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Automation goes 4.0 – The “Smart” AAC factory

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During the past years the global market requirements and economic conditions on the one hand as well as the automation possibility and sensor technology on the other hand have been changing rapidly. Core issues for today’s production of building materials are the constant further development and improvement of the state of the art technology. To meet highest demands and to keep competitiveness in a very tough market for high complex and flexible product types, low cost production in combination with highest product quality, high efficient production technology and overall plant availability are the essential features and challenges.

Overall equipment effectiveness (OEE)

To produce permanently high-quality products in a sustainable and cost-effective way as well as to constantly improve the productivity – this is the request for a production plant. As it is impossible that there is any production plant which can produce a 100% good product, 100% continuously under 100% full power; the overall equipment effectiveness factor OEE is helpful to determine actual productivity. It defines the percentage of productive manufacturing time (availability A), percentage of speed (performance P) and percentage of good product (quality Q).

$$OEE = A \times P \times Q$$

Industry 4.0

The new era of the “4th Industrial revolution” is sustained by modern automation technology, big data handling, data exchange in real time and self-optimizing processes creating what is called the “Smart

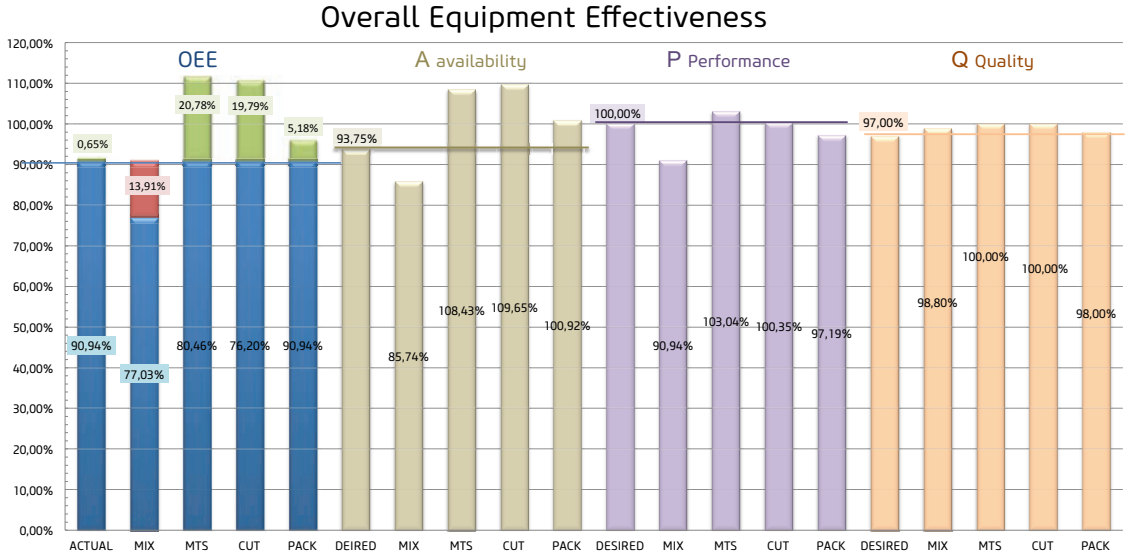

Fig. 1: Example for online OEE-monitoring for an AAC plant separated in the sections Mixing, Mould Transport System, Cutting, Packing. Source: Wehrhahn

factory". "Smart factories" are offering numerous commercial opportunities in a digital age.

This target is to be achieved by the following priorities:

1. Decentralisation of intelligence to each smart machine
2. The direct connection between real and virtual production processes "virtual twin"
3. Real-time data exchange throughout the entire production process
4. Self-managing production processes by automatic state identification with precise sensor technology, intelligent program logic and data networking.

What does Industry 4.0 look like in a modern AAC production plant?

Frank Pottin studied automation engineering in Bremen. Immediately after completing his studies, he began with the electrical design, programming and commissioning of Wehrhahn AAC production plants. Today he has over 26 years' experience in AAC production. As Director Electric and Automation, with his team of more than 30 Automation specialists, he continually develops new innovations for AAC production.

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Priority 1: Decentralization to „smart machine"

The Wehrhahn electric control system for AAC production plants consists of approx. 20 individual control units with their individual control cabinets which are integrated into the main machines. The CPU's of the individual machines are connected with each other via network so that they can be monitored, parameterized and operated in sections from one operator station only. This is how Wehrhahn developed the „machine for the socket".

The advantages are:

- Saving electric rooms
- Significant reduction of cable work on site
- I/O-Check on site no longer necessary

Fig. 2: Wehrhahn Machine in test run before delivery.

Fig. 3: The interactive data exchange between machines for self-managing production process.

- Time savings at commissioning, because machines are prewired and extensively tested with hard and software before delivery.
- Increased flexibility for shutdown of individual machines for safety reasons
- Local disconnecting switches are not necessary as the safe switch-off can be done directly at the main switch of the control cabinet

Priority 2: „Virtual twin"- The direct connection between real and virtual production

Functions of a single machine can be tested thoroughly before delivery but the functional sequences of the entire production plant, consisting of many individual machines and their interactions, cannot be tested before installation. However, here modern software tools help to simulate real conditions. But it is important that the simulation uses the original control programs and visualizations that are ready for delivery. Wehrhahn programs therefore are comprehensively simulated and tested before delivery. This simulation tool is delivered to be used by the customer after commissioning in order to optimize the system or for training purpose.
The merger of the virtual simulation under real conditions creates the "virtual twin".

Priority 3: Real time data exchange through the entire production process

For over 40 years Wehrhahn has been developing and building autoclaved aerated concrete production plants. The accumulated experience gained from more than 100 plants running worldwide led to the development of many helpful process tools that guarantee a reliable, efficient and resource-saving production of high-quality AAC product.

- Intelligent machine control + visualisation
  Wehrhahn machines are intelligently programmed so that they do not follow a fixed functional sequence any longer but can flexibly adapt to the requirements of the process or product specifications and take "decisions" themselves.

- WECOMIX
  (Wehrhahn intelligent Dosing + Mixing System)
  A dosing and mixing system that achieves consistent good mixing results by
  - o accurately calculating each batch prior to dosing
  - o automatic dosing optimization
  - o recipe-dependent dosing parameters
  - o flexible mixing sequence

- WACO
  (Wehrhahn advanced Autoclave Control System)
  An accurate, reliable and safe autoclave control that offers many advantages:
  - o Comfortable visualization and database on powerful PC, while the industrial PLC controls the valves exactly and safe
  - o Continuous monitoring and control of the pressure curve guarantees a high-quality product
  - o Automatic adjustment of set point curve in case of disturbances
  - o Energy saving with process optimized steam transfer
  - o Optimized steam release control to reduce cycle time and avoid pressure increase during the release process

- WH-EnMS
  (Wehrhahn Energy Management System)
  Many energy management systems measure in one-minute intervals only. Consequently, they can only be used for reporting the energy consumption. An intelligent energy management system like WH-EnMS does not only monitor energy load at a second-by-second sampling rate, but also allows to identify "bottlenecks", to optimize functional sequences or processes and

to detect the maintenance requirement in relation to the actual machine condition (predictive maintenance).

- PCI-System (Wehrhahn Product Control and Information System)
  The Product Control and Information system which stores machine as well as product data and automatically adjusts machine parameters to the requirements of the product.

- Safety System
  A main requirement for a modern safety system is not only to make sure that fast and secure access to machines is possible, but also to allow immediate automatic restart after leaving the security area directly at the entrance gate.

- SIA (Service Interval Application)
  The Service Interval Application detects maintenance requirements via intelligent operating hour's counters and reliable measuring technology. SIA is significantly supported by the energy management system WH-EnMS.

- Report Management
  The report management provides a precise and comfortable overview of the conditions in the plant at any time, the productivity as well as the raw material consumption and energy requirements.

Each tool itself is helpful for monitoring and controlling the production plant. But only when the tools are linked together and can share and connect their data interactively, there are many new ways to improve overall system effectiveness.

Priority 4: Self-managing production process

Self-managing efficient coordination and organisation of machines is based on measurement technology, flexible program logic and data networking.

Cake temperature and cake height course during precuring and right before cutting

The automatic cake temperature and height measurement to evaluate the precuring process improves the quality of the product, increases the productivity of the plant, saves raw materials and increases the safety for the operators. As the measurements are automatic and standardized, time-consuming manual measurements are eliminated. The results are objective, no longer person-dependent, and therefore helpful for exact recipe development, for new product types (e.g. low density AAC) or when raw materials are changed.

Increase productivity: By comparing the measured height and temperature rising curve (actual curve) with a recipe-specific ideal curve (set point curve), conclusions can be made 30 minutes before reaching the expected final cake height or cake end temperature. The recipe can therefore be optimized immediately and the next mixture can be started promptly. This means 7 more cakes can be produced at a cycle time of 4 minutes. Cakes with optimum cutting

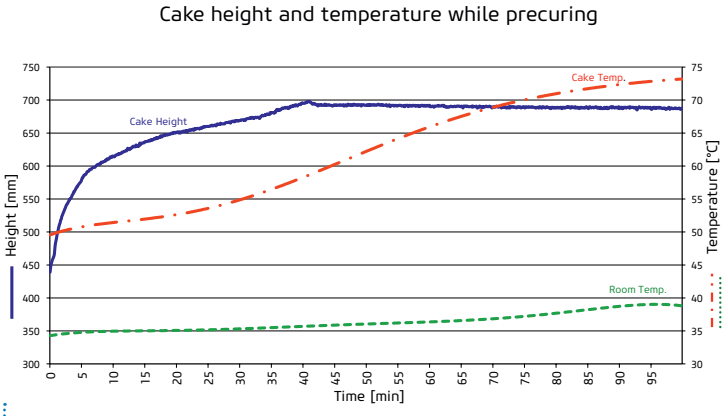

Fig. 5: Actual temperature and height curve of AAC product during the precuring process, automatically measured and indicated by Wecomix.

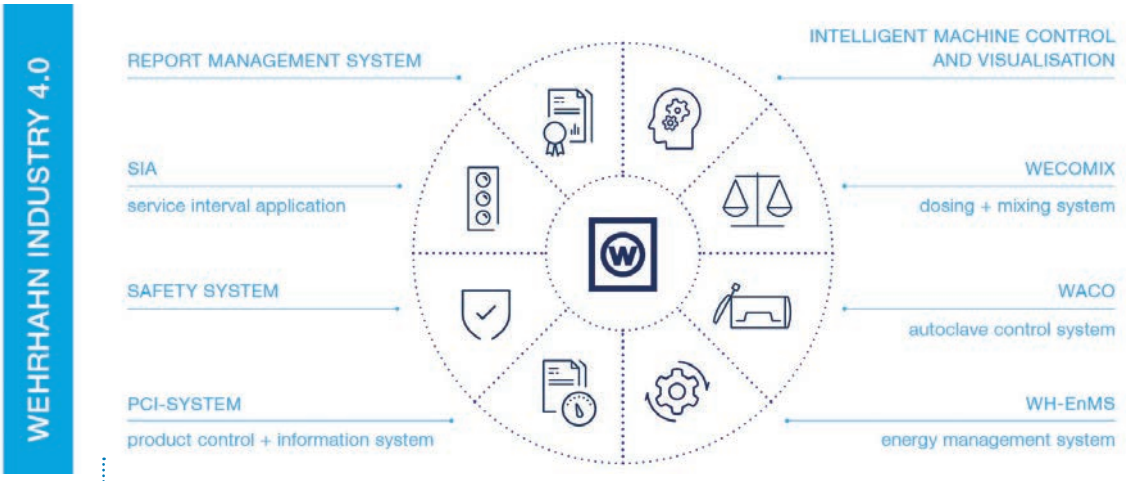

Fig. 4: The interactive data exchange between the process tools allows the self-managing production process in a Smart Factory.

strength and cutting temperature can be transported through the cutting line at a higher speed. Therefore, an optimal ratio between transport and cutting speed can be adjusted, which ultimately reduces the cycle times to a minimum.

Save raw materials: The continuous, automatic control of the cake height course in connection with the measured temperature course inside the cake helps to save raw materials. Optimized dosing of aluminium, improves product quality and reduces aluminum consumption.

Furthermore, by optimizing the mould filling height, additional raw materials can be saved.

PCI-System with automatic adjustment of machine parameters

Beginning from the dosing process, a unique identification number (Cake ID) is created for each cake, which is used during the whole production. The order management of the work preparation team gives which product types to be produced. The plant control system processes the orders and returns their status to the management. The machine parameters are automatically set via the respective stored production data which can be re-viewed even after production for quality management.

Predictive maintenance

Reliability and availability of production are the key values for industrial companies. To have a production plant still producing precise high-quality products, even after many years of operation, regular care and maintenance service is required in individual system components. However, in complex systems, it is increasingly difficult to keep an overview of maintenance requirements at any time.

Wehrhahn production plants are equipped with a precise service interval indication system. With colour change signals from 'green' to 'red' the operator and service personnel will be informed about the maintenance status of the machine components. Upcoming maintenance and required maintenance service can be performed at once. The execution and acknowledgment of the maintenance service will be logged in a message archive. To help the service team all manuals for the plant components are available in this system.

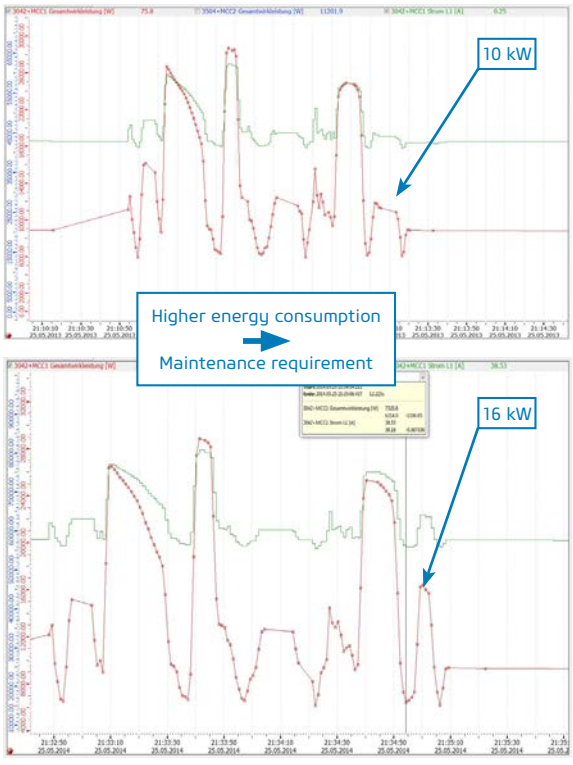

Fig. 6: Maintenance detection with WH-EnMS.

Peak power control

Electricity supply contracts usually include a fee for power peaks which often constitutes 50% of total energy costs. The maximum average power peak is measured every 15 minutes. For some contracts, the customer has to register the anticipated maximum power peak for one year in advance with his electricity supplier. If the actually measured value exceeds the forecasted value only once, then the higher rate must be paid for the full year. In some contracts even a penalty fee is due. It is, therefore, absolutely necessary to keep the power peak as low as possible, to supervise it continuously, to make a prediction about the expected power peak in order to be able to automatically initiate measures for reduction.

The "Load Peak Monitoring System" of the Wehrhahn Energy Management System WH-EnMS measures the power requirement, calculates the presumed peak power of the next 15 minutes and shuts down previously defined unnecessary consumers, like air condition, heater or air compressors if they are not needed. WH-EnMS does not only consider consumers in the production plant, but also in administration buildings, workshops or outdoor areas. Often only a short-term shutdown is necessary to guarantee the determined maximum power peak.

Data evaluation

Data report management system

Considering the measured data separately according to their origin many trends can be observed and changes occurring can be detected. But if the data are put in reasonable correlation to each other, then KPI (key point indicator) can be created and many new correlations will be found.

In order to ensure the connection of the various data, in Wehrhahn production plants all data are stored in a secured uniform database. Out of this data base different reports can be created very easily and exported to formats requested by the customer.

Data analysis

A modern production plant provides a large number of measured values, plant data, production data and machine data, which shows the condition and efficiency of the production plant or helps to make the

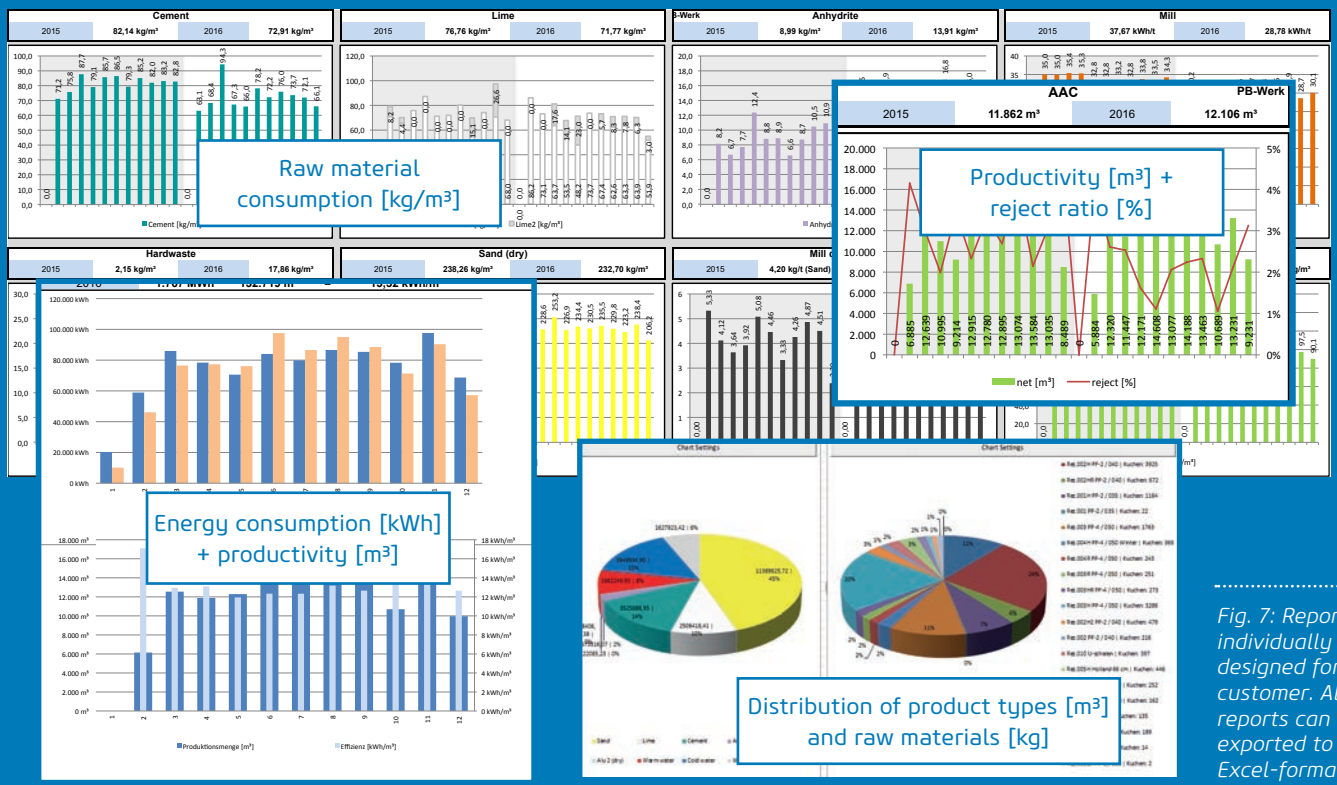

Fig. 7: Reports individually designed for the customer. All reports can be exported to Excel-format.

best decision for optimization. This requires a systematic analysis and processing of the data. Many plant managers feel overloaded by the comprehensive amount of data and wide data diversity and therefore they do not have the chance to profitably use them. Wehrhahn offers to customers a detailed analysis of all production data. Based on the experience gained from a large number of built production plants, Wehrhahn can carry out a systematic data analysis (benchmarking) and point out improvement potentials. As an equipment supplier with its own design and automation department, Wehrhahn is in a position to define measures from the potential and to implement them.

The targets of the data analysis are:

- To find and evaluate improvement potentials
- Sustainable, reliable and efficient production with high product quality
- Increase/hold of overall equipment effectiveness - OEE
- Lowest possible production costs

After the data analysis, Wehrhahn is able to program automatic monitoring of specific data analyses into the plant control system that provides data evaluations in real time.

Experience has shown, that even in a well-organized AAC plant, a savings potential of more than € 50,000 per year is possible after this kind of data analysis.

Conclusion

Industry 4.0 has become a widely used keyword and is unfortunately frequently used only for marketing purposes.

In all kind of production plants, many parameters, product, machine and measuring data come together. The meaningful connection of these data may result in experience and ideas for innovations. In many plant control systems, the data ends up in different departments, locations or registers, so that their actual coherence is not recognized and therefore unused. With a uniform database, where all data are automatically collected and put in flexible correlation to each other in real time, new insights are created which can be used to make precise decisions and enable an optimal production process.
We often try to explain conditions and prove or refute them in structured tests. Instead today's computer technologies are able to store large quantities of data everlasting, access it at any time and connect them very quickly. With mathematical algorithms completely unbiased contexts can be found which were supposed to be impossible. Some people may be worried about the possibility of using data in their private environment, but in Wehrhahn production plants, this technology enables a real-time data exchange between smart machines and a self-managing production process. That is worth to be honoured as industry 4.0.

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