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Improvements in the Command and Control of the Processes for a Sand Drying Plant

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Abstract

This article presents the work done for improving the control of a sand drying plant, part of much larger facility for dry mortars and adhesives production. Although this type of sand drier is working well as standalone equipment in several plants, in the process of integrating it in this facility were encountered serious problems in establishing the automated control of the process. The decision to establish a mixed control regime for the sand drying plant was not satisfactory, causing the erosion of the exhaust pipes for drying and cooling gases. To solve this problem, an automation loop was established to control the dynamical pressure at the level of material fluid bed. Although the problem of erosion was solved, the random variation of the humidity of sand delivered to the system generated troubles regarding the quality of the dry sand produced. Analyzing the situation occurred it was decided that the most suitable way to solve the problem of automated control of the sand drying plant is to implement a fuzzy logic expert system.

Key words: *sand drying plant, fluid bed, frequency converter, differential pressure, fuzzy logic.*

General presentation of the system

The sand drying plant supplied by Binder GmbH it is a complex and very modern plant which use the phenomenon of fluid bed of material for minimizing the amount of energy (both electrical and thermal energy) for drying materials such as sand, coal and coke.

The layout of the sand drying plant is presented in Figure 1. The sand drier consists of two sections, one for drying the sand and the second for cooling the material. The fluid bed of material is generated by a complex system which realizes a balance between the intake pressure and the exhaust under-pressure in both sections of the sand drier. In the drying section (7) the fluid bed is the result of interaction of the pressure of the hot air generated by the burner (4) and the under-pressure generated by the hot air exhaust fan (1). The hot air is filtered by the first section of the filter plant and released in the atmosphere with content of less than 10000 ppm residues. In the cooling section(8) the pressure is generated by the cooling air intake fan (3) and the exhaust fan (5) which recycles the cooling air after passing through the second section of the filter plant. The recycled air is used to increase the effectiveness of the burner due to its high temperature and low content of water vapors. According to the data provided by the manufacturer the optimum value of the module of the differential pressure which generates the desired fluid bed of material is 1 mbar.

The plant was provided initially with an automated control loop for the burner in order to correlate the volume and temperature of the hot gas introduced in the drying chamber with the quantity of the wet sand delivered to the system. However, due to peculiarities of the wet sand delivering devices (6) it was found that it was not possible to establish a mathematical model which correlate the amplitude of vibrations of the wet sand delivering devices and the amount of sand delivered to the system and thus to enable this loop. To solve the problem it was supposed that the input parameters of the sand: quantity and humidity were varying between narrow limits and the operator would be able to set the right parameters for the discharging devices. Based on this supposition, it was decided that the sand drying plant would be operated in manual mode, and the operator was in charge of setting the amplitude of the vibrations for the wet sand discharging devices (6) thus establishing the amount of the sand introduced into the drier. The only automation loop enabled in the system was established to control the temperature of the hot gases at the intake of the filter plant and thus to avoid destruction of filtering cartridges.

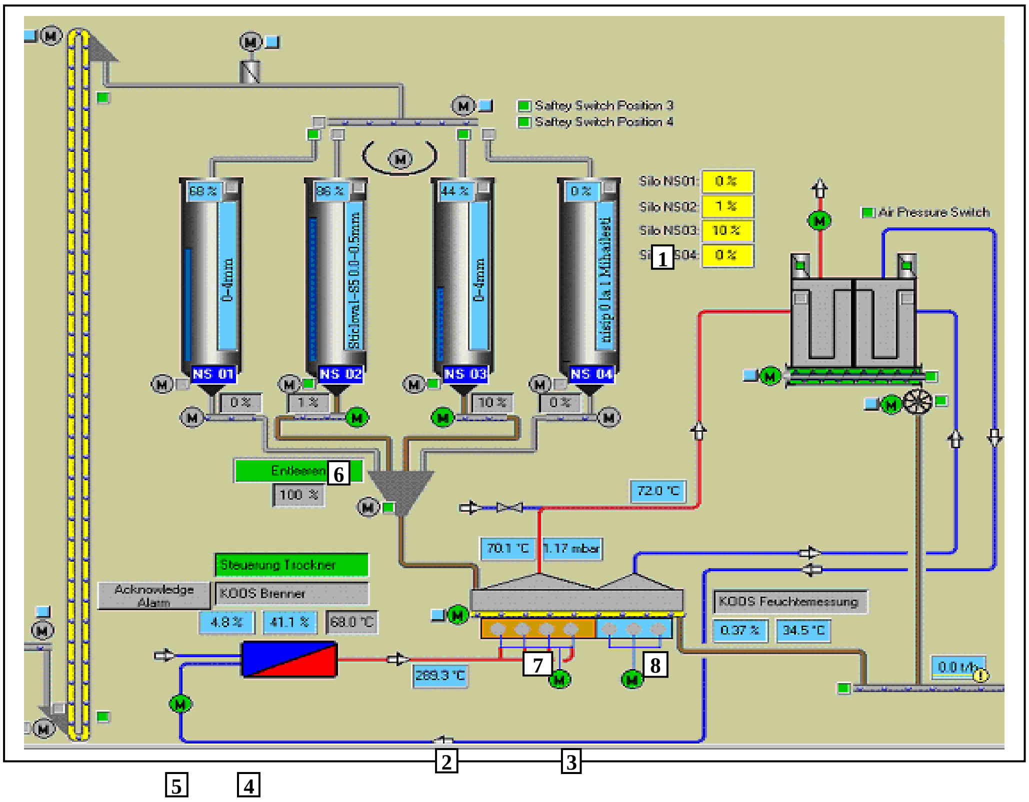


Fig. 1. The layout of the sand drying plant: Hot air exhaust fan (1); Hot air intake fan (2); Cold air intake fan (3); Burner (4), Cooling air recycling fan (5); Feeding vibrators (6); Drying section (7); Cooling section (8).

Based on those suppositions were set the working parameters for the sand drier as follows:

- Maximum temperature of the exhaust gases at the intake of the filter plant: 80 C^0;
- Maximum temperature of the hot gases at the intake of sand drying chamber: 400 C^0;
- Temperature for delivering wet sand into the dryer: 120 C^0;
- Differential pressure at the level of fluid bed 10 mbar.

It was verified the effectiveness of the automation loop established for the control of hot gases temperature and it was found that it works properly, was stable and compensate well the perturbations occurred in the system as presented in Figure 2.

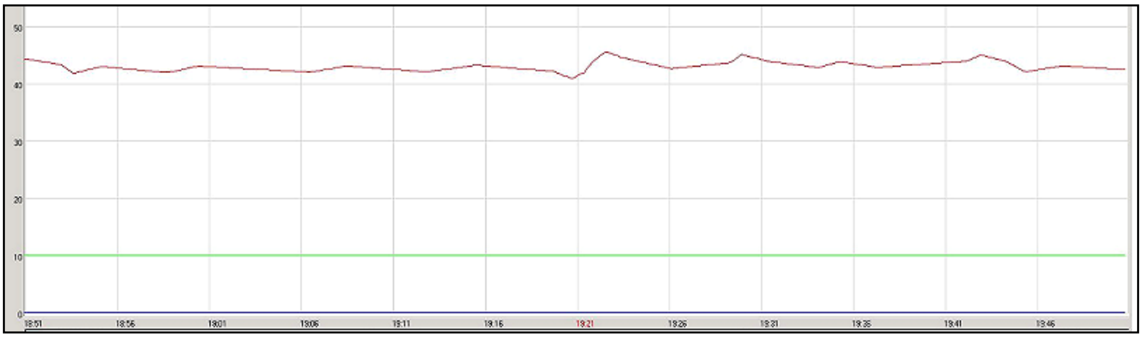
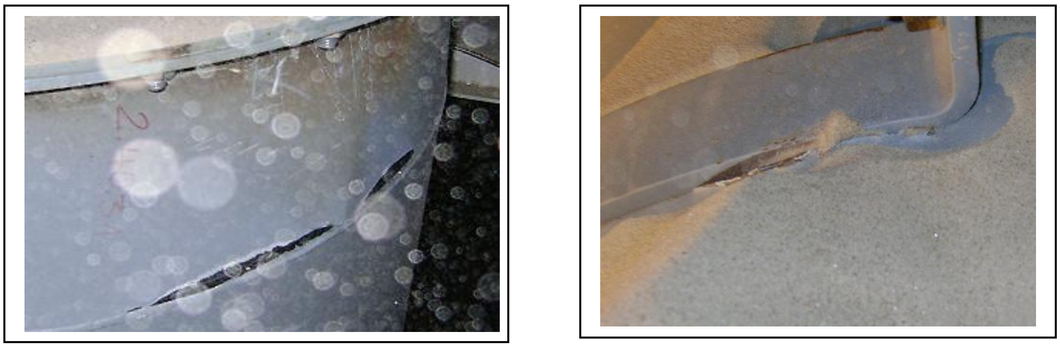


Fig. 2. The diagram of the temperature of the hot gases.

After three months of operating the system it was observed that severe erosion occurred on the pipes between the sand drier and the filter plant as presented in Figure 3 and also were observed severe erosion on the walls of the filter plant. Those phenomenon, demonstrated that initial suppositions were not entirely right: the humidity and quantity of material delivered to the sand drier were correlated and varying randomly due to the peculiarities of the wet sand discharging devices. Whenever the humidity of the sand was above 5% the wet sand was sticking on the discharging devices walls and thus the quantity of material delivered to the sand drier decreased significantly.



a) **b)**

Fig. 3. Eroded surfaces: a) on the cold air exhaust pipe; b) on the hot air exhaust pipe.

The operator was not able to replace the automation loop that should have been established for controlling the volume and temperature of the hot gases based on feedback concerning the amount of wet sand delivered to the sand drier. Whenever the quantity of material delivered to the sand dryer decreased, the module of the differential pressure at the level of the fluid bed increased and a bigger amount of material flew into the exhaust pipes eroding them. Although the high value of the differential pressure was benefic for drying the sand, the damages generated to the pipes and filter plant walls were significant and it was necessary to improve the system and to avoid further destruction.

First step in the improvement of the sand drier control

In cooperation with the producer of the sand drier it was taken the decision of establishing a control loop to maintain the module of the differential pressure at the level of fluid bed within well established values. The advantage of implementing a control loop was that, the electrical motor from the hot air exhaust fan was equipped with a Danfoss VLT Automation Drive 300 frequency converter. The VLT Programmable Logic Controller enables complete PLC functionality, providing the user opportunities to do very quick set-up of logical sequence programs by means of a graphical user interface, instead of setting up each single parameter by hand. The logic controller is able to monitor any parameter that can be characterized as “true” or “false”. This includes digital commands and also logic expressions, which allows sensor outputs to determine the operation. Temperature, pressure, flow, time, load, frequency, voltage and other parameters combined with the operators “>”, “<”, “=”, “and” and “or” forms logic expressions that controls the drive logically in any application.

The main modification for implementing the automation loop was to install two pressure sensors for monitoring the differential pressure and to connect them to the process server via the Profibus Master Class 2 connection (MSAC 2) which was implemented since the beginning into the facility.

Based on Danfoss VLT 300 facilities it was implemented an automation control loop for the differential pressure at the level of the fluid bed of material. After establishing the automation loop it was observed an improvement the process, the differential pressure in the system varying within small limits around the established reference as it is visible in the diagram presented in figure 4.

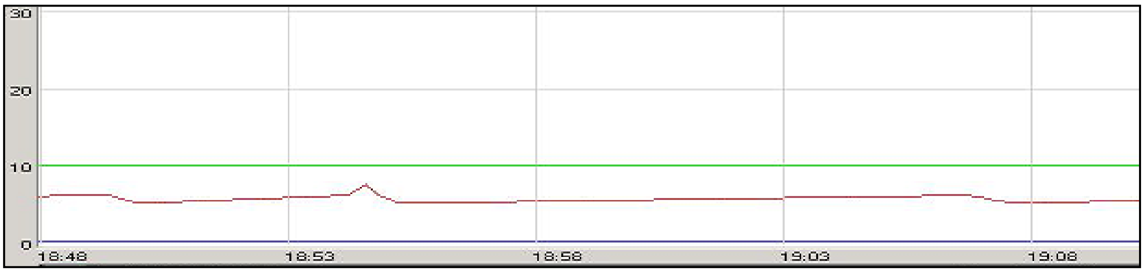


Fig. 4. Diagram of differential pressure.

However, this improvement leads to some other troubles, since the module of differential pressure was established at 1.0 mbar but the parameters of the feedstock material were varying within large limits. The humidity of the output material increases from 0.1% previously to values over 0.3% and randomly could be seen spikes of high humidity as it is presented in the diagram from Figure 5.

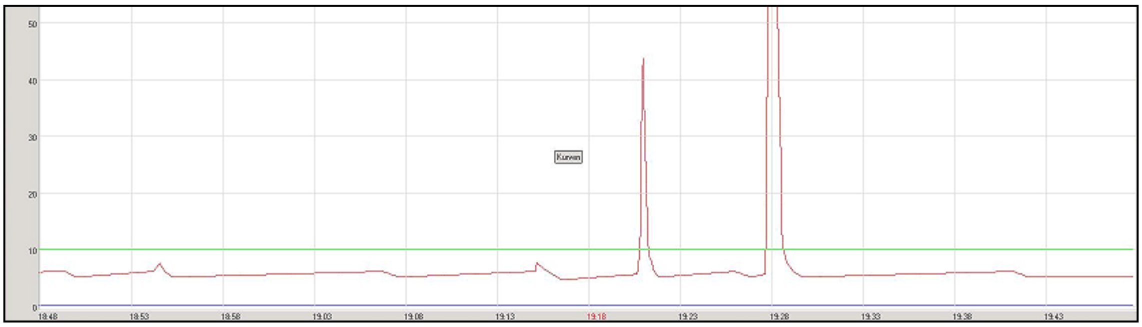


Fig. 5. Diagram of the humidity of the output material.

An explanation for those troubles is that a lower value of the module of differential pressure is decreasing the effectiveness of the drying process. A similar trouble was observed in the cooling section since the values of the temperature for the output material increased from 20-25 C^0 to 45-50 C^0, see Figure 6, phenomenon which proves that a lower value for the module of the differential pressure is decreasing the effectiveness of the cooling process.

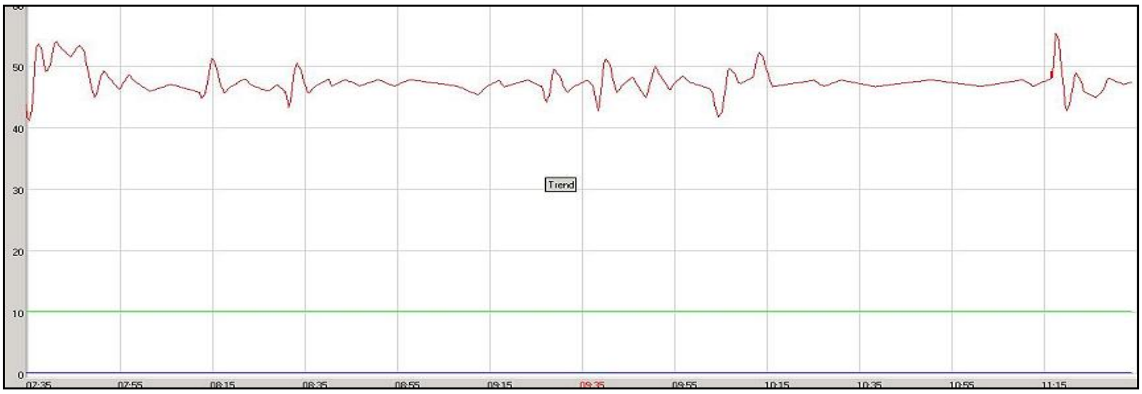


Fig. 6. Diagram of the output material temperature.

The above presented troubles show that the established automation loop did not solve the problem and there were more work to be done in order to establish a reliable control system of the process. To fix somehow the problem and to avoid clogging of the sieves, a trigger was set and for values of the humidity of the output material over 0.5% the functioning of the wet sand delivery systems was interrupted. This approach was not a long term acceptable solution due to two issues: the large amount of energy lost during those interruptions and the necessity of hiring an operator to supervise continuously the sand drying system.

In cooperation with the sand drier manufacturer and the software developer a thorough analysis was conducted and it was found that there is required a second step in the improvement of the sand drier control.

Further research and developments of the sand drier control

In order to overcome the problems occurred in the control of the sand drier were found two possible options: to establish a control loop for maintaining the humidity of the output material within the desired values (0.1%-0.2%) by regulating the quantity of input material delivered to the sand drier or to approach the control of the sand drier plant in a complete different manner and instead of looking for a certain mathematical model which describe this system, to use a fuzzy logic approach.

The first option requires a short time to be implemented and actually could have been implemented since the beginning if the designer of the plant understood that the devices for delivering the wet sand are not suited for this application and instead of them he could have used conveyor belts controlled by frequency converters. However, this option was very expensive and both the designer and the owner were looking for a less expensive compromise.

The second option is less expensive, however requires more work to be done. Traditional control systems are based on mathematical models in which the control system is described using one or more differential equations that define the system response to its inputs. In this situation where the input parameters are varying randomly it is difficult to develop an equation which defines the answer of the system. Assuming that the variations of the input parameters even though occurs randomly, are limited within known values, it is easy to establish certain fuzzy sets for inputs and therefore the expert system based on fuzzy logic could be a reliable solution.

Due to financial considerations it was decided to implement the second variant and the work started already for building a knowledge database, establishing the rule set and the inference engine.

Conclusions

The miscommunications between the system designer, the provider of the equipment and the developer of the control software could lead to further problems in exploiting the designed system. Even though some pieces of equipment were working well in other facilities almost every time when a new system is implemented troubles occurred and additional work has to be done to solve them.

Although the PID systems are well developed and easy to implement they are not suitable for all applications; complex systems often required expert system to control them.

For the sand drier system studied in this application it was necessary a period of six months of trials to reach the decision that it could have been better to have a different approach. During those months the pipes for hot air and cold air exhaust were severely damaged and there were significant energy losses. In addition, for developing and implementing the fuzzy logic control system would be required several months, during this period of time the operators of the plant should be very careful in operating and monitoring the sand drier in order to avoid output material with larger spikes of high humidity which could clogged the sieves.

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Îmbunătăţiri ale sistemului de comandă şi control al unei instalaţii de uscare a nisipului

Rezumat

În acest articol este prezentată activitatea desfășurată pentru îmbunătățirea sistemului de comandă și control al unei instalații de uscare a nisipului, element component al unei fabrici de mortare uscate si adezivi. Cu toate că acest tip de echipament funcționează fără probleme ca instalație independentă în alte fabrici, la integrarea acestuia în cadrul fabricii de mortare uscate studiată au apărut probleme în ceea ce privește controlul automat al procesului. Decizia de a stabili un regim mixt de control al procesului nu a dat rezultate satisfăcătoare determinând erodarea conductelor de evacuare a gazelor folosite pentru uscarea respectiv răcirea nisipului. Pentru remedierea problemei s-a procedat la introducerea unei bucle de control al presiunii dinamice la nivelul patului de material fluid. Problema eroziunii a fost rezolvată, însă, datorită variaţiilor aleatoare ale umidităţii nisipului introdus în sistem, s-a constatat că apar probleme în ceea ce priveşte calitatea nisipului uscat produs. În urma analizei situaţiei apărute s-a constatat că implementarea unui sistem expert de tip fuzzy logic pentru controlul funcţionării instalaţiei de uscare a nisipului este calea cea mai indicată pentru rezolvarea problemei controlului automat al instalației.