

Using Mortar Mixing Pump for Magnesia Mortars Preparing and Transporting

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Abstract. The article is devoted to the problem of preparation and transportation of magnesia mortars with the help of screw mortar mixing pumps. The urgency of the wide use of mortars on magnesia binders (Sorel's cement) in construction is substantiated due to their high characteristics: strength, hardening speed, wear resistance, possibility of using organic and mineral aggregates, ecological purity and economic efficiency. The necessity for the development of a technique for calculating the main parameters of a mortar mixing pump for its application in the technology of preparation and transportation of magnesia mortars is demonstrated. The analysis of various types of modern mortar mixing pumps is given. The conclusions are drawn about the advantages and disadvantages of standard schemes. The description of the experiment for determination of the productivity of a mortar mixing pump is described depending on the plasticity (mobility) of the used magnesia mortar. The graph and description of the mathematical dependency of the productivity of the mortar mixing pump on the magnesia mortar plasticity are given. On the basis of the obtained dependency, as well as the already known formulas given in the article, a new method is proposed for calculating the main parameters of the screw mortar mixing pump in preparation and transportation of magnesia mortar: productivity, feed range, supply pressure, drive power.

The modern interest in alternative types of binders in construction can be compared with the interest in alternative (with respect to hydrocarbons) fuels. The essence is the same - experts, scientists and engineers are looking for the ways to make the construction industry more economical, efficient and less energy-intensive and material-cost. To date, providing the building complex with cheap, durable and environmentally friendly materials is one of the main conditions for the sustainable development of the world community. Therefore, the interest in familiar and forgotten traditional materials and technologies, such as magnesium binder, is not accident.

In many countries, partial replacement of the basic material - Portland cement with cheaper binders, the so-called "local materials" is practiced [1,2]. Leading scientists and practitioners in the field of construction called for their wide application. The production of such materials of local resources at the factories located in the immediate vicinity of the construction site is most often more profitable and allows a significant reduction in the cost of construction. And taking into account that the cost of materials is up to half the cost of construction, the expediency of such an approach becomes obvious [3].

At the same time, many scientists noted that many properties of materials and products based on caustic magnesite are better than Portland cement. They do not require moisture storage during



hardening, provide high fire resistance and low thermal conductivity, wear resistance, compressive strength and bending strength [4-7]. Magnesia concretes are characterized by elasticity, high early strength, lightness, resistance to the action of oils, greases, varnishes and paints, salts, they have bactericidal properties, etc. [8-11].

The magnesia binder (Sorel's cement) is a two-component material. The first component is caustic magnesite (MgO) which is a product obtained by firing at the temperature of 750-1000 °C natural magnesite (MgCO₃) and then grinding it to a powdery state. The second component is aqueous solutions of salts (MgCl₂, MgSO₄, FeSO₄ etc.) called sealers. When caustic magnesite is sealed with these aqueous solutions of salts, an artificial stone material is formed, characterized by rapid hardening and high strength [12,13].

The currently used technology for the construction of monolithic structures on a magnesia binder is based on the use of concrete mixtures. Preparation of mortars on a construction site is conditioned by fast setting time of the magnesia binder and is carried out in a mobile forced cyclic mixer from the pre-prepared and bagged dry mixture, which is sealed by aqueous solution of magnesium chloride of the required density [14,15].

The use of magnesia mortar instead of concrete allows to significantly improve the efficiency of monolithic structures technology without reducing their design characteristics due to a number of features: higher mobility, self-leveling ability, lower power requirements for mixing and transporting machines, lower energy consumption of work, etc. [16,17].

In this case, the most acceptable solution is the use, instead of mobile cyclic mixers, of mortar mixing pumps (plaster aggregates) of continuous operation with a screw pump, as machines that prepare and deliver mortar to the laying site through a mortar pipe. Such machines allow to combine three technological operations: preparation, feeding and laying the mixture, even in hard-to-reach and cramped places, and also to make this process continuous, which significantly increases labor productivity (in plastering, using such machines increases productivity 3-4 times).

In the domestic and foreign practice, mortar mixing pumps are used for plaster coatings and bulk floors from dry construction mixes.

The analysis of modern mortar mixing pumps of various manufacturers showed that, with similar overall dimensions and the same type of operation scheme, they differ in the layout of the main units, design and cost. The same scheme of work and the use of a screw pump in these machines provides high productivity, an average of 25-30 l/min, uniformity of feed and high quality of the prepared mortar [18].

To date, the market is widely represented by various models of such machines, differing in design and layout (Figures 1, 2).

The most efficient design is a machine with a screw feeder for feeding dry mixture to the mixing zone, as well as with separate drives for the dry mixture dispensing system and the system for mixing and pumping the material. The advantages of such a scheme are as follows: a screw feeder provides a continuous supply of dry mixture, which is reflected in the constancy of the composition of the prepared mortar; independent drives simplify the kinematic scheme, thereby increasing the reliability of the machine.

One of the limiting factors for the wide use of such machines in the technology of magnesia mortars is the lack of techniques for calculating the process parameters: productivity, feed range, supply pressure, drive power, average speed of the mixture, etc.

To solve this problem, the experiments were conducted on the effect of the plasticity of magnesia mortar on the productivity of a mortar mixing pump, as the most important technological parameter.

The scheme of an experimental installation for the study of the productivity of the mortar mixing pump is shown in Fig. 3. The water pump was connected to the tank with sealer. Aqueous solution of magnesium chloride with the density of 1.2 g/cm³ was used as the sealer. The dry magnesia mixture was prepared in advance in the required volume (mixture composition - magnesia cement: sand = 1:2 by weight), and was loaded as necessary into the receiving hopper of the machine. The required flow rate of the sealer was set on a special measuring scale of the flowmeter of the machine, depending on

the plasticity of the mortar that should have been obtained (120, 140, 160, 180, 200, 220, 240, 260 mm by the Suttard viscometer) [19,20]. A rubber-wool-based pipe with the internal diameter of 25 mm and the length of 10m before pumping the mortar was wetted with the mixture of the sealer and magnesia cement in the ratio of 1:4 by weight by pumping this mixture through the mortar mixing pump.

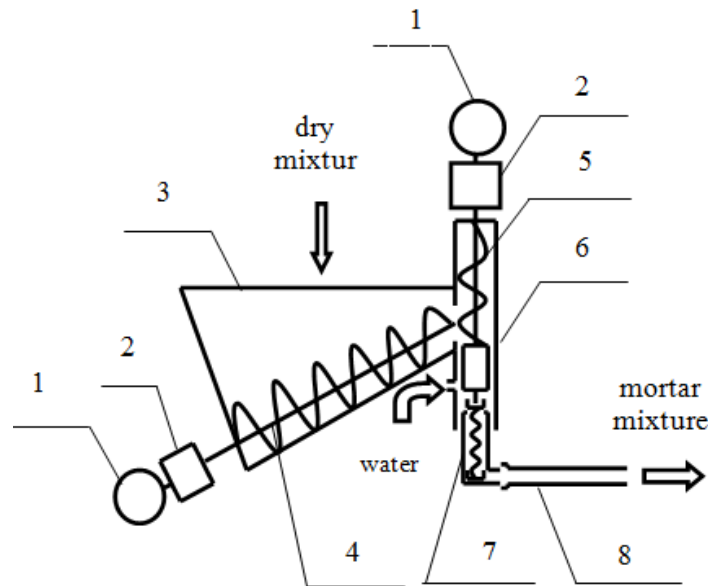


Figure 1. Kinematic scheme of a mortar mixing pump with separate drives for feeding dry mixture, mixer and screw pump equipped with a screw feeder. 1 - electric motor; 2 - reduction gear; 3 - dry mixture receiving hopper; 4 - screw or blade feeder; 5 - mixing screw; 6 - mixing pipe; 7 - screw pump assembly; 8 - mortar pipe.

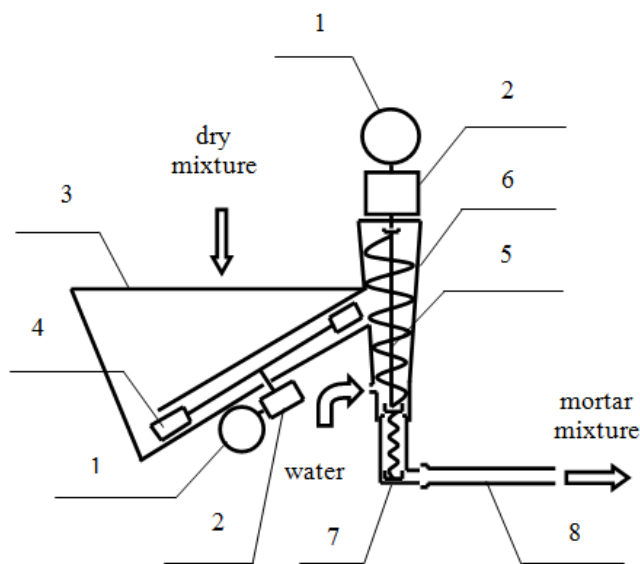


Figure 2. Kinematic scheme of a mortar mixing pump with separate drives for feeding dry mixture, mixer and screw pump equipped with a blade feeder. 1 - electric motor; 2 - reduction gear; 3 - dry mixture receiving hopper; 4 - screw or blade feeder; 5 - mixing screw; 6 - mixing pipe; 7 - screw pump assembly; 8 - mortar pipe.

The capacity of the mortar mixing pump was determined in liters per minute, as the arithmetic average for a machine running time of 3 minutes when pumping the prepared mortar into the measuring container.

Based on the results obtained, a graph was plotted (Figure 4), from which it can be seen that the dependency of the productivity of the mortar mixing pump on the mobility of the magnesia mortar is nonlinear and described by formula (1) with the accuracy of approximation of 0,9957

$$y = 4 \cdot 10^{-6} x^3 - 0,0011 x^2 + 0,1334 x + 7,9905 \quad (1)$$

where, y – capacity of mortar pump, l/min; x – mobility of magnesia mortar, mm.

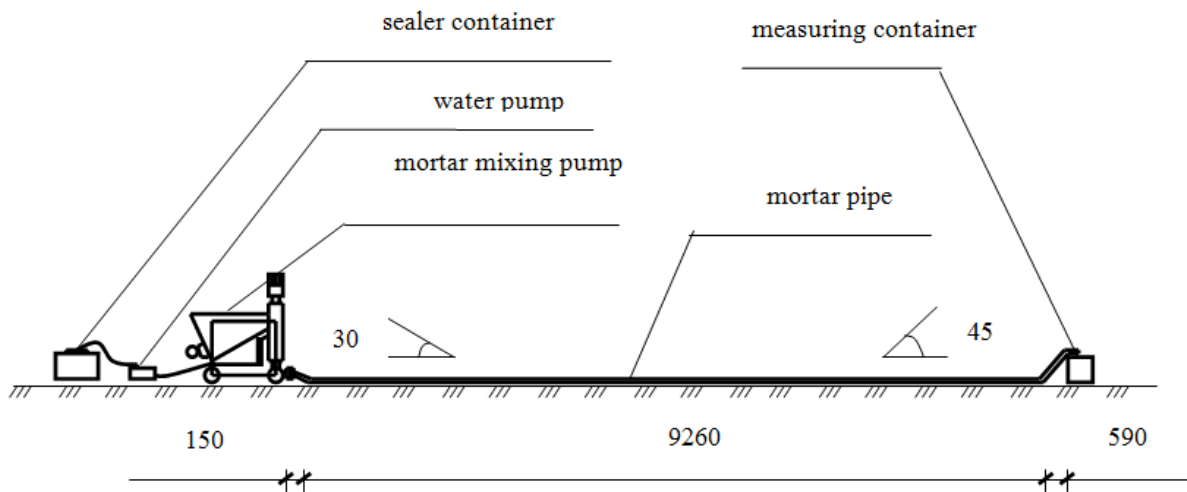


Figure 3. Scheme of the experimental installation for determining the dependency of the capacity of a mortar mixing pump on the plasticity of the magnesia mortar.

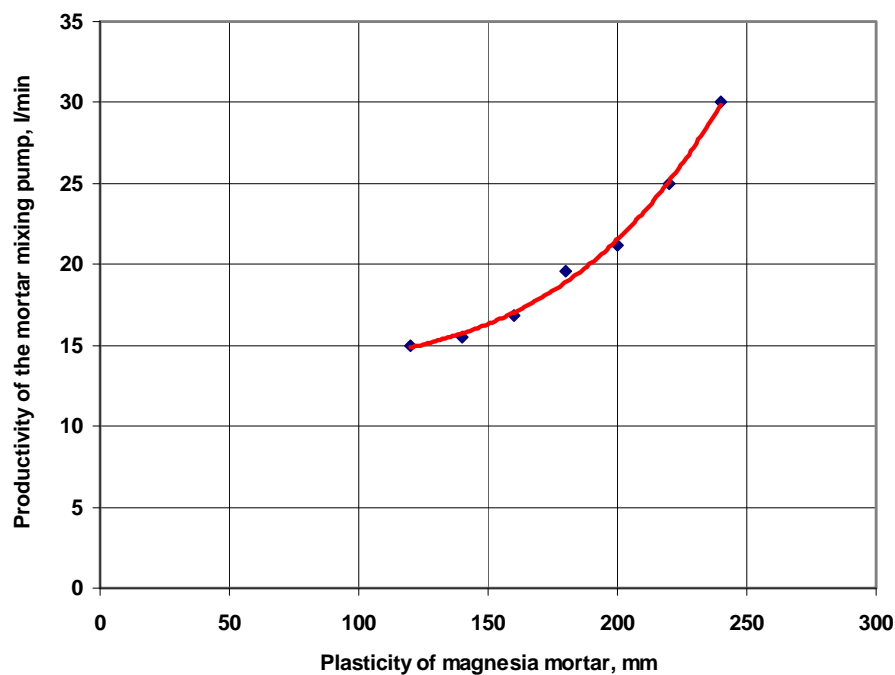


Figure 4. Graph of the dependency of the mortar mixing pump on the plasticity of the magnesia mortar

In addition to productivity, the important technical task that allows further constructive improvement of the mortar mixing pump and the optimization of the technology for preparing, transporting and laying the magnesia mortar is to determine the average speed of transportation of the mortar through the pipe V , and also to determine the required drive power of the screw pump, N . To do this, it is possible to use the existing mathematical apparatus [21].

The average speed of transportation of the mortar (V) through the pipe by means of a screw pump is determined by the formula:

$$V = \frac{y}{900\pi D^2} \quad (2)$$

The power of the screw pump drive (N), kW, is determined by the formula

$$N = \frac{PV}{1020\eta} \quad (3)$$

$$P = P_1 + P_2 + P_3 \quad (4)$$

where, η - the efficiency of screw pumps; P – total force of the mortar movement in the pipe, H; P_1 – force caused by the resistance of the mortar in the pipe, H; P_2 – force caused by the resistance from the weight of the mortar on the vertical and inclined sections of pipes, H; P_3 – force caused by the local resistance of pipes.

$$P_1 = 100\pi R^2 \Delta p L \quad (5)$$

$$P_2 = G \sin \alpha \quad (6)$$

$$G = 10^{-4} \pi \gamma R^2 L_1 \quad (7)$$

$$P_3 = \Sigma 10^{-4} \pi R^2 \xi V^2 \gamma / 2g \quad (8)$$

where, R – internal radius of the pipe, cm; L – total length of the pipe, m; Δp – hydraulic resistance to the movement of the mortar per 1m of the length of the pipe, MPa; G – gravity, H; α – angle of the pipe, degrees; γ – specific gravity of the mortar H/m³; L_1 – length of the inclined pipe, m; ξ – coefficient of the local resistance depending on the configuration and geometric dimensions; $V^2/2g$ – velocity head, m.

Thus, considering the analytical dependencies obtained, it was jointly possible to receive a technique for calculating the technological parameters of the mortar mixing pump - capacity, feed range, supply pressure, drive power, depending on the properties of the magnesia mortar, which, on the one hand, allows to design the technology for producing monolithic structures based on magnesia mortars, on the other hand, to design specialized mortar mixing pumps to work with magnesia mortars.

Acknowledgment

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