CONTROL AND SUPERVISION FOR AN INDUSTRIAL GRAIN DRYER

Clemente Cárdenas, Eduardo J. Moya, David García and Oscar Calvo
Fundación CARTIF, Parque Tecnológico de Boecillo. Parcela 205. 47151 Boecillo, Valladolid, Spain

Keywords: Supervision, Control, Industrial Process, PLC, SCADA, Profibus, PID.

Abstract: Automation and control of processes in a food industry is a very important aim. The main reasons are: guaranteeing a better quality of the final product, reducing cost time and improving the use of the raw materials. Specifically, drying and storage grain industries have plants which, in many cases, are out of phase. Besides, they are controlled by machine operators. Our work has consisted in developing a total and supervision automated system to control most of the processes. A first step has been to automate four cereal dryers in order to collect data. Subsequently, a control has been designed to get a constant value of moisture of the grain. At the same time, these data have been used to obtain a total traceability of the process.

1 INTRODUCTION

In most cereal drying industries it is very important to store the final product in optimal conditions along time in order to achieve a good preservation.
Combination of several measures is necessary:

- Grain cleaning and sorting, avoiding any undesired product or seed.
- Drying until a moisture level is reached, to guarantee the correct preservation.
- Storing temperature Control during all the time that the product remains in the facilities.

In general, once recollected, grains don't have a suitable degree of humidity and temperature to be stored in silos for a long period of time. That is why it is necessary to increase the temperature in order to reduce humidity, making the drying a process of great relevance. Therefore, supervision and automation offer the operator the necessary tools to control the drying process accurately, using historical and real-time process performance information.

Improving control enhances consistency and saves energy by ensuring key process variables are more stable. Processes may also be operated closer to optimum values or constraints.

Process automation is not innovative, but if supervision and control solutions are customized, as in this case, we can deduce, then, that we are innovating.

In the following sections we describe an example of control of such processes.

2 DRYING AND STORAGE PROCESSES

Basically, the cereal drying process consists in passing a hot air current through the product, in order to reduce the moisture inside the grain.
There are several factors to take into account from the point of view of the process and also from that of the product:

- The product can have different humidity percentages.
- Moisture reduction depends on each type of grain.
- Each product has a temperature upper limit and a humidity lower limit to consider .
- The goal is to achieve a maximum performance in Tons/hour, as well as a minimum energetic consumption.

A horizontal grain dryer consists of a perforated metal sheet connected to a source of heated forced air supplied by a diesel or gas burner. The grain conduit has upper and lower ends to receive and discharge, respectively, a quantity of grain to be dried by heat conveyed to the grain through the perforated sheet. Rollers with an agitator keep grain moving downward into the dryer. It is also necessary

Cárdenas C., Moya E., García D. and Calvo O. (2009).
CONTROL AND SUPERVISION FOR AN INDUSTRIAL GRAIN DRYER.
In *Proceedings of the 6th International Conference on Informatics in Control, Automation and Robotics - Robotics and Automation*, pages 405-408
DOI: 10.5220/0002192904050408

that several extractors ease the ejection of humid air out of dryer.

The inside of a horizontal dryer and a detail of the rollers are showed in figure 1.

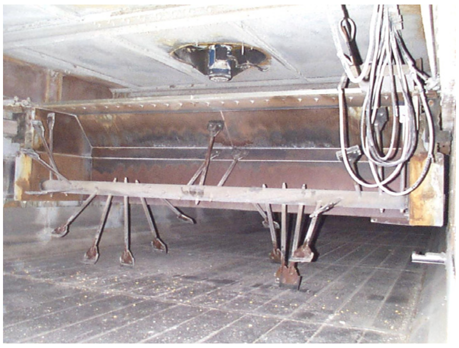

Figure 1: A typical horizontal dryer.

Before the final storage into silos, the grain is cooled.

Periodically, once the product is stored, it is advisable to control the grain temperature to avoid a lost of quality or possible explosions due to high temperatures. Implantation of a temperature and humidity control and supervision system in silos, guarantee a quality for the final customer. When the temperature rises above a reference signal, fans are switched on to introduce cool air. At the same time, the warm air is put out of the silos by means of extractors. More details of these processes are showed in (de Dios, 1996).

3 SUPERVISION, AUTOMATION AND CONTROL PROCESSES

It is necessary to integrate inside processes with many interacting elements, automation and control systems. Next, each of these systems will be explained.

3.1 Automation of the Process

Automation operation is a first step to control and supervise any process. It is used to carry out sequential motors start and stop, processes stop due to failures, motor speed control or temporisation actions. Automation architecture consists of:

- A first PLC´s to control four dryers and a second PLC to control silos fans.
- Two PC to install Silos and Dryers SCADA systems.
- Two Grain moisture measuring instruments.
- A PC-PLC PROFIBUS Communication Card.

The PLC is connected with decentralized periphery devices using PROFIBUS DP. This has been possible by letting one unique PLC control four dryers. The moisture equipment is connected to the Dryer SCADA PC through a serial RS-232C port. In figure 2 an automation scheme is depicted.

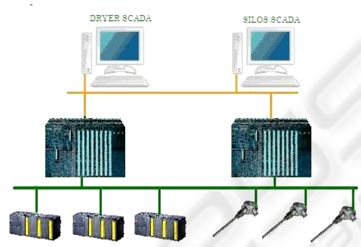

Figure 2: Automation scheme for silos and dryers control.

Each silo contains twenty four temperature sensors located in six levels and one outside the silo. There are also two humidity sensors (one inside and one outside). These sensors are connected to a ADC through four channels, which are connected to the Silos SCADA PC . (see figure 4 for a detailed view).

3.2 Supervision

One of the most important tasks has been the design of the supervision system. Instead of acquiring a commercial SCADA, a supervision programs have been developed with the Visual C++ tools.

According to the type of product, the supervision system makes it possible to change some parameters in order to control the drying conditions. It is possible to activate the number of extractors, to time the grain feeder, to change the discharge time, even to switch on a second flame in the burner.

In the stored grain process a complex supervision and control system has been developed. Not only can we supervise the temperature of each silo to six levels, but we can control the temperature based in different choices. For example, depending on the external air humidity and temperature, a time period or a temperatures difference can activate extractors and fans.

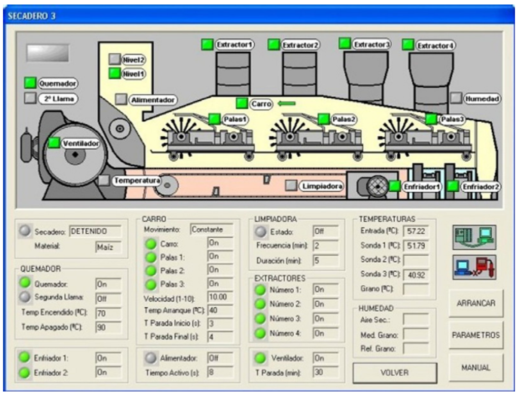

Figure 3: A window of dryers SCADA application.

In every reading, the control compares the actual values with the ones defined by user. If for instance the actual temperature is higher that the limit set , the system turns on the aerations system. Once the temperature below that set point the PLC shuts off the aeration system. Examples of such controls are showed in (Silva, 2003) and (Srzednicki, 2005).
A larger and more complex system totally controllable and observable through the internet, by user our SCADA Web (Janeiro, 2006) is being developed.

The parameters of both supervision systems can be changed from a window as depicted in Figure 3 and figure 4 .

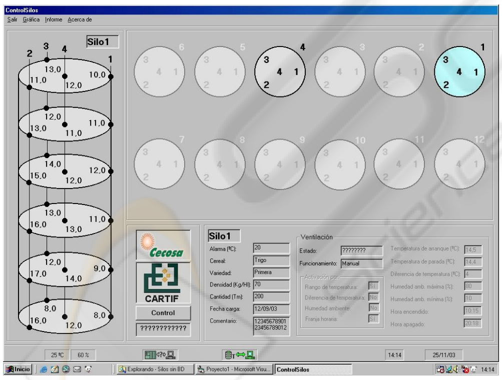

Figure 4: Temperature Silos SCADA application.

The prime emphasis in these processes has been on improving the security of existing machines. Due to different controls implemented it is possible to generate a important number of alarms. The most important one is the temperature control, used to avoid possible fires inside of the dryers.

The communication between all equipments; computers, humidity measuring instruments and PLCs, is continuously being checked.
All these alarms and other parameters are registered in a database, to be analysed in order to verify the stored and drying conditions, and improve the processes.

Figure 5: Alarms registration.

3.3 Moisture Control System

Most development work has centered on the optimization of machine design and capacity, and the application of these machines to existing processing strategies. The result has been the development of more compact dryers in recent years. The manner in which processing itself is carried out, must be considered. There are works related to to the engineering aspects of the process, but researchs carried out on dryers control are not quite extensive. Recent studies are based on the use control techniques principally PID (Guofang, 2006),predictived (Qiang, 2001) and fuzzy control, (Zhang and Litchfiled, 1993),(Bremmer, 1997) and (Chunyu et al., 2007).

Control techniques principally consist of a computer program and a number of sensors measuring process properties. It is also necessary to have some forms of SCADA/PLC systems.

The goal is to design a feedback controller for the plant shown by the block diagram in figure 6, which includes the feedback interconnection of the plant and controller, and elements associated with the performance objectives.

The moisture error of the discharged grains was used as input parameter of the controller. The output parameter of the controller was the speed of the rolls.

Continuous-flow grain drying is a non-linear process with a long delay; it is often subjected to large disturbances and therefore is difficult to control. The ON/OFF and PID designed controllers have been an adequate control method in this type of machines.

The grain humidity has to be controlled by changing the temperature inside the dryers.

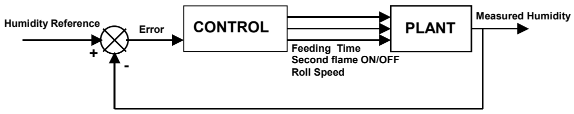

Figure 6: A dryer control diagram.

It has been verified that it is more effective to switch the two flames of the burner than modifying the speed of the rolls. The combination of an ON/OFF control of burner with a PID control actuating in roll speed makes it possible to achieve an optimal control of humidity grain in these dryers.

In spite of this good behaviour of this type of controls, we are developing robust control due to long delays and disturbances in some cases. A work of an implemented robust control in a similar process can be viewed in (Cárdenas, 2003).

Simulations test show that the robust controller performed well over a wide range of drying conditions.

4 CONCLUSIONS

Process automation and supervision seem to promise significant potential for development in the future.

The efficency of dryers has been increased significantly. This has been achieved by making them larger, more space efficient and by increasing control and supervision systems. The incorporation of these controls has also made itpossible to reduce the grain humidity before it is stored into silos. In addition, data collection and analysis, as well as product traceability, ensures optimum quality for customers and tools to enhance profitability.

The control method provide a new solution for grain drying process.

Advanced controllers are being simulated with good results and we expect to implement them in the factory in the future for a better optimal energy consumption.

ACKNOWLEDGEMENTS

This work was supported in part by “Programa Nacional de Recursos y Tecnologías Agroalimentarias”, (PROFIT) from the Spanish Technology and Science Ministry.

REFERENCES

Bremner, H., 1997. An application of model-based fuzzy control to an industrial grain dryer. *Transactions of the Institute of Measurement and Control*, volume 19, nº4, pages 185-191.

Balas, G., J. C. Doyle, K. Glover, A. Packard and R. Smith., 1994. *μ-Anaysis and Synthesis Toolbox for use with MATLAB*. The Mathworks.

Cárdenas, C., Garcia, J.D., Baeyens E., Olmos J.D., 2003. Robust controllers for granulation processes in the food industry. *AFOT 03 Congress*.

Chunyu, Z., Qinglei, C. et al., 2007. A model predictive of a grain dryer with four stages based on recurrent fuzzy neural network. *In Springer Berlin, editor, Lectures Notes in Computer Science*, volume 4491, pages 29-37.

De Dios, C. A. (1996). Secado de granos y secaderos. *Organización de las Naciones Unidas para la agricultura y la Alimentación*. Santiago, Chile

Guofang, L., Zhihuai, M., 2006. An intelligent controller for grain dryer. *American Society of Agricultural and Biological Engineers*. Paper nº 066197.

Janeiro, J., Moya, E., Garcia, D., Calvo, O., Cardenas, C., 2006. Remote Supervisión and Maintenance of Industrial Proceses. *ICINCO´07 Congress*.

Qiang, L., Bakker-Arkema, F.-W., 2001. Automatic control of crossflow grain dryers, Part2: Design a model-predictive controller. *Journal of agricultural engineering reseach.*volume 80. nº2, pp 173-181.

Silva, J., Alves, G.R, Alves, B.M., 2003. A scale model of a grain storage tower equipped with micro web servers. *International Journal of online engineering*

Srzednicki, G., Hou, R., Driscoll, H. R., 2005. Development of a control system for in-store drying of paddy in Northeast China. *Journal of Food Engineering*, volume 77, Issue 2, pages 386-377.

Zhang, Q., Litchfiled. 1993. Fuzzy logic control for a continuos crossflow grain dryer. *Journal of Food Process Engineering*. Volume 16, pages 59-57.

Cadder., 1992. Computer control system for continuous and semi-continuous grain dryers. Result 106. *Building and industry publications*.