

# Automation of the Technological Process to Produce Building Frame-Monolithic Modules Based on Fluoranhidrite

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**Abstract.** The paper first proposes the automation of the technological process to produce building frame-monolithic modules from production wastes, namely technogenic anhydrite and fluoranhidrite. A functional diagram of the process automation is developed, the devices to perform control and maintenance with account of the production characteristics are chosen.

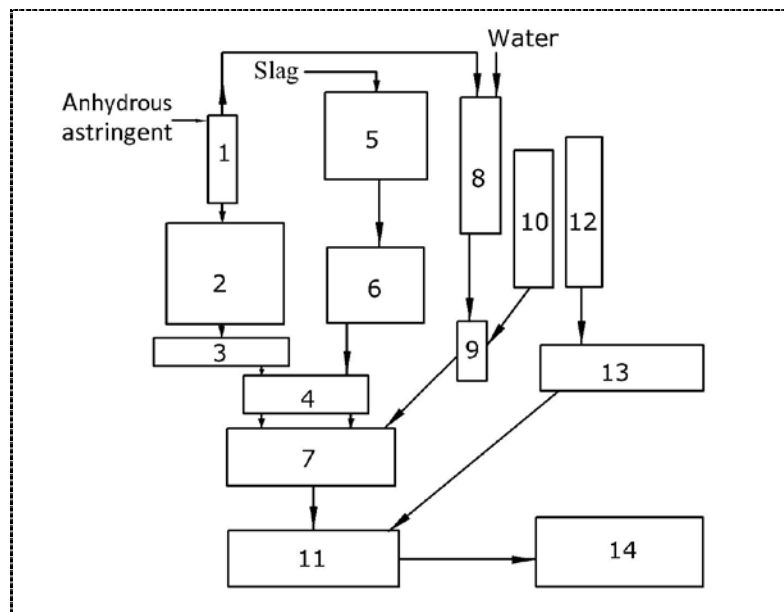
## 1. Description of the technological process to produce frame-monolithic modules based on technogenic fluoranhidrite

Fluoranhidrite is one of the most common wastes in the chemical industry. Scientists of TPU have proposed a new method for manufacturing of fluoroanhidrite-based building frame-monolithic modules.

The production scheme for anhydrite frame-monolithic modules (FMM) is shown in figure 1.

Anhydrous astringent (AA) produced from technogenic anhydrite unification is delivered to anhydrite astringent feed hopper 2 via the pneumatic pipeline through cyclone 1. From feed hopper 2, it is delivered to skip 4 via metering screw 3. The undersized fraction (less than 20 mm) of ash and slag is dumped into feed hopper 5 and delivered to skip 4 with metering screw 6. From skip 4, bulk materials are loaded into concrete mixer (CM) 7. A measured amount of water flows from tank 10 through batcher 9 to CM 7. To provide disposability of this technology, after cyclone 1, dust-loaded air is delivered to water absorber 8 (water is absorbent). After filling hopper 2, water circulating is stopped through absorber 8 and the pulp anhydrite suspended in water ) is delivered to CM 7 through batcher 9. After mixing, anhydrite-slag concrete is delivered to the inter-former space of the preassembled removable reusable formwork around the metal frame on the ground where the module is produced 11. The module frame is made on the ground for module metal frame production 13. The frame is made the rolled steel pre-delivered to warehouse 12.





**Figure 1.** Production scheme for anhydrite frame-monolithic module production: cyclone (1); anhydrous astringent feed hopper (2); anhydrous astringent metering screw (3); skip (4); ash and slag feed hopper (5); ash and slag metering screw (6); concrete-mixer (7); absorber (8); batcher (9); tank with water (10); ground for frame-monolithic module manufacturing (11); warehouse to store rolled steel and removable metal forms (12); ground for module metal frame manufacturing (13); warehouse for semi-finished-products –frame-monolithic modules(14).

To meet the requirements of the construction code in the production process, all stages of the process are to be controlled. For this purpose, first of all, the parameters that facilitate the start-up, adjustment and normal technological process are to be controlled. These are input and output parameters, and if they change, the object may undergo disturbing influence.

The parameters for frame-monolithic module manufacturing are as follows:

- anhydrous astringent weight in hopper No. 1;
- undersized slag weight;
- level of water in tank No. 2;
- water flow 5;
- anhydrous astringent flow rate;
- rotation of the concrete mixer shaft;
- mass level in the concrete mixer;
- the air pressure magnitude in the compressor receiver;
- vertical and horizontal position of the metal channels to weld the module frame;
- mass level in the inter-framer space;
- mass density in the inter-framer space.

Quality control of the wall material must be carried out through controlling the amount of water-soluble calcium sulfate in the technogenic anhydrite that provides binding properties of the anhydrite astringent on the one hand. On the other hand, it is necessary to control the amount of each component of the mortar within a single loading of the concrete mixer [1–7].

## 2. Selection and justification of the functional scheme for automated production of the anhydrite FMM

To be reliable, the hardware and software system should comprise at least three levels. The lower level contains sensors and actuators. The middle level includes a master controller. The operator's workstation with a personal computer is located at the top level.

The process of manufacturing frame-monolithic premise modules requires accurate dosing of basic components for the specified productivity, and accuracy in geometric spatial dimensions. Therefore, a functional scheme of the automation system should comprise a frequency converter, a contactor, a normalizing summing amplifier, an induction motor, a weight gauge, a metering screw, a feed hopper, limit switches, a laser level gauge, a radioisotope densimeter, a betatron, a manometer, a level gauge and a flow meter.

## 3. Selection of sensors and elements for the measuring system

To control the weight of the anhydrous astringent and undersized slag in the hopper, it is necessary to install at least three weight sensors, considering the weight of the hopper and the equipment fixed on it.

The normalizing device should comprise at least three inputs for the sensors capable of accumulating the input signals.

The limit switches VK-200 and the snap-action limit switches VK-300 are taken for the operation in the electrical circuits to control AC voltage up to 660 V, a frequency of 50–60 Hz, and DC voltage up to 440 V under the influence of the controlling stops (cams) at certain path points of the controlled object. These switches are resistant to splashes and spills of accidental water or oil [8].

BURKERT S030 flow meter is suitable for measuring the volume flow rate.

The radio-wave (radar) level gauges intended for a variety of process tanks (hoppers, reservoirs, silos), stationary objects, and for sending and receiving information using other technical means of automatic control systems are suggested for non-contact continuous measurement of the bulk and liquid levels.

The gamma densimeters, which provide the density measurements in the range of 600–2500 kg/m<sup>3</sup> with an error of no more than 2–2.5%, are suitable for measuring density.

The air pressure in the compressor receiver is measured by the manometer connected to the electrical relay circuit to control the compressor motor.

The geometric dimension control of each of the produced module frames is carried out using a laser level gauge, for example, BOSCH PLL 360 SET with a tripod: diameter working range is 20 m, measurement accuracy is 0.4 mm/m, laser beam projection is linear, number of beams is 2, laser beam alignment is automatic.

The betatrons, induction electron accelerators, are used to control the steel welded joints with a thickness of 100–900 mm. The betatron is a transformer with a primary winding fed by high voltage current, with a frequency of 50 Hz or higher.

Thus, implementation of the developed automatic system with the proposed equipment will enable the control of anhydrite frame-monolithic modules production to produce the construction products of high quality [8], and will allow the automation of the building construction in the construction industry.

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