INTERNET / INTRANET ORIENTED ANALYZER IN THE CEMENT INDUSTRY

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Abstract: Production plants of cement, lime and other construction materials have to be equipped by laboratories that carry out analysis of production samples. The most efficient way of the closed loop automatic control of the production quality seems to be the application of smart distributed analysers equipped with embedded PCs. The paper deals with the development and application of an Internet oriented smart analyser of the specific surface determination of powder materials especially used in the cement and cognate industry. Authors discuss reasons, advantages and open issues of the solution and document its efficiency on the quality of produced materials.

Keywords: industrial control, intelligent instrumentation, Ethernet, control equipment, decentralized systems

1. INTRODUCTION

In the cement and other construction material production is necessity to carry out very complicated, expensive and time consuming analysis of producing materials in order to achieve demanded quality of production in the most effective manner. For that purpose the cement, lime and other production plants are equipped by laboratories to carry out analysis of production samples. The sample acquisition and their consequent transport is a task of the transport system generally realized by a pneumatic tube post. Analyses of construction materials and their count can have effect on production fluency of the plant and produce the production delay.

This production delay can influence negatively not only the production time, but can also destabilize the all production supervisory control. Elimination of the potential instability of the supervisory control conduces to the application of more complicated and more expensive synthesis of the supervisory control of the technological process. Application of decentralized automatic analysers -wherever it is effective- is one method how to minimize the transport delay evoked by the material analyses and how to decrease cost of sample transport to central laboratory.

By this method it is necessary to establish and to operate an effective and reliable communication system among decentralized analysers and control and data acquisition subsystems of the production plant. In the recent time such communication subsystems are built on the basis of industrial field buses that at first carry out integration of process control systems. The next communication subsystems in the process control environment create standard LANs, connecting supervisory process PC and working stations. In connection with development of IT and with their penetrating from the commercial and information areas into other human activities (Hajovsky *et al*, 2003; Zezulka and Cach, 2002), including industrial production, has arisen the possibility to utilize recent IT also for information subsystems of technological processes (Fiedler and Zezulka, 2003).

It represents in the discussed area the possibility to integrate decentralized analysers of material properties by means of Internet/Intranet. This method reflects actual surveys presented by German ZVEI organization (in SPS Magazin 4/2004) that indicates Ethernet to become the most important communication industrial subsystem in the forthcoming years. The same survey also indicates penetrating of Internet and WEB technologies into the automation technologies to be the most important tendency of very close future (in next 2 to 3 years). Authors understand existing disadvantages of Ethernet/Internet particularly:

- indefinable medium access of connected nodes (main requirement in real – time systems)
- unsatisfactory safety and security of translated dates in comparison with safety and security of field buses
- more complicate and more expensive Ethernet interface for simple low cost process instrumentation (e.g. single sensors and actuators)

Authors on the other hand appreciate big advantages of Ethernet/Internet such as:

- transparency of communication in all control levels in the hierarchical control architecture
- continuously growing speed of Ethernet (fast Ethernet)
- possibility to create small Ethernet segments without collisions (switched Ethernet)
- possibility of application master slave control on the application communication level to avoid collisions
- low cost application of results of expensive development from commercial and IT area into industrial automation domain

These tendencies and existing development would be very effective to utilize also in cement production in above-mentioned application - in intranet connection of Blaine analysers. The analyser is not situated in the hard real – time control loop, therefore a small medium access delay would be acceptable, but it is naturally connected to the Internet via Ethernet interface in the supervisory PC. The distributed variant of smart analyser is equipped with low cost Ethernet interface. Availability of Internet communication of analyser corresponds to lower security requirements of data from analyser. On the other hand the Internet connection of analyser enables monitoring of data from analyser in arbitrary time and arbitrary PC all over the production plant by use standard web browser only. It would be very attractive for the management and operators of the plant. One of such an Internet oriented data acquisition system can be even the material analysis of specific material surface.

2. AUTOMATIC BLAINE ANALYZER

The Blaine method is one of the ways of the specific surface determination of powder materials especially used in the cement and cognate industry. The well-known principle of the Blaine method is based on the evaluation of the permeability of the material bed the porosity of which is defined by the specific weight of the measured material compressed to the defined volume. The time of the passage of the air with defined quantity and defined pressure through the material bed determines the relative value of permeability. This method is widespread and favourite among technologists because it provides very reliable information used for the control and monitoring of the powder material production (Ciganek and Kreysa, 1991; Schulze, 1974). Continuous information of powder cement specific surface determination is more available for closed loop control of cement milling process. Therefore automatic analysers substituted some years ago simply manual discontinuous Blain analysers in cement plants.

Earlier models of automatic Blaine analysers used vibration for compressing the measured material in the glass measuring head. The optical level sensors measured the volume of the compressed sample. The value of the specific surface was calculated as a function (square root) of the time of passed air through the sample and a non-linear function $f(V)$ of the measured volume of the compressed sample:

$$B = K_d . K_{AS} . f(V) . \sqrt{t} . f(\vartheta) \qquad (1)$$

whereas

B	the specific surface (Blaine) [$cm^2.g^{-1}$]
K_d	the coefficient of device
K_{AS}	the coefficient that is defined for each line and each type of material, serves as a linear (one point) calibration
V	the volume of the sample inside the measuring head (after the compression of the sample caused by vibrations) [mm^3]
ϑ	the temperature of the measured material (was taken as a constant) [°C]
t	the measured time [s]

The volume V is measured by a level sensor, which is realized by photo sensors. The temperature is taken as a constant.

However, using this quasi Blaine method for measuring some powder materials in their production can cause some problems if the higher or irregular quantity of an intensifier (e.g. based on ethylenglycol) is used. Physical parameters of these materials, their compression conditions in vibrations and the optical measuring of the sample level in the measuring head cannot secure the required measuring accuracy and repeatability.

The necessity of the calibration in two points for each measured material, the obtaining and archiving suitable calibration samples for lower and higher specific surface and the procedure of the calibration were complicated for a user, too.

The above-mentioned lacks have been eliminated by a modification of the mechanical design of a new automatic analyser AB800. In the new analyser there is the measured material mechanically compressed inside a steel measuring head to the constant volume exactly in the same way as by Blaine method.

The value of the specific surface is then calculated as a function (square root) of a measured time and temperature.

$$B = K_d . K_c . \sqrt{t} . f(\vartheta) \qquad (2)$$

whereas

$$f(\vartheta) = \left(1 - \frac{\vartheta - 20}{1500}\right)$$

B the specific surface (Blaine value) [cm2/g]
K_d the coefficient of device
K_c the calibration coefficient of the measured material
ϑ temperature of the measured material [°C]
t the measured time [s]

The analyser consists of a measuring unit and a supervisor PC system (Pedersen and Zavadil, 2004). All mechanical parts of the instrument including a dosing device, a bypass and a controlling SIMATIC system with CPU, power sources and pneumatic parts for control of the instrument are embedded in the measuring unit.

The measuring unit of the instrument is designed for an installation both in operation conditions in a grinding area and in laboratories where it can work in an ON-LINE operation in a connection with an automatic sampling device or with a pneumatic transport system. It can be also used in a hand control (OFF-LINE) for measuring of samples in common laboratory activities. The on-line operation means the analyser is working in synchronization with the production, under the assumption the time to process the samples and the production time are respected. In the off-line operation the analyser is not part of the grinding line.

The control system of the measurement unit with an operator touch panel provides easy setting of necessary parameters for the start of measuring and calibration, display of results and status of the running cycle. The control program includes diagnostics with automatic display of messages and enables manual operation for service purposes. All these control functions of the embedded control system are formed for fully independent operation of the AB800 measurement unit even if the remote master control system is not connected. The Internet oriented communication (optionally) of the analyser is realised by an embedded web server into the measurement unit in order to provide monitoring, data exchange, and supervisory control over the Internet.

3. DESIGN OF BLAINE ANALYZER AB800

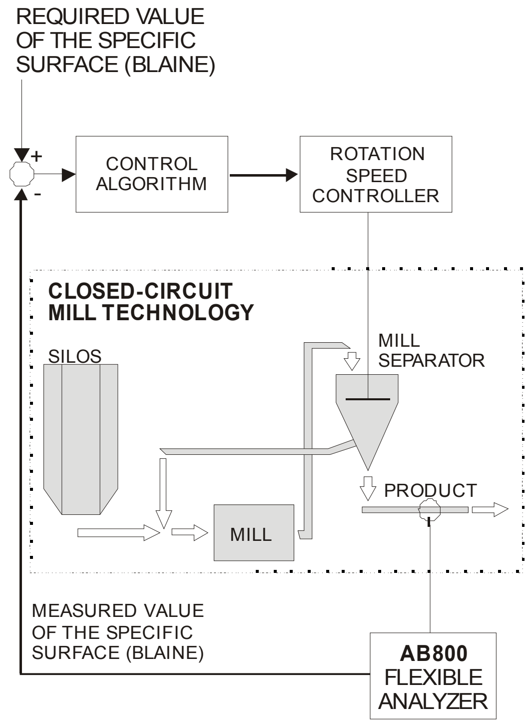

Fig. 1. Principal scheme of the AB800 analyser utilization in the process

The measuring unit is located in a double cabinet, where in the upper cabinet are the mechanical parts of the instrument with a dosing device and a bypass, see Fig. 2.

The basic mechanical part with the precise electronic scale (Sartorius) is attached to the sliding frame, which provides easy maintenance, by its shifting out. The electronic scale with the controlled vibration feeder ensures exact dosing of measured material into the measuring head. For an easy sample loading into the analyser, the second - external vibration feeder situated on the backside is used. The entrance window of this feeder can be used both for hand measurement and for a connection to an automatic sampling and transport system. Together with the external feeder, the fans of the internal dedusting system and the bypass tube for the discharging of the oversupplied and measured material are located on the back side of the measuring unit. The colour touch panel for an operator is integrated in the top of the upper cabinet of the analyser.

Fig. 2. The analyser AB800

The lower cabinet of the measuring unit contains a controlling Siemens SIMATIC S7 system with CPU, DI/DO, Communication units including power sources and pneumatic valves for control of the mechanical parts of the instrument.

The power supply and pressure air required are to 230 V and 0.6 MPa respectively, while the energy consumption are max. 180 VA and 2000 ccm for one cycle.

The measurement range of specific surface is 1500 to 8000 cm^2/g for dry powder materials. The specific weight of is in the range 1.8 to 3.5 g/cm^3.

The quantity of the sample for one measurement cycle is dependent on the specific weight of the material and varies in the range 40 to 80g for porosity of the compressed sample near to 50%. The quantity of the sample for each type of the material is automatically set by the embedded microcontroller if the specific weight and porosity are defined.

The value of porosity can be optionally set regarding to good material compressing condition for the whole measured range of the corresponding type of the material. The way of the material compressing – the smooth speed of the pressing and the guaranteed constant maximal pressure strength of the sample inside the steel measuring head to the constant volume which is repeated for each sample is the significant advantage of the automatic analyser if compared with manually operated equipment. For a set pressure air to 0.5 MPa the maximal pressure strength inside the measuring head is 50 $kg.cm^{-2}$.

The time of one measuring cycle depends on the material fineness and its other parameters such as humidity and stickiness, which influence the time of the sample processing. Also the rest quantity of dosed material that has to be cleaned influences the cycle time. For the measurement of cement Blaine value of which is not higher than 5000 $cm^2.g^{-1}$, the cycle time is max 7.5 minutes which guaranties measurement of 8 samples per hour during common cement production.

The maintenance of the analyser does not require any special activity, only optical checking and cleaning of the dust is recommended ones a week. The emptying of the dust container and cleaning of the dust filter are carried out ones a month. Every other maintenance activity is required after 15000, res. 30000 measuring cycles.

The analyser provides an interface for monitoring and control that is connected to a supervisory PC. The connection is either Ethernet or Profibus based. The latest variant of the AB800 does not require a designated supervisory workstation as it includes an embedded PC. The embedded PC provides an Ethernet interface to connect the analyser into intranet/Internet. There is an web-server running that enables monitoring the analyser and the analysis through a web interface. A proprietary TCP based protocol is applied for communication with a supervising and monitoring program. The supervision can be now done from any PC in the intranet with the supervisory program and corresponding rights.

The analyser AB800 is considered to be one the best automatic analysers of the specific surface determination of powder materials. In the Fig. 3 the results of accuracy and repeatability in the measurement of Portland cement PC30dz45S are presented. For this test 26 test series in irregular intervals during 10 days were carried out. For each series a new material was always used from the total quantity of 5 kg while the delivered material (5 kg cement) was not further homogenised. The analyser was calibrated to Blaine value 3575 cm^2/g before the start of the test. As it can be seen from the results the highest absolute deviation

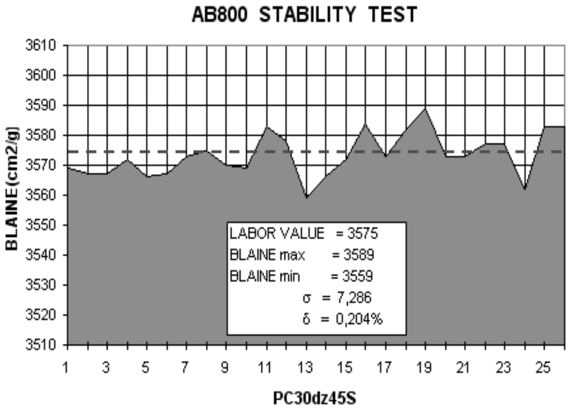

Fig. 3. Stability test results of the AB800

was 16 cm^2/g which corresponds with the accuracy better than ±0.5% even if we can suppose the 5 kg delivered material was not 100% homogeneous.

The common way of sample analysis without automatic analysers is to conduct the measurements in a laboratory. The method used in the AB800 analyser is based on the same principle, but the analyser provides much more reliable measurements and quality of the results, as the samples are not prepared by hand.
The guaranteed accuracy of the analysis is 2 %, but as can be seen from the test results in Fig. 3 the accuracy is much better, it can be even below 0.5 % that is impossible to be achieved in common laboratory tests.

4. CONCLUSION

Contribution deals with recent development in process instrumentation for purposes of control of technological processes. On example of a flexible analyser of specific surface determination of cement and other powered materials with a new approach of electronic subsystem conception is presented.

The automatic analyser of specific surface of powder materials model AB800 introduced to the market by company AUTEC s.r.o. provides a user the Off or On-line control of the grinding process and monitoring of the production for the quality control system.

Analyser can be incorporated into the complex of fully automatic monitoring and control systems together with the automatic sample tube transport device and automatic sample distribution. In this case one analyser can evaluate samples taken out from various grinding units or transport ways and simultaneously monitor the samples from the dispatch. Thus the analyser can be included into the system of devices and instruments for the function of ISO9000.

The AB800 version brings in significant progress in the technology thanks to implementation of modern devices and technologies. Compared to the older versions, the analyser now is PLC based, employs stepper-motors with intelligent drives, optical level sensors and others.

However for some users the application of the automatic analyser can be very useful if they are interested in a evaluations of a long time correlation of the standard strengths with Blaine values eventually with the particle size distribution if corresponding automatic device is at the disposal. Such measurements and evaluations are very interesting and important especially for the materials and grinding process where the properties of components are very different and also the parameters of the grinding device change.

The instrument can be installed either in the process near the mill or the material transport connected to an automatic sampling system or in the plant laboratory. The new generation of material analysers is equipped with embedded Ethernet interface and web servers to enable data communication, monitoring, diagnostics, calibration and control via Internet/Intranet.

REFERENCES

Cigánek, A. and K. Kreysa (1991). Zweiparametrische Steuerung eines Zementmahlprozesses. *Zement-Kalk-Gips*, **7**, 364-370.

Fiedler P. and F. Zezulka (2003). Interoperable Technologies for Automation, *ICIT´2003*, 877-880, Maribor, Slovenia.

Hajovsky R., B. Horak, J. Kotzian, J. Koziorek and V. Srovnal (2003). Embedded Remote Measurement and Control System Apply GSM. In: *Programmable Devices and Systems 2003-IFAC Workshop*, 55-60. Pergamon Press-Elsevier, UK, 2003, ISBN 0- 08-044130-0.

Pedersen, S.T. and M. Zavadil (2004). New Products for At-line Analysis, *World Cement*, **6**, 75-76.

Schulze, H. (1974). Adaptive Verfahren zur digitalen Regelung von Kugelmühlen in Zementwerken. *Regelungstechnik und ProzessDatenverarbeitung*, **6,** 174-177.

Zezulka, F. and P. Cach (2002). Progressive IT in industrial automation applications. In: *QRM 2002, 4th International Conference on Quality, Reliability and Maintenance QRM'2002*, 323 – 326. St.Edmund Hall, University of Oxford, UK, ISBN 1 86058 369 5.