MODULAR, INTELLIGENT AND DISTRIBUTED SYSTEM TO CONTROL WATER TREATMENT PLANTS

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Abstract

There are many examples of small villages which are provided with quality problems in the potable water supply. The treatments to resolve the above mentioned problems are hard tied to the types of pollutants in the water. This demands the development of custom-made facilities with a maintenance that needs specialised labour. Both things mean an increase of the facilities cost. The consequences of this are that either these works are not carried out, or that its maintenance is neglected.

In view to resolve these problems the IEA Research Group of the University of Seville takes several years developing water treatment systems especially designed for small urban populations.

To do this, a modular control system has been developed that allows high adaptation flexibility to the specific needs of each population, without raising the deployment cost. It offers a robust design, guaranteeing that it will run even in isolated rural environments, where the appearance of electrical perturbations is usual. All this, along with an intelligent management, allows an autonomous working without needing to do any preventive maintenance.

Keywords: distributed control system, fieldbus, water treatment.

Introduction

The water treatment plants present important differences depending on the quality and destination of the water to be treated. On the one hand, there are a few big facilities, accompanied by important civil works realized by construction companies for big populations. On the other hand, there are a lot of facilities with a significantly low production, made by multitude of PYMES, assigned to small and medium populations.

In the latter sector, the water treatment plants are of handmade conception, with custom-made models designed for the needs of each client. They have a high individual cost, both of manufacture and of maintenance. They also have difficulties in the post-sale service, due to the wide range of spare parts and multiple displacements to do every repair.

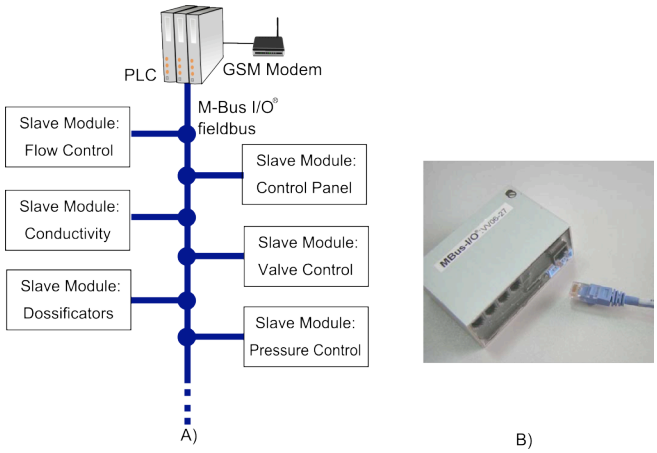

Figure 1: Control System A) Fieldbus B) Examplo of module

Control System

To face these problems, based on the experience accumulated in the IEA Research Group in topics of automation, a control distributed system has been developed especially designed for water treatment plants (Menendez et al, 2004).

This distributed control is based on a master element (PLC) which communicates by means of a bus with various slave modules, each of which is associated with specific tasks of the process (see figure 1). These distributed electronic modules do not limit themselves to expand the inputs and outputs of the main element; they also are in charge of the local control of the part of the process with which they are associated, so that the element of top hierarchy is only entrusted with coordinating the global functioning of each of the processes. This philosophy of modular control allows the design of an economic and flexible treatment plant, adapting to the concrete needs of each installation. The advantages of this distributed system allow every control module to be located close to where the associate process is. This way the typical costs of the wiring can be minimized up to 85 % in the centralized control systems.

Although the advantages of the distributed control are well-known (Thomesse, 2005), an originality of our design lies in the use of a new fieldbus (Menendez et al, in Press) called MBus-I/O®. An outstanding feature of this fieldbus is its aptitude to power the modules across its own bus cable with 24Vdc and 24Vac. This feature allows a reduction in the cost, because it doesn't need any additional wiring for this purpose. This is not usually found in other standard fieldbuses and in any case power capacities are typically limited to small consumptions (MODBUS, 2005; Kleines et al, 2008) due to problems of EMI. As a solution to this, the MBus-I/O® presents a structure with multiple ground wires with specific functions that increase significantly the robustness of the system. All this is obtained using a simple UTP cable, a standard cable with 4 braided pairs, even ten times more economic than the one recommended by other power fieldbuses.

The electronic slave modules realize specific tasks like the valve position control, dosage control, flow measurements, human-machine interaction (HMI), etc... These modules have an architecture based on a powerful microcontroller that facilitates the implementation of intelligent local control functions (Menendez et al, 2001), even with capabilities of auto-detection of anomalies. This allows the costs to be minimized compared to the use of commercial devices (Menendez et al, 2001). This joined to a system of rapid connection, makes these modules very easy to install or to substitute in case of breakdown, without specialised labour being necessary.

The whole control system, including sensors and actuators, has been designed by criteria of minimal consumption (Barbancho et al, 2001) in order to increase the flexibility and hardiness of the system.

In addition to the whole structure of local control of the plant, the PLC is in charge of managing the communication with a remote control center (see figure 2). This remote supervision can be done with a GSM/GPRS connection by means of an SCADA application that allows to know the state of the plant, as well as to detect any functioning anomaly. As well, it has been programmed with a SMS mobile courier service, which informs the person in charge of the plant instantaneously when detecting an anomaly, facilitating an effective and economic maintenance (Menendez et al, 2007).

Results and Discussion

The technology commented previously has been successfully used for the development of several industrial water desalination plants prototypes with capacities from 10 up to 400 m^3/day. The last ones developed, with registered trademark CIBERDESAL® (Menendez, 2006), are being used by the *Junta de Andalucia* to resolve the problems of quality of the drinkable water that have some small populations of Andalusia due to the presence of salt and nitrates in the wells that supply them. These water plants contribute fundamental innovations with regard to the conventional desalination plants, on having been especially designed (for his functioning capacity and facility of maintenance) to integrate into small and medium-sized populations, minimizing the costs and the impact of these structures.

These plants have worked in an uninterrupted and autonomous way since their installation in a noisy environment, despite the shortcomings in the electrical supply, including atmospheric discharges, as to the own conductivity of the water that facilitates the transmission of the perturbations on the diverse inputs / outputs of the system. The use of the new MBus-I/O® has been a key element to achieve that the plant works completely unattended with a maximum immunity to electrical perturbations, as we could have verified

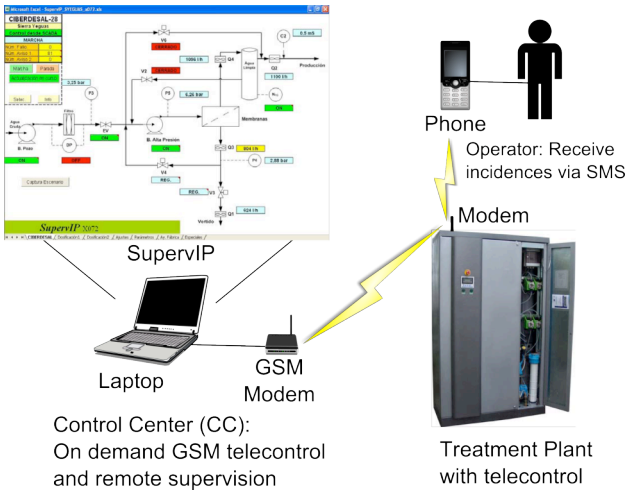

Figure 2: Remote Control

by means of electromagnetic compatibility essays (Musolino & Fiori, 2008) according to IEC 61000-4-4 rule. All this has demonstrated that the proposed system is not only economic to install and support, but also it turns out to be very robust, being therefore a suitable solution to answer the needs of small populations.

Conclusions

In this work, a system of modular, intelligent and distributed control has been proposed that allows a high grade of flexibility, with both low installation and maintenance costs. Also, its capacity of auto-detection of anomalies, along with the remote control system capable of warning a worker automatically by SMS, means that the proposed solution turns out to be especially indicated to resolve the problems of water treatment that are endured in numerous small villages with difficult access.

In spite of its economy, the system has proved to be very robust, operating in an autonomous way even in facilities with a high level of electromagnetic perturbations. This feature is fundamental so that the automated plants could operate completely unattended.

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