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Intelligent automation modules in AAC production plants - part 1: advanced autoclave control

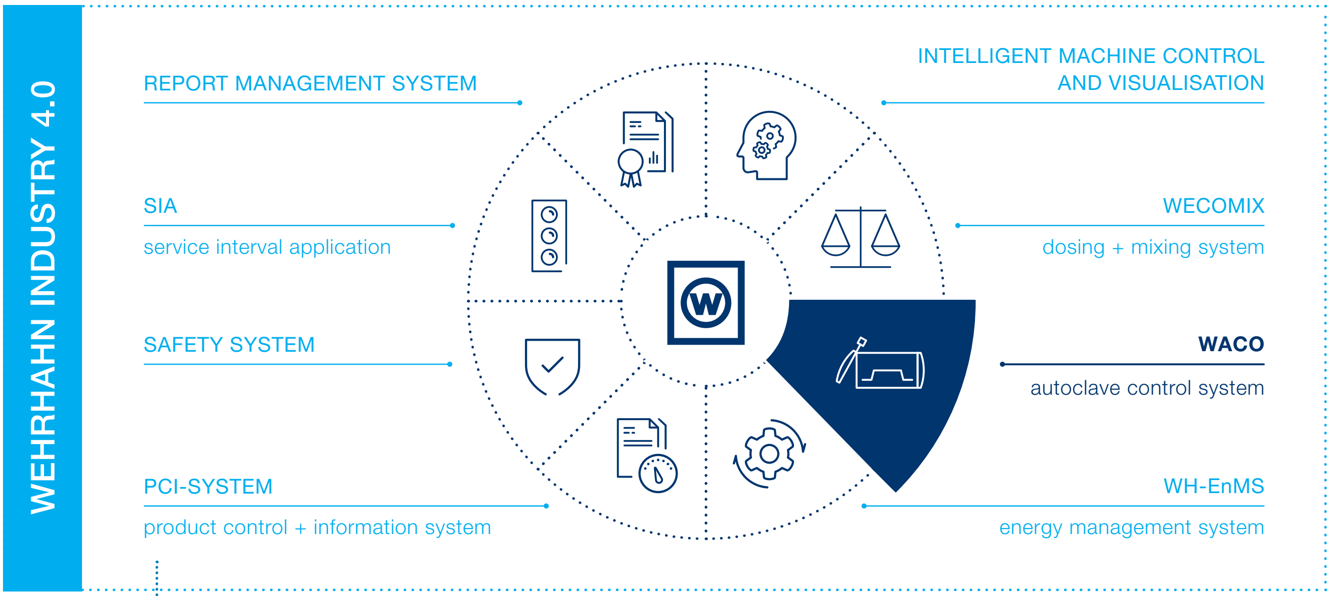
Increased productivity, highly efficient use of raw materials, improved product quality and safety, reduced working time: intelligent electric control systems have a decisive influence on plant productivity. State-of-the-art AAC production plants include overall automation systems with a bundle of different control modules which communicate with each other to ensure high plant efficiency rates. In Wehrhahn AAC production plants customers may benefit from eight such control modules. This sounds very complex but is rather intelligible once the modules are individually introduced. In part one of a series of articles Wehrhahn is focusing on the Autoclave Control system.

The autoclave control in a production plant is a key driver in the production process, as autoclaving is one of the most sensitive steps in the production process and significantly determines the product quality. During the autoclaving process various calcium-silicate hydrate crystals are formed at a temperature of approx. 180-190 °C using saturated steam.

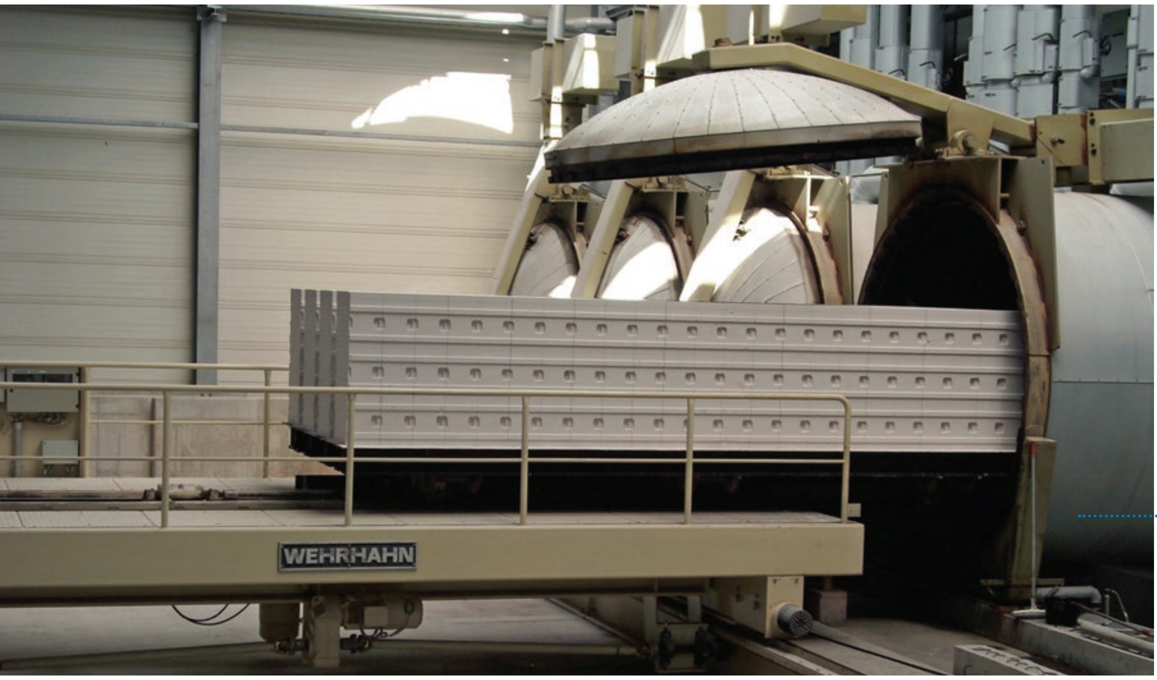
As at the beginning of the autoclaving process, even at low temperatures, the calcium hydroxide dissolves very well, first of all Ca-rich crystals are formed. As the temperature increases, more and more SiO_2 dissolves, until finally, at the appropriate temperature and autoclaving time, a large number of tobermorite crystals ($C_5S_6H_5$) are formed. Tobermorite is the most important CSH-phase, giving AAC its outstanding properties, as well as high compressive strength, low shrinkage and very good thermal insulation properties at a low density.

The precise control of the pressure and temperature increase results in the perfect autoclaving, thus, determining the quality of the AAC product. Usually, the autoclave is pressure-controlled, since the pressure is the same throughout the autoclave and is easily measurable.

Actually, it would be advantageous to control the inflowing quantity of steam over the temperature inside the product currently being cured. For a per-



AAC - automation modules for a precisely coordinated Automation Control System.



An intelligent Autoclave Control System is one key factor for high-quality AAC production.

fect autoclaving process a constant temperature throughout the product is required. This can only be reached in the interior of the product with a time delay due to the kinetics of the heat transfer process. However, due to practical reasons, the product core temperature is hardly used as a parameter in autoclave control systems.
As a consequence, in many AAC plants the focus is only on steam pressure, neglecting the temperature balance of the cake before autoclaving and the transfer of temperature into the interior of the AAC cake during autoclaving. In addition, the temperature can be far below the corresponding saturated steam pressure; e.g. due to air inclusions because of incomplete evacuation. Improperly cured products can be the result.

In a modern automation concept, the following properties play an important role:

- Safe and precise control of the autoclaving process
- Energy-efficient optimization
- Product-dependent automatic setting of autoclaving parameters
- Transparent monitoring of all autoclaves and heat recovery systems
- Data exchange with quality management systems
- Flexibility in the use of existing valve- and measuring technology
- Maximum safety in the entire process

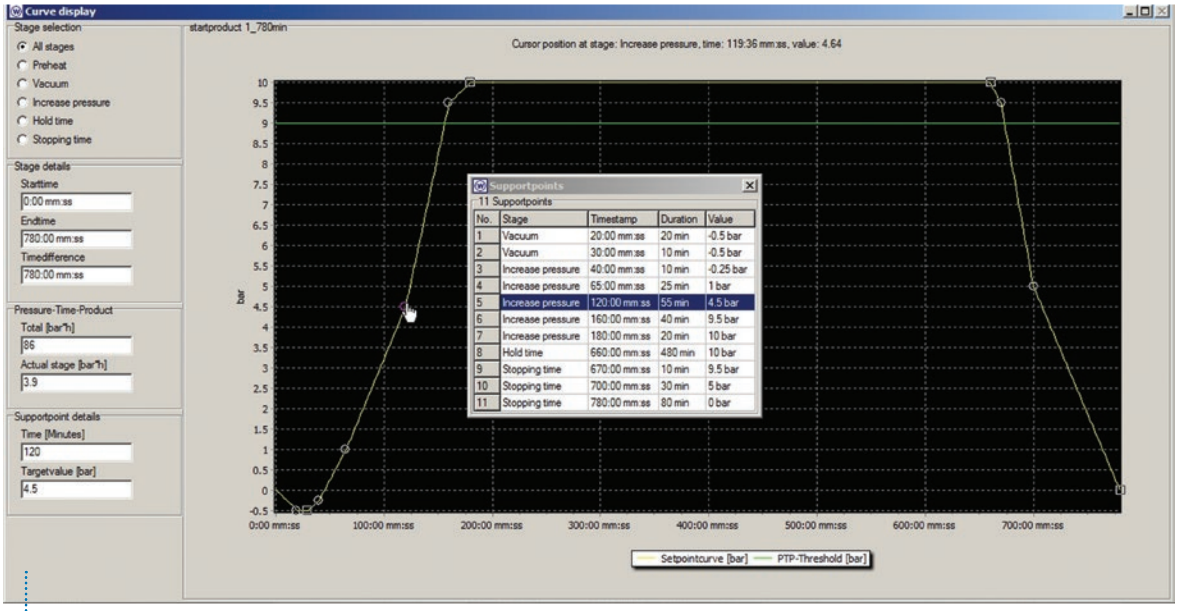
Safe and precise control of the autoclaving process

Whilst the "man-machine communication", i.e. the setpoint curve creation, setpoint curve selection and data collection, is conveniently carried out on a high-performance PC, the control is completely taken over by a safe PLC industrial control.

By graphically creating the setpoint curve, the autoclaving process can be specified quickly, comfortable and clearly on the PC monitor. By a simple input of any number of curve points, the best curve for the optimum autoclaving process, based on the requirements of the respective product, can be set precisely. Here the high performance, the large storage space and the usability of the PC offer the best possibilities.

After selecting a setpoint curve on the PC, the complete curve is loaded into the PLC via bus system. During the entire autoclaving cycle, the PLC controls all valves and monitors the installed sensors, independently of the PC: precisely, quickly and safely.

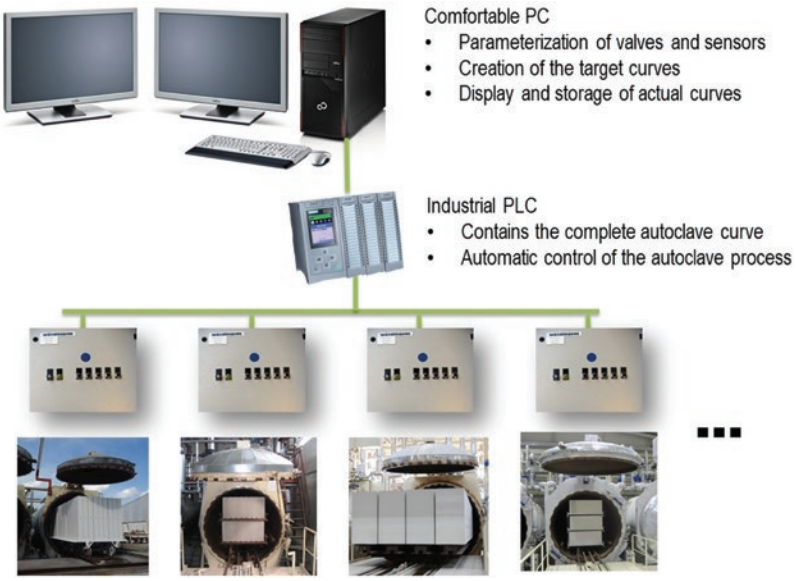
One for both: the combined Autoclave Control System for AAC and Sand Lime Brick production.



Graphical creation of setpoint curves by mouse movements or entering of values in a table.

Throughout the autoclaving cycle, the optimum pressure rise or pressure drop is precisely ensured so that the product quality is guaranteed at all times and product damages are prevented.
Faults and deviations are continuously monitored and re-adjusted in real time, while the PC only serves as data storage and for visualisation purposes for the operator. If the PC fails due to a fault, the PLC will automatically continue the autoclaving process! The PC could even be substituted during production. Changes in the visualization or in the database can be made during production.
The PLC also records the most important data of the steam boiler in order to ensure stable steam supply, or to react accordingly in case of steam deficiency.

Comfortable PC for monitoring and storage while the industrial PLC controls the valves and sensors.



Energy-efficient optimization

Steam transfer between the autoclaves

If the steam transfer is activated, the control system automatically checks whether steam from another autoclave is available. The steam can even be transferred from different autoclaves during a single autoclave cycle, so that a multiple transfer depending on the pre-set pressure difference is possible. Depending on the current market requirements, an efficient autoclave control system should provide the option to pre-select between capacity-optimized or energy-optimized operation.

Steam transfer from and to the steam storage

If steam storage facilities (e.g., Ruth accmulator) are available, the steam of an autoclave currently at the end of its autoclave cycle may be fed into that storage. Or, a rising autoclave may be fed from steam storage. The transfer from autoclave to autoclave is more useful from the energetic point of view, it can be easier to work with steam storage in case the timing between ramping up and down does not fit together (i.e. in case of different products with different autoclaving times). Often two storage facilities are used, one for high and one for low pressure.

Use of residual steam and/or condensate for a heat recovery system and building heating

The condensate and the residual steam should be intelligently used to facilitate best possible product quality and energy efficiency in the plant. Here, the preheating of the boiler feed water and hot water for the mixing process are important constituents of the energy saving potential. An effective quality and heat management concept also includes heating of the precuring area, the waiting area in front of the autoclaves and the social and office buildings.

Use of the exothermic reaction

A visible exothermic reaction indicates an excellent crystal formation within the AAC and a properly functioning pipeline and valve system. A key parameter in the process is the calculation of the "time x pressure product", the PTP (Pressure-Time-Product). Since the autoclaving process is determined by the pressure-time product, a consideration of the pressure increase associated with an exothermic reaction can be used to reduce the autoclaving cycle. This results in both energy and time savings, increases autoclave capacity and ensures consistently good quality through proper crystal formation within the AAC. In return, if the pre-set target pressure is not reached, the autoclaving time is automatically extended until the preselected PTP is reached again.

Product dependent automatic setting of autoclaving parameters

Due to the communication between the "autoclave control", "mixing control" as well as the "cutting line control", a product allocated autoclaving curve can be automatically chosen by the system. By the implementation of a Product Control and Information system (PCI) all product dependent parameters can be set automatically, thus preventing operator errors.

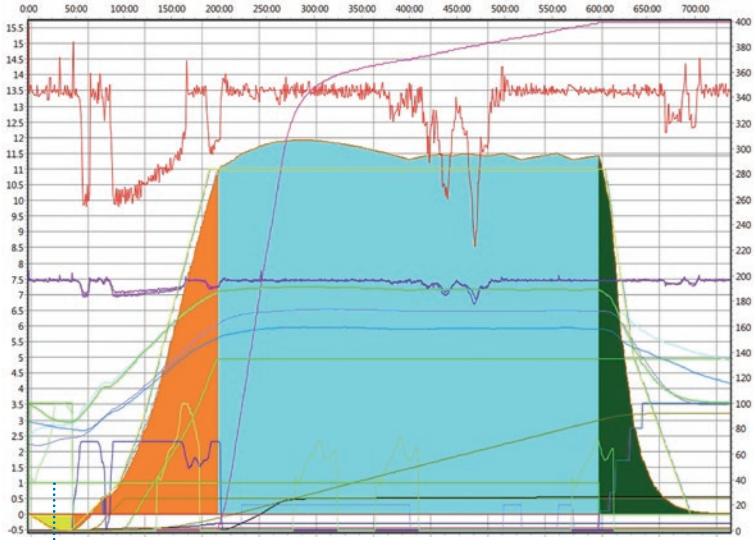
Transparent monitoring of all autoclaves and heat recovery systems

For quality assurance, all three target and actual curves have to be displayed online and stored permanently:

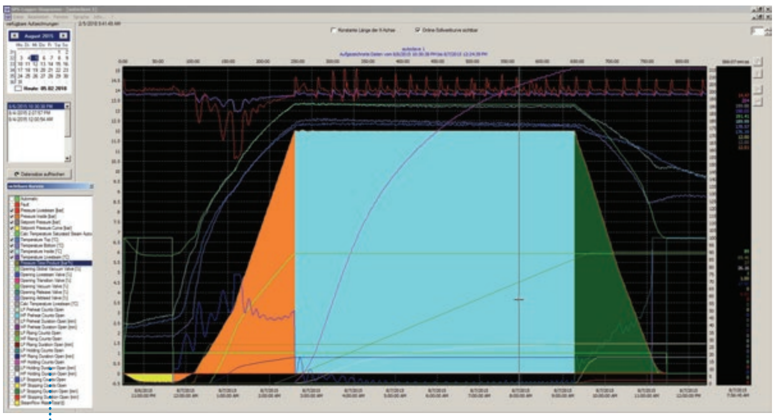
1. The entered product-dependent target curve
2. The automatically adjusted target curve due to faults, process-related deviations and exothermic reaction
3. The actual curve

For process monitoring, it is important that all three curves are displayed continuously, in real time and congruent. The operator needs to be enabled to see the curve before and after the actual time. Above all, the adjusted nominal curve shows how the further autoclave cycle will proceed and when it will be finished.

For subsequent analyses of the autoclaving process, the pressure profile of the live steam supply, drainage of the condensate, opening degrees of all valves and signals such as automatic mode or error message are stored in addition to all pressure, temperature, setpoint and actual curves. On the monitor, the operator can select and deselect all values individually for easier evaluation. Using a ruler function, each curve point can be read as a value. Zoom functions help to visually enlarge curve sections in order to examine individual areas or curve points even more precisely.



The use of an exothermic reaction reduces the autoclaving time and increases autoclave capacity.



A well-structured monitoring of autoclave curves and all process data is essential to analyse the autoclaving process.

In combined plants (AAC plus sand lime brick plants) it is advisable that each production line is equipped with its own PLC, while a combined visualisation allows a smooth change between the specific autoclaving curves of both production lines. This enables the operator to manage and monitor both processes simultaneously. The separation into two separate PLC systems enables modernisation or maintenance of one production line while the other can continue to produce.
Steam transfer from one production line to the other is possible thanks to the bus coupling of both PLC systems.

Data exchange with quality management systems and energy management system EnMS

A modern production plant provides a large number of measured values, plant data, production data and machine data, which show the condition and efficiency of the production plant or help to make the best decision for optimization. This requires a systematic analysis and processing of the data. Many

plant managers may feel overloaded by the comprehensive amount of data and wide data diversity and therefore they do not have the chance to profitably use the data provided.
Today computer technologies are able to store large quantities of data, allow access at any time and connect them very quickly. With mathematical algorithms completely unbiased contexts can be found which so long were supposed to be impossible. The prerequisite for this is that all product data are available in a unique database and can be linked together in any way required to form key performance indicators (KPI) or a systematic data analysis (benchmarking) can be performed.

Since the autoclaving process determines the quality of the product, it is important that the autoclave control reliably and sustainably stores all data in a SQL database. The same database in which the data from the other production steps (e.g. precuring, cutting, packing) as well as data from the raw material preparation and from the dosing and mixing system should be available. Through a unique cake ID all production data can be combined with each other, which further improves product quality and optimises the overall production process. All data in the data base or in CSV data format are available for the plant management system for further evaluation.
The connection to an energy management system (EnMS) is compulsory for energy-efficient and cost-optimized production. The measurement of steam, gas, water and electrical energy consumption is a pre-condition for the detection of leaks, correct cost allocation combined plants (AAC and sand lime brick) and may be used to prove energy consumption and energy saving measures to local authorities.

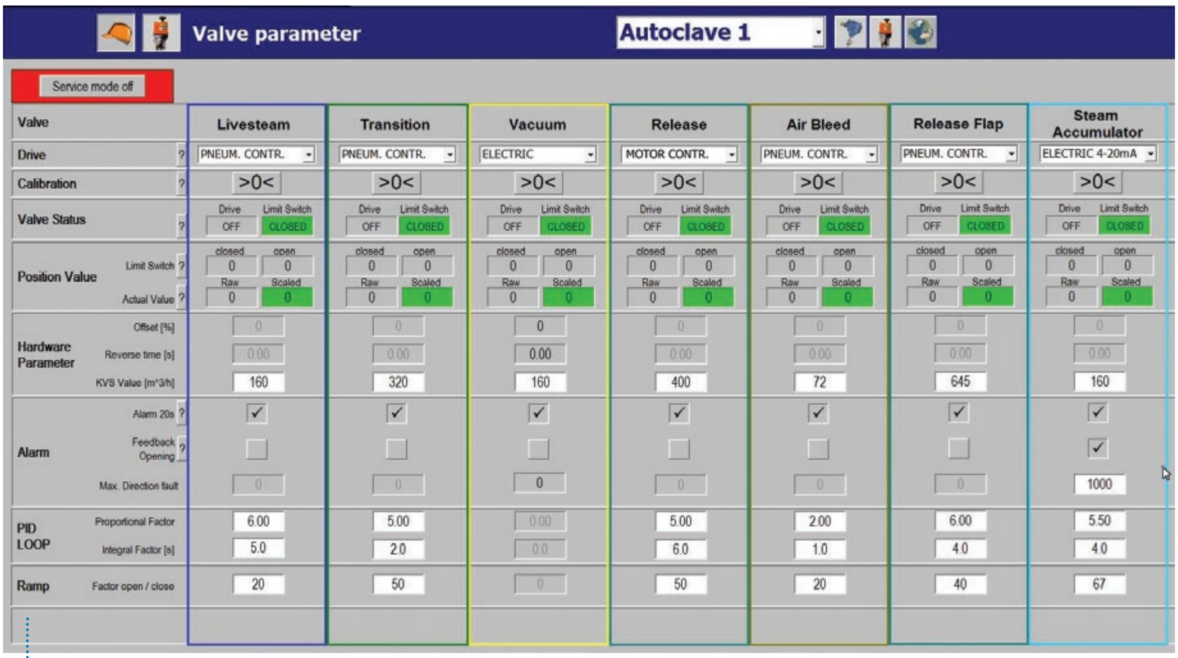
Further information about a modern Energy Management System EnMS will follow in one of the next issues of AAC worldwide.

Flexibility in the use of existing valve and measurement technology

Many AAC production plants also have sand lime brick production facilities. In addition, AAC companies worldwide run several production lines of different ages. Many years later, several production facilities are extended by additional autoclaves to increase productivity.
The different requirements between sand lime brick and AAC production as well as the technical development of valves and sensors leads to a mixture of completely different sensor and actuator types. It is not uncommon to find both motor-driven and pneumatically driven proportional valves to be installed in the same production plant. Even for temperature sensors, there are different signal transmissions, such as PT100, analog current signal, analog voltage signal and various bus transmission systems. A modern autoclave control provides the possibility to integrate different types of actuators and sensors.

Ensuring safety

A basic tool is the top/bottom temperature observation during the autoclaving process, since certain temperature differences in the autoclave must not be exceeded during the various autoclaving phases. The safety devices at the autoclave doors are also monitored. Without a proper signal, the autoclave cycle will not start and manual or automatic opening of steam valves is blocked, while condensate valves remain closed.



Flexible control system for different kind of valves and sensors.

Depending on the maximum pressures specified in the system, an excessive pressure increase in the autoclave is discharged through a valve in order to make it useable before the safety valve may respond and the steam is blown off the roof without the possibility of using it.

A return of steam from the autoclave to the steam boiler is prevented by monitoring the fresh steam pressure. Furthermore, there are various plausibility checks and lockings, such as contrary operating valves.

While the autoclave control system is a key factor, there are a number of other modules of the automation system in AAC plants, e.g. Energy Management, Service Interval Application and Dosing + Mixing System, etc. More reports will follow in the next issues of AAC worldwide.

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 27 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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