Technology and Automation of Non-Autoclaved Aerated Concrete Production

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Abstract. This article describes the technology and automation of non-autoclaved aerated concrete production. The proposed technology differs from traditional technologies by joint grinding of raw materials, which reduces production costs and energy consumption. Automatic control circuits for mechanisms executing technological operations are developed. Statistical analysis and verification of a non-linear multiple model confirmed the adequacy of the model: all regression coefficients are significant at the accepted level; all equations are significant; Gauss-Markov conditions are met; model specification is consistent with experimental data. It is possible to choose a composition of mineral additives that would provide the greatest strength of the cement matrix, solving the optimization problem with an equation corresponding to a certain mode of cement hardening. Such technology allows to get competitive high quality wall material, to reduce the cost of production by reducing the number of technological operations, for example, dry grinding of raw mix components, energy consumption and equipment for dry components grinding. The presented technology is recommended for design and use in the production of non-autoclaved aerated concrete wall blocks.

1. Introduction
Products made of cellular concrete are used in industrial and civil engineering in many countries and under different climatic conditions. Cellular concrete is one of the effective materials for enclosing structure, it is used both in the form of panels and in the form of small wall blocks, as well as in monolithic construction. Non-autoclaved aerated concrete have a low thermal conductivity and is made of available raw materials[1-5].

Literary analysis showed that the issue of developing optimal compositions and the influence of technological factors in the energy-efficient non-autoclaved aerated concrete production is very acute [4-15]. This paper presents the technology and automation of non-autoclaved aerated concrete production with dry components joint grinding[3]. The joint grinding of aerated concrete dry components, such as Portland cement clinker, gypsum stone, silica component and mineral additives (diopside) allows to get the wall material with a density of D600, class of strength B3.5 and thermal conductivity not exceeding 0.13 W / ( m • °C) [2, 3]. Based on the analysis of market and existing analogues, it can be concluded that the proposed walling material for identical density values has higher strength properties.
2. Mathematical processing of the research result

2.1. Production technology of non-autoclaved aerated concrete

The dry grinding of components is carried out in the ball mill 1456A with a capacity of 5 tons / h. Components beforehand are dosed in percentage ratio: Portland cement clinker – 27.0-28.5%, quartz sand – 31.5 %, gypsumstone – 2.27 %, diopside – 1.42-2.55 %. The crushed dry mixture is poured into a storage hopper and, after another dosing, into the aerated concrete mixer SMS 40B with a usable capacity of 5 m³. In parallel the aluminum suspension is prepared. Dosed aluminum powder and sulphanole, as well as water with a temperature not lower than 40 ° C, are placed in a dispersing mixer with a volume of 0.05 m³ and are mixed for 100 seconds.

![Functional diagramms auomation of non- autoclaved aerated concret production.](image)

In the process of recipes preparing, the water-solid ratio, the total content of solid materials, portions of clinker, quartz sand, mineral additive and gypsum stone are set. From these values, the required amount of water is calculated. The feed from the hopper and the dosing of grinded components is performed by the dosing screw, which serves as a weighing container, directly into the mixer.

Water is pumped, as well as water suspension of aluminum powder. The sequence of loading into the mixer is as follows: water, grinded dry components. After stirring the mixture for 3 minutes, an aluminum suspension is added, and then the mixture is stirred for 1.5 minutes. Accuracy of components dosing is 2%. The temperature in the mixer is 38-42°C. The total cycle of aerated concrete mixture preparation is 8.5 minutes.
Equipment set of this technology is shown in Figure 1. The set consists of six receiving hoppers (1) of various capacity, batchers for sand (2), clinker (3), gypsum (4), additives (5), aluminum powder (6), sulphanole solution (7), ball mill (8), loading screw (9), hopper (10) with a capacity of 15 tons for grinded dry mix storage, batcher of continuous action (11) for dry mix measuring and feeding it to the blender (15).

The preparation of aluminum suspension takes place in a dispersing mixer (14). The equipment also includes four pumps, two pumps (H1 and H2) feed heated water in doses to mixer (14) and blender (15), H3 and H4 pump water from the reserve hopper (12) to the storage hopper (13) and the aluminum suspension to the blender (15).

Asynchronous three-phase motors with power from 11 to 132 kW provide the electric drive of mechanisms. An electro-pneumatical and hydraulic locks with one-reverse drives are used as regulators. For technological needs, water with a temperature of 40-45 °C is used. Water treatment schemes can be various and are selected for each object taking into account the specifics of thermal energy sources (urban network, own boiler). In exceptional cases, an electric water heating may be used as an emergency option.

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**Figure 2.** Charts of contacting: a) weight head is sand batcher; b) limit switches of shutters; c) time relay.

### 3. Results

Production of aerated concrete is automated. The equipment diagram presented in Figure 1 includes automation:

a) loading components into feed hoppers, dosing, loading components into the mill;

b) components grinding, loading the resulting dry mixture into the storage hopper;

c) dosing supply of water to the mixer from the storage hopper and dosing supply of dry mix from storage hopper, blending with aluminum suspension and final mixing the aerated concrete mass.

In addition to the main process mentioned above, the process of preparing an aluminum suspension and feeding it to the mixer is automated.

Figure 2 shows three contact charts. In Figure 3 the electrical circuit for controlling the inlet and outlet shutters in the sand batcher is shown.

In accordance with the contact chart (Figure 2a) when emptying the dosing hopper (zero mass P0) the weight head SP1 contact closes. Then K1 relay turns on, K1.4 contact closes the AM2 (actuating mechanism) outlet shutter of batcher, K1.1 contact opens the AM1 inlet shutter. The vibrator in the feed hopper (not shown in Figure 1) turns on, filling of the batcher begins. When the dosing hopper is full (nominal mass PH), the weight head SP2 contact closes, voltage is removed from K1 relay, through the closed K1.2 contact the electromagnet YA2 is energized, as a result, the inlet (upper) shutter closes. At the same time, K1.3 contact commands to open the outlet (lower) shutter, it will happen if the inlet
shutter is closed (K4 contact is closed). The dispenser hopper starts emptying, it ends by closing the weighing head contact SP1 and repeating the cycle.

Figure 3. Automation scheme for dosing and loading of dry components into the mill: YA1-YYA4 – electromagnets of shutters; KK1-K6-intermediate relays; SQ1-SQ4- limit switches of shutters; SP1-SP2- contact of weighing dosing head.

Figure 4. Relay block scheme: SB1-SB2 – control buttons; K7-K15 – intermediate relays; KT1-time relays; SQ6- blender shutter limit switch; HA – electrinc bell.

Automatic interlocks that exclude the opening of outlet shutter while the inlet is opened (K3 contact is opened) and, conversely, opening the inlet shutter while the outlet is opened (K5 contact is opened)
are provided. This is achieved by installing the limit switches SQ1-SQ4 on the shutters, their opening contacts fix the position of shutters (opened - closed), and their closing contacts apply voltage to blocking relays K3-K6 (see chart on Figure 2b).

Figures 4 and 5 show control schemes of mechanisms that feed components of aerated concrete mix (water, dry mix, aluminum suspension) to the blender and their mixing. To perform these operations, the VS-10-64 six-program time relay is used, its contacts are set for the time corresponding to duration of these operations. Duration of components loading, their mixing and unloading is determined from specified (beforehand calculated) volumes of components, and also taking into account the efficiency of used mechanisms (pumps, dosing screw and blender).

SB1 button starts the mix cycle. At this time, the relay K7 turns on the magnetic starter KM1 of the pump H2, which supplies heated water to the mixer. Time relay KT1 is turned on, its contacts are closed successively (see chart on Figure 2c) and with the help of intermediate relays K9-K14 perform the specified operations. Two minutes after the cycle started, the closed contact KT1.1 energizes the relay K9, which turns off the pump H2 and turns on the mixer screw with continuous action. Within one minute, the required amount of dry mix is loaded into the blender, then the relay K10 by contact KT1.2 turns off the dosing screw. In the next three minutes, components are mixed, then prepared in the mixer aluminum suspension goes down into the blender. The contact KT1.3 of the time relay is closed and the pump H4 is turned on. After a short period of time, the pump H4 with contact KT1.4 is turned off.

Further final mixing of all components takes 1.5 minutes. The closed contact KT1.5 gives voltage on K12 relay, it turns off the blender and opens its outlet shutter. As the aerated concrete mixture is unloaded, the contact KT1.6 of the last (sixth) program commands to close the outlet shutter of the blender and, as the SQ6.2 limit switch is triggered, a signal sounds for the end of work. The time relay KT1 and all control intermediate relays are cut off power. The automation equipment is ready for the next mixing cycle.

Figure 5. Scheme for controlling the blender. Pumps and dosing screw: KM1-KM4- magnetic starters; KK1-KK2 – thermal relays; KK1- ime relays; SQ5-SQ6- blender limit switches.
This scheme can be accepted in the construction of a shop on aerated concrete production according to the technology developed by us. Technology allows:

1) to get competitive high quality wall material;
2) to reduce the cost of production by reducing the number of technological operations, for example, dry grinding of raw mix components, energy consumption and equipment for dry components grinding.

4. Conclusion
When complex mineral additives containing several components are introduced into the composition of cement materials, they can influence each other, enhancing or weakening the action of individual components. Thus, the authors studied the influence of individual mineral additives (diopside and limestone) and their complex on increasing the cement strength and established factors affecting this process.

Statistical analysis and verification of a non-linear multiple model confirmed the adequacy of the model: all regression coefficients are significant at the accepted level; all equations are significant; Gauss-Markov conditions are met; model specification is consistent with experimental data. It is possible to choose a composition of mineral additives that would provide the greatest strength of the cement matrix, solving the optimization problem with an equation corresponding to a certain mode of cement hardening.

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