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Optimization of the production process increases plant capacity

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Within 5 years, the company Egoriewski Zavod Stroitelnyh Materialov (EZSM), one of the biggest AAC manufacturers in Russia, discovered the potential of the bouncing technology of the line Vario Block 1440 supplied by Masa GmbH. In close cooperation with Masa, EZSM could optimize the individual sections of production. Thus, the plant capacity and efficiency could be raised considerably.

In 2007, the shareholders decided to install a plant for the manufacture of autoclaved aerated concrete in Egorievsk (Moscow region). After analysis of the quotations of various suppliers, the German company Masa GmbH (formerly Masa-Henke) – one of the global market leaders for the development and supply of technology and equipment for the manufacture of AAC – was chosen as supplier. This decision turned out to be dead right. Unfortunately, the project had to be postponed due to the economic crisis 2008 - 2009. Assembly works started in April 2011. The first concrete blocks were manufactured in 2012.

The EZSM plant is equipped with a production line type Vario Block. The planned capacity is 1,440 m³ of aerated concrete per day. The special feature of this particular plant is the use of the bouncing technology. [1]

When production started, an average daily output of 1,100 m³ was achieved. The plant was in operation 24 hours with 4 shifts, the number of employees was 260. Approx. 190 - 200 cakes with a volume of 5.625 m³ each were cast per day, the monthly output added up to 30,000 m³. As per the recorded data, the cycle time was 7 - 8 minutes, the fermentation time of the cakes was 150 minutes. These figures indicate that the manufacturing costs were considerably higher than originally calculated, which meant a setback to the competitive position of the plant.
The achieved production volume of 75 % of the planned capacity could not be assigned to deficits of the machines and equipment but was a consequence of organizational aspects and insufficient qualification of the staff. Expectations in the performance of the plant had been very high, but they had to be scaled down. Despite the high degree of automation, the plant still has to be operated by humans, and the equipment can only be as good as the persons that operate it. It turned out that organizational problems and insufficient skills of the staff and not disturbances in the functioning of the machines turned up quite frequently and caused interruptions. Sometimes, just a few steps had to be carried out at the control desk to continue in automatic mode. This meant, however, that precious time was lost and the manufacturing process was disturbed. As a consequence of these findings, all employees were instructed and trained on the job so that they all had about the same skills. As a result of these measures, the required output of 1,440 m³ per day could be achieved.

2013 and 2014 were successful years for EZSM, the plant worked smoothly and the promised capacity could be achieved. However, this output was not sufficient to satisfy demand. Therefore, and in consideration of the potentials of the Vario Block line, the management set a new goal – to increase the output to 43,000 - 44,000 m³ of AAC per month. Subsequently, action was taken to increase the plant capacity beyond the originally planned volume and – as a side effect – reduce production costs. In the course of this process, the bouncing technology with its special characteristics turned out to be the key to success.

A catalogue of measures comprising approx. 80 points was developed. The main tasks were:

- Improvement of the manufacturing process
- Increase of the efficiency factor
- Rise in output (KPI)
- Modernization of the equipment
- Improvement of the plant organization, particularly further qualification of the operating personnel

At a production capacity of 1,440 m³, the fermentation time was the main obstacle to a rise in output. Between filling the moulds and cutting the first cake, there was a time gap that was used for maintenance works. It turned out that this gap was not required. For maintenance and cleaning of the equipment, there was an interim time in each shift that occurred when the block size or the required density of the blocks were changed, or when the mixer near the casting tower had to be cleaned. It was decided to cut down the fermentation time at the expense of a reduction of the water content in the water/solids ratio of the aerated concrete compound [2]. At this point, it became clear that our fermentation time is long enough for the bouncing technology.

The effect of the bouncing tables (fig. 3) remained questionable. Amplitude and frequency of the bounces was not too big. In rare cases, when a cake bypassed the bouncing table for technical reasons, no considerable differences compared to those cakes that had been bounced could be detected.

Mr. N. P. Sazhnew [3] and Ms. M. W. Katafaewa [4] provided great support with the analysis of the technical processes of the manufacture of AAC with using the bouncing technology and in the optimization of recipes. After adaption of the water/solids ratio and the adjustment of the bouncing tables, the fermentation time could be reduced (fig. 1).

Fig. 2: Dosing, mixing, casting: The complete mixing tower with its different levels is characterized by its compact design.

EZSM laboratory examined and evaluated the physical qualities of the products with big and with small pores. An increase of the compressive strength could be detected. All other characteristics did not deviate considerably. But the increased temperature effected a reduction of the consumption of the gas-developing agent by 3 - 4 % and an improved structure

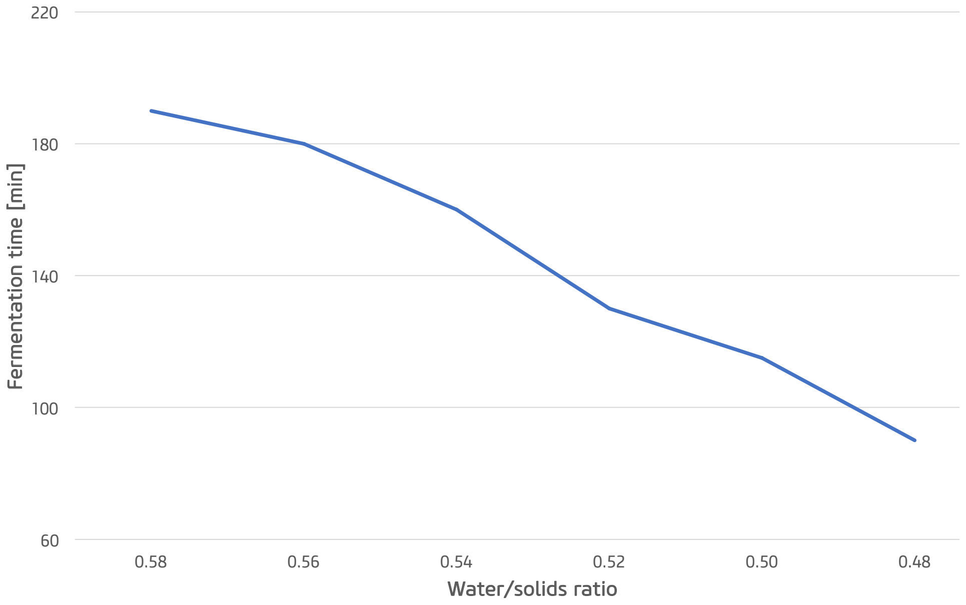

Fig. 1: Development of the fermentation time depending on the water/solids ratio

Fig. 3: After the filling process the filled mould is moved to the bouncing table

of the AAC compound at the contact surfaces to the casting mould. This was clearly visible along the edges of the casting mould. After the increase in performance and acceleration of the side plate circulation, the temperature of the side plate was high enough. This led to an acceleration of the fermentation process along the edge of the cast compound. At a distance of 20 - 50 mm from the mould wall, the structure of the compound had been macropore and fluffy before [5]. The higher temperature and the increased viscosity of the mixture at casting considerably reduced this defect.

Working with an adapted water/solids ratio improved the hardening parameters. The moisture reduction of the green cake to 27 - 30 % and the increase of the cake temperature shortened the hardening curves [6]. The pressure increase phase as well as the pressure keeping phase were adapted. Thus, the hardening process was steadier. The circulation system that is necessary for an increased efficiency could be adapted accordingly. Moreover, the cycle time of the steam transport was prolonged and the quantity of condensate decreased. This reduced the gas consumption of the steam plant by approx. 5 %.

A further increase of the production volume was postponed due to problems with the sand slurry for the manufacture of AAC with a higher density that needed urgent treatment. At this point of time, the mill worked at its maximum and the main motor at 85 - 95 % of its maximum. Once again, the bouncing technology was the decisive factor to solve this problem. The standards for the specific surface of the ground silica sand were defined anew. The quantity of grinding bodies was reduced and the capacity of the mill extended to 30 t/h. Thus, the raw material preparation section could be supplied with sufficient quantities of sand slurry. The load of the ball mill motor, however, remained on the same level as before. Due to the reduction of the specific surface according to Blaine from 2,400 cm^2/g to 2,100 cm^2/g for the block with density 600 kg/m^3, the slump of the compound was found to be higher than before, as expected. After the modification of the water/solids ratio and some process adaptions, a drop in density of the finished products could be avoided.

From time to time, EZSM faced problems regarding the constant supply of raw materials. Due to the increased production volume, some suppliers were not able to provide the required quantities in time. Therefore, it was decided to try other suppliers. These tests also served to find raw materials suitable for process changes and that could also help to improve the quality of the finished products and reduce

Fig. 4: When the mixing process has been completed, the casting device feeds the mixture into a casting mould.

the manufacturing costs. In a first step, due to the low water/solids ratio of the compound, the search focused on application possibilities of the grinding aids in the production process, specific surface, speed and temperature of slaking, normal density of the cement-water mixture, gas developing kinetics, and grain size of the gas developing agent.

The characteristics of the bouncing technology enabled an easy selection of cement, lime and aluminium combinations. The Process Engineering Department developed approx. 8 - 10 recipes for each range of density, considering the specifics and quality features of each supplier. Using the bouncing technology in particular helped to finally achieve some sort of raw material reliability and independence.

The optimizations definetely contributed to an increase in the plant performance beyond the planned capacity and also to a reduction of the production costs. The actual condition of the equipment and the disturbance statistics were analyzed and, based on these findings, the service intervals could be determined. A maintenance plan was compiled. This helped to use the available ressources efficiently and to reduce unscheduled standstill times of the plant to a minimum.

Further modernizations to improve the performance and the capacity and to reduce the energy consumption were carried out. The complete raw material transport was restructured. Reserve pipes to the feeding silos were laid, pneumtic pumps were installed, the sand supply system to the preparation tank (for subsequent feeding to the ball mill) was changed. New conveyor screws with higher capacities were installed, the oiling station was equipped with additional spray nozzles to accelerate the oiling process. The hydraulic system for the cranes was modified by the installation of additional pump stations and hydraulic oil coolers, a "summer/winter" function for the side plate buffer was added to the control system of the crane. To extend the cutting plant, an additional set of columns was installed, and under the block transfer device, a fifth sorting table was placed.

The modernization of the bottom cut processing plant was a special task [7]. In cooperation with a local company, the manufacture of fast wearing parts, such as stirring devices and certain types of running wheels for slurry pumps, and some bigger components was arranged. The combination of all these measures helped to achieve the required production level.

Fig. 5: Cutting line: As the aerated concrete block stands upright, it is possible to use short cutting wires. These enable highly precise geometrical cuts.

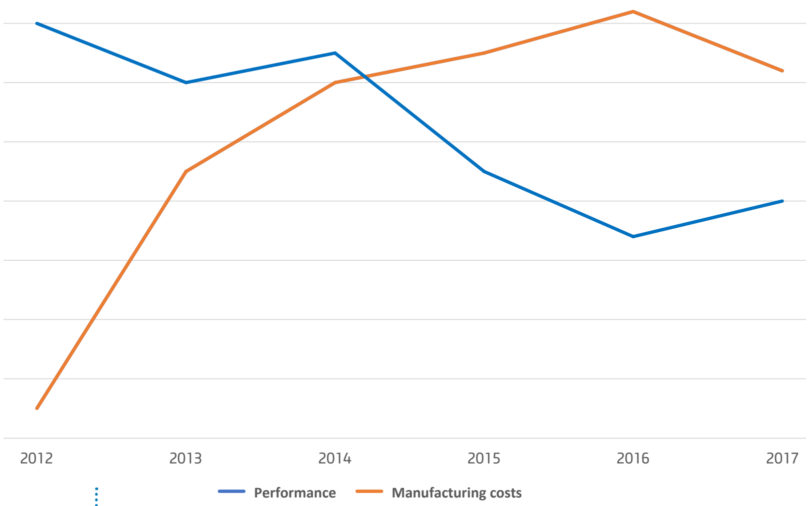

Fig. 7: Development of performance and manufacturing costs

However, the improved performance and increased output would not have been possible without adequate operating staff [8]. Therefore, particular importance was attached to staff motivation and training. The sequence of operations was defined, and operating instructions were issued for each section, including the obligation for examination of the process steps. An annual qualification test brought out possible weaknesses. The results of these qualification tests directly influenced possible bonus payments for each employee. The improvement of the technical knowledge of the staff and the motivation system turned out to be the decisive factors for a sufficient plant performance.

The implementation of the bouncing technology and the major part of the reorganisation and improvement measures were carried out 2015 - 2016. The cycle time could be reduced to 4.5 minutes. Now the raising of the compound on the two bouncing table does not take more than 9 minutes. The fermentation time is approx. 90 - 110 minutes, irrespective of the product density. Thanks to the appropriate selection of recipes and control of the raising process after casting, the change of raw materials did not cause any disturbances to the production process. The efficiency factor continuously remained on a level of 98.7 – 99.1 %. The capacity of the plant could be increased by approx. 8 %, and the total production costs could be reduced by 13 % (fig. 7).

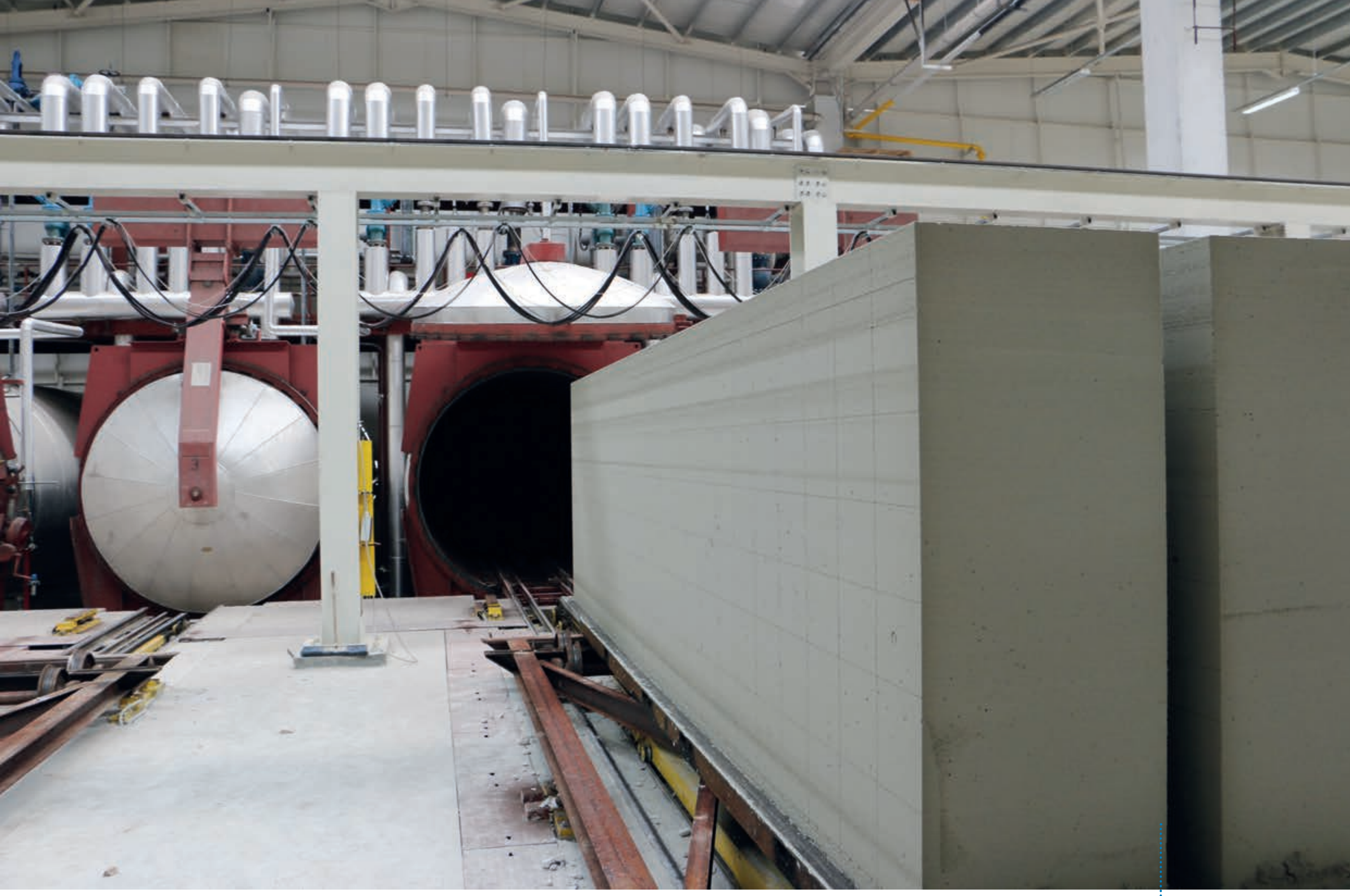

Fig. 6: Autoclave: The aerated concrete is hardened under steam pressure in special, sealed pressure vessels, the autoclaves, thereby achieving its final strength.

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