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Processes occurring in the contact zone of the working element of a machine with a plastic concrete mixture

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ABSTRACT:
The article presents an analysis of the operation of working elements of machines used for the surface treatment of concrete mixtures. The analysis of the phenomena that change the properties of processed materials in the contact zone of the working surface of the machining element and the surface of the processed material allows the determination of the dependencies of the parameters related to the shaping process of concrete surface treatment operations, especially the quality characteristics after processing. Therefore, attention was paid to the advisability of learning about these phenomena in the contact zone of the working element with the processed material in order to develop and select materials for the production of working elements of machines enabling the programming of the quality of the processed surface.

KEYWORDS:
surface treatment of plastic materials; technological transport of plastic material

1. Introduction

Examples of the analysis of working elements of machines and devices for surface treatment of concrete mixtures and other composite materials used during their transport are described in the literature [1-5]. During the contact process, processes occur that change the properties of the processed materials in the contact zone of the working surface of the machining element and the surface of the processed material. It is advisable to learn about these phenomena, especially in the contact zone of the working element with the processed material in order to develop and select materials for the production of working elements of machines enabling programming of the quality of the processed surface.

2. Description of the state of the structure using a work element with a work surface

When the working element moves on the treated surface of the concrete mixture, destructive processes occur, which are described by the laws of rheological processes. In practice, these processes take place in the slip contact zone of the concrete mix relative to, for example, concrete transport pipes (concrete pump). The most complex processes take place under the disc of the working element of a concrete surface treatment machine. Understanding these phenomena allows for a justified choice of materials when constructing such working elements. The size of the working elements of concrete surface treatment machines causes an impact on the surface layer of the concrete mixture to a depth of 8 mm - 46 mm, i.e. a size equal to 2-4 fractions of the thick filling of the concrete mixture. The nature of the deformation distribution is similar to

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a parabolic horizontal distribution. The maximum thickness of the plastically flexible layer is achieved when the concrete mixture is affected by a working element in the form of a disc, which has a high rotational speed and low translational speed. The minimum thickness of the flexible layer is characteristic of stiff, small-grained textures.

3. Analysis of the wall slippage of the concrete mix layer under the influence of the disk of the surface troweling machine

Basic deformations occur when the working element moves onto the surface of the processed material, and the concrete mixture is squeezed out of the processed surface in the form of a plastic mass, creating a layer of wall slip that facilitates the movement of the machining disc. When processing stiff concrete mixtures (not very plastic), there is a lack of plastic mass to create the so-called layer. Wall slippage occurs, which ultimately leads to a decrease in the quality of the processed concrete surface.

The layer of deformation that forms under the disc is shown in Figure 1, where a thin layer (0.2 mm - 1.8 mm) of wall slippage of the disc relative to the surface of the processed concrete is visible.

This allows us to draw a conclusion about the presence of a layer of wall slip and the turbulent nature of its movement when working with a disc between the flexible surface of the processed material. In this process, the machined surface is characterized by high smoothness of the machined surface.

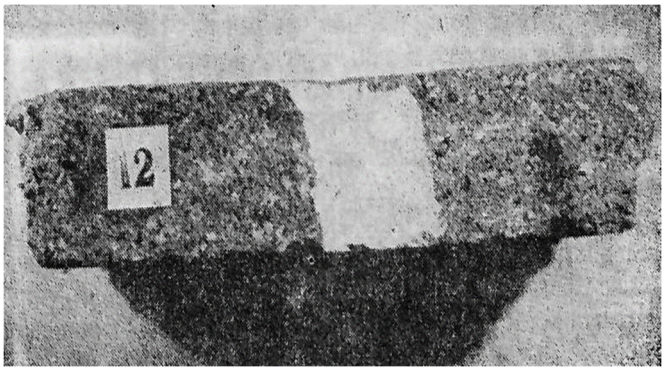

Fig. 1. The nature of the deformation of the layer created by the action of the disc on the plastic concrete mixture [2]

A small layer of wall friction shows the so-called dry friction, this process is characterized by the occurrence of a shiny surface of the steel working element, i.e. the disc. When processing more plastic concrete mixtures, the working element is covered with a layer of cement laitance. This allows us to conclude that there is a layer of laminar displacement of the concrete mass in the wall slip layer of the working element.

When processing highly plastic mixtures, an increased amount of concrete mixture is squeezed out of the surface, which reduces the quality of the processed surface. In the process of treating a concrete surface with a metal disc, due to the movement of particles towards the outer diameter of the disc, it was noticed that negative pressure forces occur under its surface.

4. Assumptions for the diagram of the impact of the disc on the processed concrete layer

The use of processing elements, for troweling concrete surfaces, made of materials with a high coefficient of friction increases the intensity of the process of troweling concrete surfaces.

Due to the thixotropy of the concrete mix, the turbulent boundary slip layer has a time-varying viscosity coefficient according to Reynolds [1], who determined that for liquids in turbulent motion, internal friction is proportional to the square of the velocity. From a physical point of view, this can be explained by the fact that as the velocity increases, the asymmetric particles are oriented along the axis along the flow length.

The amount of compliant material for the flow cross section can be determined from the formula:

$$Q_y = \vartheta_{p.0} \int_0^H 1 - \left(\frac{y}{H}\right)^{\frac{n+1}{n}} dy.$$

where:
$\vartheta_{p.0}$ – working speed of the machining disc,
$\left(\frac{y}{H}\right)$ – geometry of the layer susceptible to influence.

The amount of material passing through the elementary impact areas of the disk or the area of the smoothed surface was determined from the relationship:

$$Q_s = Q_y S_{p.0}$$

where $S_{p.0} = f(\vartheta_{p.0};\ \vartheta_3;\ B)$.

The optimal determination of Q_s ensures the achievement of smooth surfaces of processed concrete, or an increase in the decorative and functional properties of the treated surfaces.

5. Conclusions

- The purpose of the analysis is to determine the parameters of the working elements of discs made of materials with increased friction coefficient parameters, e.g. with adjustable hardness, in order to determine their selection to increase the quality of e.g. processed concrete.
- Steel discs for troweling concrete made of St3 steel guarantee the ability to achieve smooth surfaces of processed plastic concrete mixtures at low rotational speeds (30 rpm - 66 rpm) and low translational speed of 0.01 m/s.
- Possibility of analytically determining the optimal amount of plasticized material (concrete mix) in the so-called flow cross-section under the surface of the machined disc Q_y allows programming the quality of the machined concrete surface.

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Procesy zachodzące w strefie kontaktu elementu roboczego maszyny z mieszanką betonu plastycznego

STRESZCZENIE:
Przedstawiono analizę pracy elementów roboczych maszyn stosowanych do obróbki powierzchni mieszanek betonowych. Analiza zjawisk zmieniających właściwości obrabianych materiałów w strefie kontaktu powierzchni roboczej elementu obrabiającego z powierzchnią obrabianego materiału pozwala określić zależności parametrów procesu kształtowania operacji obróbki powierzchni betonu, a szczególnie cechy jakościowe po obróbce. Zwrócono uwagę na celowość poznania tych zjawisk w strefie kontaktu elementu roboczego z obrabianym materiałem, aby opracować i dobrać materiały na wykonanie elementów roboczych maszyn dających możliwość programowania jakości obrabianej powierzchni.

SŁOWA KLUCZOWE:
obróbka powierzchniowa materiałów plastycznych; transport technologiczny materiałów plastycznych