AUTOMATION OPTIMIZATION OF A CASCADE UTILIZATION SYSTEM USING GEOTHERMAL WATER WITH MODERATE TEMPERATURE

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Abstract
Lucrarea propune dezvoltarea și evaluarea unui sistem de monitorizare și control la distanță pentru instalațiile de colectare a prafului de cereale, utilizând un smartphone ca interfață principală de operare. Sistemul proiectat integrează senzori pentru măsurarea parametrilor relevanți ai procesului, un controler programabil pentru achiziția și prelucrarea datelor, un modul de comunicație pentru transmiterea informațiilor și o aplicație mobilă destinată supravegherii și comenzii de la distanță. Soluția urmărește creșterea gradului de automatizare, reducerea timpului de intervenție la apariția unor defecțiuni și îmbunătățirea eficienței operaționale..

Keywords: Controller, Automatic system, Sensor, Technological installation, Cyclon

INTRODUCTION

The grain industry involves a number of technological processes such as receiving, transporting, cleaning, drying, storing and processing grains. In all these stages, significant amounts of fine powders are generated, resulting from mechanical friction, partial breakage of the grains and handling of the granular material. This dust, especially cereal dust, creates technological, sanitary and industrial safety problems. Its accumulation in production spaces affects air quality, accelerates equipment wear and tear, and can lead to explosive atmospheres. (Angel Vidal, et al, 2010, Bennet S, 1994, Raul Garduno-Ramirez, et al, 2005)

To limit these effects, dust collection systems are integrated into the technological flow in the form of suction and filtration systems, generally consisting of fans, ducts, filters, separators, flaps and automation elements. The performance of such installations depends on the correct functioning of each component, the condition of the filters and the maintenance of process parameters within design limits. In practice, many small and medium-sized establishments still use traditional surveillance methods based on regular local checks, which can delay the identification of defects and the intervention of operators. (Crispin Allen, 1990, Curtis D.J.,1988, Iancu Carmen, 2010)

The development of communication technologies, smart mobile devices and applications specific to the industrial environment has created the premises for the implementation of accessible and efficient remote monitoring solutions. The smartphone has become a relevant tool not only for communication, but also for visualizing process data, receiving alarms and transmitting commands to automated systems. Its integration into a control infrastructure offers important advantages: quick access to information, high mobility of personnel, reduction of dependence on local panels and the possibility of operational intervention. (F. S. Blaga, 2009, H. Silaghi, et al, 2009, Z. T. Nagy, et al, 2005)

In the context of the modernization of processes in the grain industry, the monitoring and control of dust collection facilities is an essential component for increasing safety, energy efficiency and environmental protection in the workplace.

The development of an intelligent, smartphone-based remote monitoring and control system provides the possibility of real-time monitoring of the plant's operating parameters, such as air flow, filter status, dust charge level and energy consumption. Through mobile applications, the operator can quickly intervene in the process, receive alerts in case of malfunctions and optimize the operation of the equipment without being physically present at the installation site. (Danfoss, 1986, G. Ionescu, 1983, Ilhan Kocaarslan, 2006)

The concept of the system is as follows: it is composed of a system of processes and equipment that run programs. Together they form an entity, and the main characteristic of the system is the organization and structure of their elements.

The structure of the system is, in fact, a stable way of organizing the interconnected elements, based on the way they interact and their compatibility problems. (Martin C et al, 2006; K. Leiviskä et al., 2005; H. Silaghi. et al., 2009)

The entire system is perfectly reflected in the way it interacts with the external environment.

If we take into account any phenomenon or object on the material or data plane, we can identify a system, as well as its characteristic structure. Thus, we can consider any device a separate technological system.

All interactions between the environment and the system and vice versa that occur through the separation surface represent the output, input and disturbances. (Astrom, 2002, Borangiu Th, et al, 1986, C. Popescu, et al, 2001, Crispin Allen, 1990)

An automatic system is considered a combination of two distinct systems. These two systems are, in fact:

technological installation (I);

automation device (A); He is the one who establishes the law or the algorithm for conducting the process. (Martin C et al., 2006; K. Leiviskä et al., 2005; H. Silaghi. et al., 2009)

The sizes that occur within a closed automatic system are according to Figure 1:

r – the reference size or program prescribed to the system;

u – the size of the command or management of the process;

y – the adjusted or output size;

yr – the principal reaction quantity;

pi – disruptive quantities

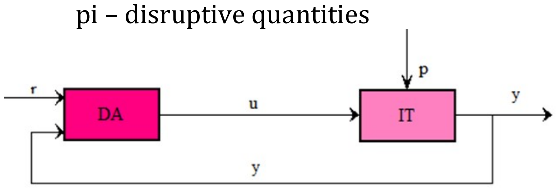

Figure 1. Automatic closed system

An important aspect of closed-loop systems is the presence of the backlink or main reaction between the automation device and the automated process. This reaction is very important, even essential, because it informs the automation device about the value of the output size y. (Astrom, 2002, Borangiu Th, et al, 1986, C.Popescu, et al, 2001, Crispin Allen, 1990)

Automation Device

The automation device is composed according to Figure 3.2 of an EP prescription element that helps to fix the program of the automatic system; at the same time, we have a comparison element C that compares the working program the reference r(t)) with the output size obtained through the transducer Tr; EA amplification element; the EE execution element and the EC correction element, which are the ones that ensure the proper functioning of the entire system. The technological installation (IT) is subject to disturbances pi. These can be defined by the resistant torque or by the variations in the parameters of the motor agent and the action of the execution size m, which ensures the change in the flow rate of the working agent introduced into the motor. (Martin C et al, 2006; K. Leiviskä et al., 2005; H. Silaghi. et al., 2009)

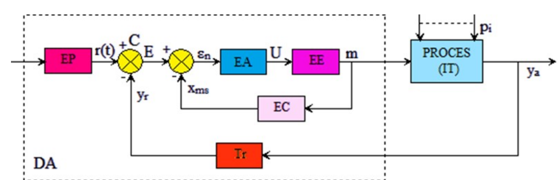

Figure 2. the technological installation presented as a subsystem

MATERIAL AND METHOD

For the realization of the proposed system, hardware and software components specific to industrial automation and mobile communications were used. The experimental structure included a grain dust collection plant consisting of a suction fan, filter with textile elements, air-dust transport ducts, control flaps and electrical control panel. In order to monitor the process, sensors were integrated to measure the differential pressure at the level of the filter, the temperature of the fan motor, the operating status of the fan and the estimated degree of clogging of the filter element.

The central control unit was represented by a programmable controller or an industrial microcontroller, chosen for the ability to pick up analog and digital signals, process data and communicate with an external interface. For connectivity, a wireless communication module was used, compatible with Wi-Fi or GSM/4G networks, depending on the infrastructure available at the installation site. The user interface has been implemented in the form of a mobile application installed on the smartphone, which allows you to display the main parameters, receive notifications and send commands to start, stop or reset alarms.

From a software point of view, the system included a level of local data acquisition and processing, a secure transmission protocol and a graphical interface for the mobile device. The operating logic has been designed in such a way as to ensure the periodic updating of the measured values, their comparison with the safety thresholds and the generation of alarms in case of exceeding the allowed limits.

In this study, a dust collection plant specific to grain processing was used, consisting of the main components such as a separation cyclone, a bag filter, a centrifugal fan and air-dust transport ducts. For the monitoring and control of the operating parameters, the following components were used:

Differential pressure sensors, for assessing the degree of clogging of the filter;

Airflow sensors, for determining the efficiency of air circulation within the system;

Dust particle sensors, for monitoring the concentration of particles;

Control unit (microcontroller or PLC), responsible for data acquisition and processing;

Wireless communication modules (Wi-Fi/Bluetooth), for transmitting data to mobile devices;

Smartphone, used as an interface for monitoring and control through a dedicated application.

For the development of the mobile application, specific software platforms were used, allowing the visualization of data in real time, the transmission of commands and the generation of notifications.

In order to carry out the remote control of a cyclone used in the preliminary disinfection of raw grains or oilseeds, we used modern controllers implemented numerically with the block diagram shown in Figure 3, sensors and a smartphone.

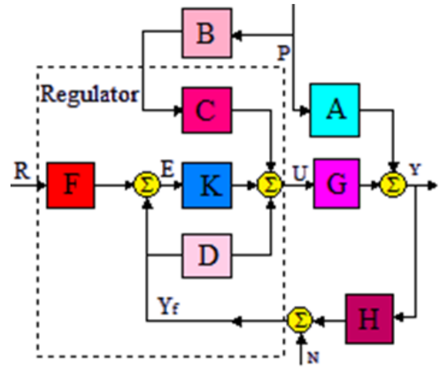

Figure 3. Loop with digital PID controller with two degrees of freedom

The controller used consists of a comparator and a compensator (k). The g-block of the element path shapes the automated process. The transducer is block h.

This form of algorithm, called the PID algorithm, is linear in parameters. In this case, the proportional action (amplification), the integral action (automatic restoration) and the derivative action are clearly highlighted.

The actual algorithm used by the controller to run the process, however, is different because the corresponding derivative action term, which appears as one of the results of the pid compensator, is not physically achievable, and for this reason we choose the approximation.

DEVELOPMENT OF A SMARTPHONE APPLICATION

For the development of the mobile application, specific software platforms were used, enabling real-time data visualization, command transmission, and notification generation.

CiclON is an application that interfaces with the computer system located in the cyclone control room, allowing remote control of the installation.

Application usage: the "**search**" button scans the surroundings to identify compatible devices for pairing. Once paired, the cyclone is added to the list of available connections.

The "**connections**" button opens the page where all paired devices are stored. Once saved, the cyclone can be accessed and controlled at any time.

The "**settings**" button manages the basic configuration of the application, including notification modes when a process is completed and the volume of the associated alarm.

The research methodology consisted of the design, implementation, and testing of a remote monitoring and control system, carried out in several stages:

1. Technological process analysis

The main components of the dust collection installation and the relevant monitoring parameters were identified in order to optimize the system's operation.

2. Design of the monitoring and control system

The functional scheme of the system was developed, including the integration of sensors, the control unit, and the communication module.

3. Hardware and software system implementation

The sensors were connected to the control unit, and the data transmission to the mobile application was configured. The application was developed to enable real-time parameter visualization and command transmission to the system.

4. System testing and validation

The system was tested under real or simulated conditions, focusing on:

Measurement accuracy,

Data transmission stability,

Command response time,

Alert system functionality.

5. Results analysis

The obtained data were analyzed to evaluate the efficiency of the proposed system and its impact on optimizing the dust collection process.

In the experiments, the following criteria were monitored: the time to update the data in the application, the time to transmit alarms, the accuracy of the displayed values compared to the local measurement, the execution time of the commands and the general stability of the system in continuous operation. The data collected were comparatively analyzed to highlight the degree to which the proposed solution meets the requirements of safety and efficient operation.

Simulation tests included cases such as artificially increasing the differential pressure, heating the engine above a predetermined threshold, and interrupting communication.

The implementation of the prototype demonstrated the technical feasibility of using a smartphone as a monitoring and control interface for grain dust collection plants.

The next figure shows the interface of the developed mobile application.

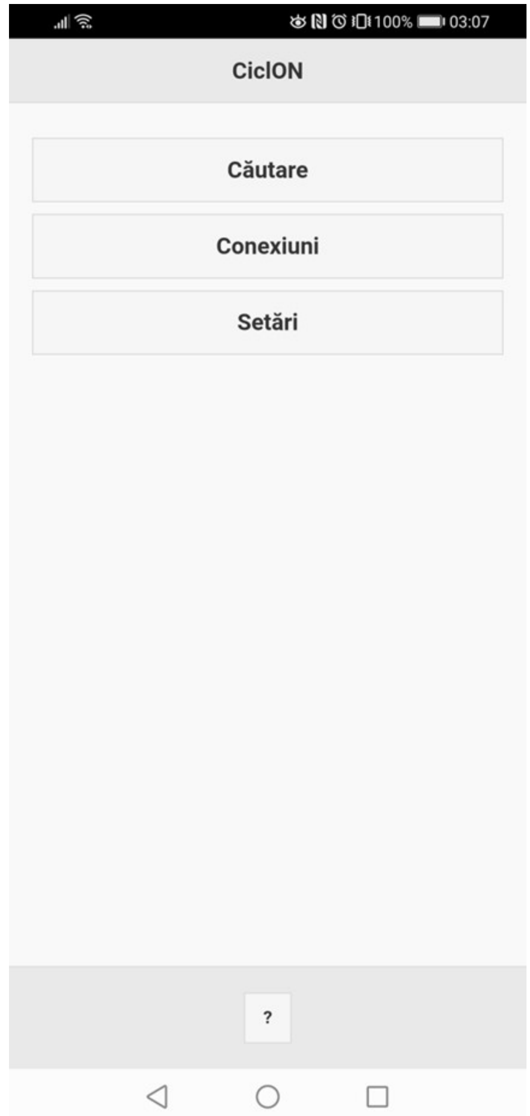

Figure 4. The Interface of The Developed Mobile Application

RESULTS AND DISCUSSIONS

The implementation of the prototype demonstrated the technical feasibility of using a smartphone as a monitoring and control interface for grain dust collection plants. The system was able to constantly acquire and transmit the values of the main parameters, giving the user a clear picture of the status of the installation. The monitored parameters could be visualized in real time, and the mobile interface allowed the rapid identification of deviations from the normal operating regime.

During the tests, the differential pressure at the filter level proved to be one of the most relevant indicators for assessing the degree of dust charge of the filter system. The increase in this parameter above the set limit was promptly detected by the system, and the user received an alarm notification on the smartphone. This result is important because in real operation, clogging the filters leads to a decrease in suction efficiency, an increase in energy consumption and additional strain on the fan.

Engine temperature monitoring highlighted the system's ability to signal potentially dangerous conditions before a breakdown occurred. In test scenarios where the temperature exceeded the safety threshold, the app generated warnings and the system allowed the fan to be turned off remotely. This function is particularly useful in situations where operating personnel are not in close proximity to the plant and a quick reaction is required to prevent damage to the equipment.

Another relevant result was related to the reduction of the operator's reaction time. In the classic operating version, identifying a problem involves going to the switchboard, local verification and manual interpretation of the condition of the installation. Through the proposed solution, critical information is available directly on the mobile device, which allows for remote preliminary diagnosis and better targeted intervention. From an operational point of view, this can help reduce unplanned downtime and streamline maintenance activities.

In terms of remote control, the system responded appropriately to start, stop and reset commands, provided a stable connection was maintained. However, tests have shown that overall performance largely depends on the quality of the communication network. In the event of a weak or unstable connection, delays may occur in updating data or transmitting commands. This highlights the fact that the solution must be integrated into a reliable and secure communications infrastructure in order to be used in real industrial operation.

From a safety point of view, remote control should be approached with caution. The possibility of ordering via smartphone brings obvious advantages, but it also requires additional measures regarding user authentication, encryption of communication and the clear definition of access rights. In the absence of these measures, there is a risk of unauthorized access or erroneous orders. Therefore, the development of such a system should not be limited to functionality, but should also include cybersecurity requirements adapted to the industrial environment.

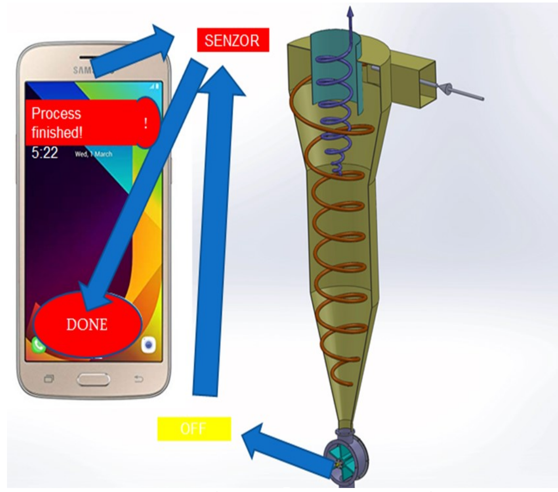

Figure 5. Remote Cyclone Driving via Smart Phone

The results obtained indicate that the proposed system can be an effective solution for the modernization of grain dust collection facilities. Compared to conventional surveillance methods, it offers a higher level of information accessibility, faster reaction to events, and support for predictive maintenance. However, for large-scale deployment, extensive tests are required in real industrial mode, over longer periods of time and under various operating conditions.

CONCLUSIONS

The paper highlighted the importance of efficient monitoring and control of grain dust collection facilities, in the context of current requirements for industrial safety, process continuity and digitalization of exploitation. The use of a smartphone-based system has proven to be a viable direction to improve the surveillance of technological parameters and to facilitate rapid interventions in case of abnormal operating situations.

The developed system has demonstrated that it can successfully integrate data acquisition, remote transmission, alarm generation and operational control functions via a mobile application. The monitored parameters, such as differential pressure and engine temperature, proved relevant for assessing the condition of the plant and for anticipating defects or hazardous conditions. Consequently, the proposed solution contributes both to increasing operational safety and to optimizing maintenance activities.

An important advantage of the system lies in the mobility offered to the operator and fast access to data, regardless of the positioning in relation to the installation. This leads to a reduction in reaction time and a better organization of technical interventions. At the same time, the research highlighted the fact that the performance and reliability of the solution depend on the quality of the communication infrastructure and the implementation of adequate IT security mechanisms.

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