is proportional to the displacement of the vibration, and this last is to its tower convert in a tension to continuous current, that is given back like signal to an indicator and a signal to the circuit of alarm.

The instrument of vibration measure used in our application is constituted by a sensor of vibration (Model U1-FH) and an instrument of vibration control (Model AVR-148) [11]. In fact, the sensor of vibration, model U1-F, is similar to the construction of a loudspeaker to permanent magnet. The sensor is attached to the machine on the one hand with screws and on the other hand to connect to the system of registration with the special cables.

With sensors of Vibro-Meter, we can measure in general most the critical parameters in the surveillance of machines, but particularly what concerns vibrations. In this domain, Vibro-Meter proposes a vast range of sensors, of conditioners of the signal as well as an effective signal transmission.

Sensors of proximity and other translators of displacement are based on currents of Foucault and present a high linearity with an active compensation of the temperature. Some sensors, as piezoelectric accelerometers, have favors to be deprived of the mobile pieces, what permits to guarantee their reliability and a long life span.

The piezoelectric sensor is used as detector of shock, vibration or percussion. It captures the mechanical vibrations that transmit itself in a material.

Figure 1 presents the diagram block of the system vibratory surveillance of a pump used in a TPP.

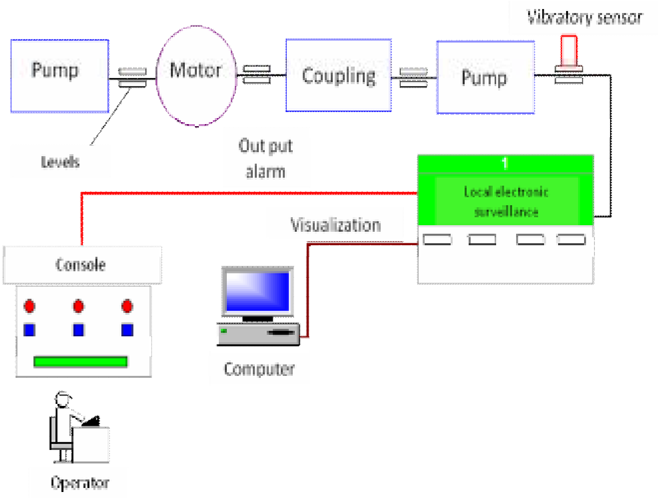

Fig.1. Block diagram of vibratory surveillance.

To achieve a complete monitor of surveillance, we always associate a module of treatment UVC 691 (Figure 2) with a module of surveillance with a high performance PLD 772 (Figure 3).

UVC 691 is a module of signal treatment assorted to different sensors and conditioners via a galvanic separation.

Most modules of Vibro-Meter provide unipolar signals in the range of 0 to 10 V DC. However, the PLD 772 can accept some bipolar signals in the range of 0 to ±10 V DC.

In fashion of programming of the PLD 772, the user has the possibility to define the calibration of the display and all parameters of alarm.

Fig.2. Module of treatment UVC 691.

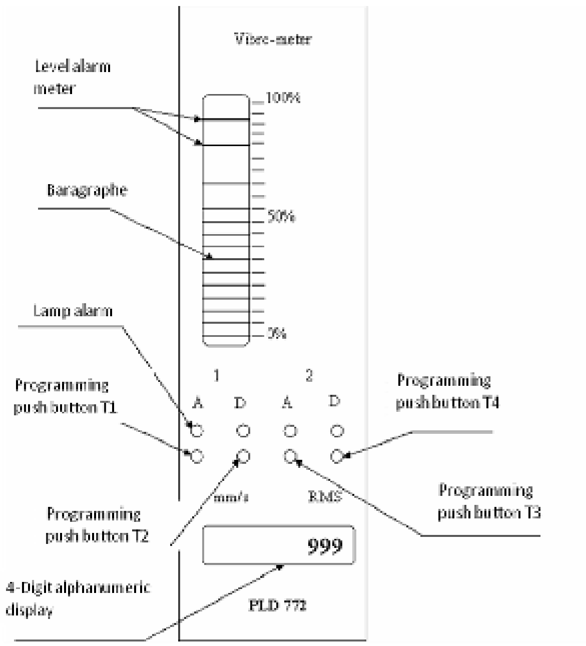

Fig.3. Module of surveillance PLD 772.

While equipping the PLD 772 of an interfacing RS-485, the module is capable to the digital communication (Figure 4). Thus, a system of surveillance can make part of a cabled network. A computer detains the main computer role. All other modules PLDS 772 in racks are some secondary stations. Such a link between a system of surveillance and a main computer is in measure to do functions of programming from afar and of data transfer.

The central computer can read the calibration of every module at all times PLD 772. Instructions of set up and a special authorization permit to modify parameters of calibration or doorsteps of alarm of every surveillance module. Commands become thus easy and the result is from afar a fully programmable surveillance system.

The computer calls each module periodically to ask it the measured values (DC signals) and the state of alarm of every channel. Such a process of acquirement suits the registration of data and the creation of a data basis very well with the acquisition in DC in order to do an analysis of tendency subsequently using software of conditional maintenance.

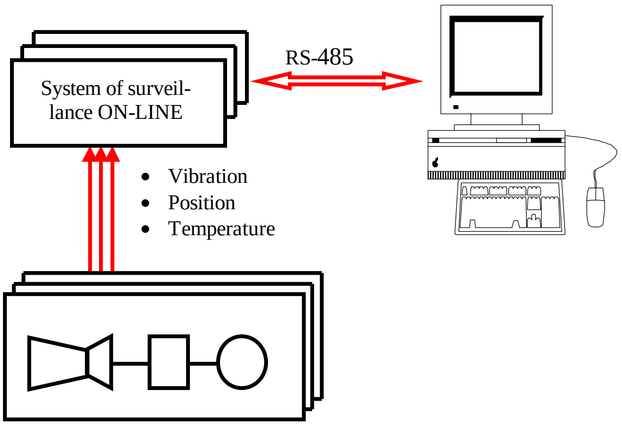

Fig.4. Transfer of data between units

3. USING A SCADA SYSTEM IN A TPP

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.

The SCADA system usually consists of the following subsystems:

- A Man-Machine Interface (MMI) is the apparatus which presents process data to a human operator, and through this, the human operator, monitors and controls the process.
- A supervisory system, acquiring data on the process and sending commands to the process.
- Remote Terminal Units (RTUs) connecting to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory system.
- 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. For example, a PLC may control the flow of cooling water through 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 [12-13].

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. The SCADA automation system always includes several functions, e.g., signal sensing, control, human machine interface, management, and networking.

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 and distribution and gas distribution. The monopoly of the power generation has been abolished, and the first IPP is a reality. The transmissio^{2}n and distribution losses of the Tunisian electricity grid are about 12% of the power generated [14].

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 to the S.T.E.G to answer to the country evolution demand under the best conditions of continuity and security [15].

Among the units of electricity production of the S.T.E.G, the center of production of electricity of Rades (near to Tunis) 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, 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 [16-19].

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 the type of 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 use of higher temperature, and therefore higher pressure, steam.

This overheated steam drags the HP rotor (high pressure) of the turbine in rotation and relaxes to the exit of the HP body of the turbine, so it comes back again in the furnace to be until 540° after, it will be sent back to the MP body (average pressure) then to the BP body (bass pressure) of the turbine.

During these steps, the calorific energy is transformed in available mechanical energy on the turbine. Thus, this mechanical energy will be transmitted to the alternator, being a generator of alternating current, in the goal to produce the electric energy.

After the condensation, water will be transmitted thanks to pumps of extraction in the station of BP to be warmed progressively before being sent back to the furnace through the intermediary of the food pumps.

This warms progressive of water has for goal to increase the output of the furnace and to avoid all thermal constraints on its partitions. And this station of water is composed of a certain number of intersections that is nourished in steam of the three bodies of the turbine. Finally, the cycle reproduces indefinitely since steam and water circulate in a closed circuit (Figure 5).

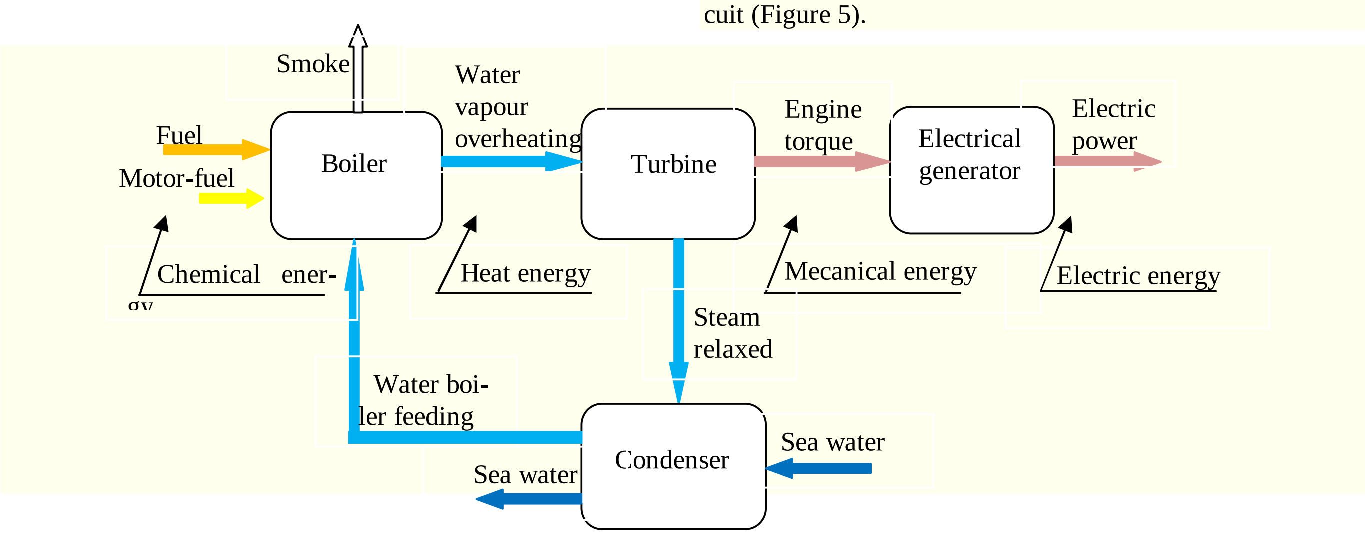

Fig.5. Functionality of a thermal power plant.

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.

An example of a SCADA system of a TPP is presented (Figure 6). The stations belong to a superior network Ethernet (10 Mb/s). Principally, this network enables to exchange files between the stations. It enables to avoid the overload of the Node bus network. In fact, the SCADA system is composed by modules that exchange information thanks to the communication network [20]. It exist three levels in the SCADA system: acquisition; treatment and Men/Machine Interface.

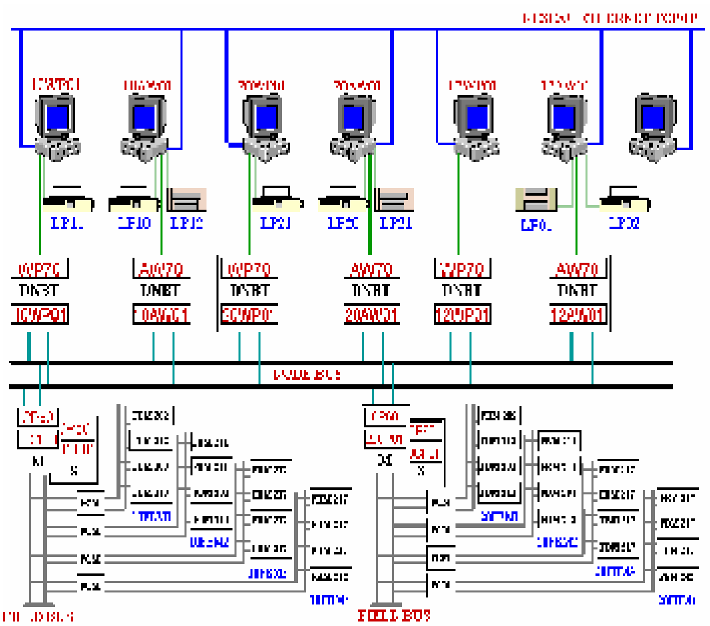

Fig.6. Architecture of a SCADA system.

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.

4. CONCEPTION OF DISPLAYS FOR THE PUMPING PROCESS

FoxDraw is a graphical configurator used to build I/A Series process graphics to be displayed via FoxView software. It allows creating and maintaining dynamically updating process displays. Displays can represent the plant, a process area, or a detailed portion of the process.

FoxDraw provides numerous time and effort saving features to make building, configuring, and maintaining displays easy. Included with FoxDraw is a large library of graphical components ready to be included and configured in displays.

FoxDraw includes over 1200 prebuilt objects such as pumps, tanks, pipes, motors, valves, and ISA symbols. Standard libraries include vast selections of simple and complex objects with which to build displays.

We have built many displays with FoxDraw that are used by FoxView, and become the I/A Series interface to the pumping process of the TPP (Figure 7).

Monitoring display and diagnosis display are important for the supervisory system. A global view of the system should appear the information needed for the pumping process.

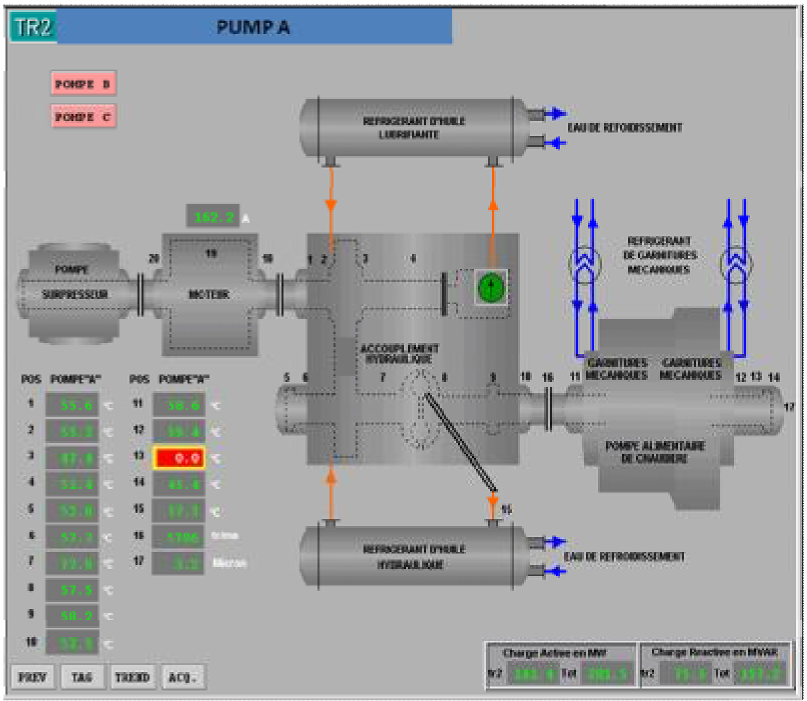

Fig.7. Display of the pump A of the TPP.

5. CONCLUSION

In this paper, an application of supervision of a system of vibratory surveillance in a thermal power plant was presented. This application enables us the creating and the maintaining dynamically updating the pumping process displays.

The supervisory system must take into account the physiological 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. However, the paper discusses the need to monitor the process and possibly control the operation of a thermal power plant from virtually anywhere.

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