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About a Possibility of Usage of Sugar Beet Industrial Carbonate-Containing Byproducts in Dry Construction Mixtures and Oil Paints Manufacturing

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Abstract. The paper presents data on the research of the possibility of use of the carbonation sludge of sugar beet production as a filler in the building mixtures and oil paints production. Thermally modified carbonation sludge (TMCS) - a finely dispersed black material containing approximately 98% of $CaCO_3$ and up to 2% of amorphous carbon. It is shown that the obtained material belongs to the category of finely dispersed fillers, which corresponds to the requirements for plastering mixtures and mortars. Experimental samples of primers, floor leveling mortars and oil paints, made with the carbonation sludge, met the basic requirements for analogous industrial materials.

Introduction

The accumulation of industrial byproducts is traditionally one of the most pressing problems that affect all spheres of human life and all corners of our planet. The existence of the mankind itself in the future depends on the solution of this problem.

The only possible way to solve it is to improve production technologies and find the ways to maximize involvement of the secondary resources i.e industrial byproducts.

One of the most promising areas in the field of resource saving is the usage of byproducts as a raw material for the production of the various building materials [1-3].

The raw mineral material base of the construction industry currently consists of two types of raw materials: natural and industrial materials (industrial byproducts) [4].

The usage of natural raw materials is associated with the certain difficulties and material costs. With all the diversity, raw materials are deposited unevenly, which puts certain regions in a difficult position. The quality of the raw materials within the limits of one field fluctuates and, when the deposits are depleted, it is usually reduced. At the same time the industrialized regions generate a huge amount of byproducts.

A large amount of byproducts accumulated in a number of the leading industries indicates the incompleteness of technological schemes and the sectoral approach to the processing of the natural raw materials, aimed at extracting the target product only [4].

A lot of scientists around the world work at solving this problem. Studies show that it is possible to produce building materials from the wastes of different industries that are not inferior in quality to traditional ones [5-8].

In many types of the building products the fillers are more than half the mass. Thus, a large percentage of fine-dispersed fillers is used in production of building mixtures, paints, rubbers, products based on polymers, etc. [9-12]. Using industrial byproducts, suitable in the composition and physical and chemical properties, instead of the natural materials helps to reduce the cost of the final product and simultaneously reduces the amount of technogenic wastes disposals [13-17].

One of the large-tonnage byproduct generated in the agricultural and industrial regions is the carbonation sludge of sugar beet production that contains calcium carbonate and organic impurities (Fig.1) [18].

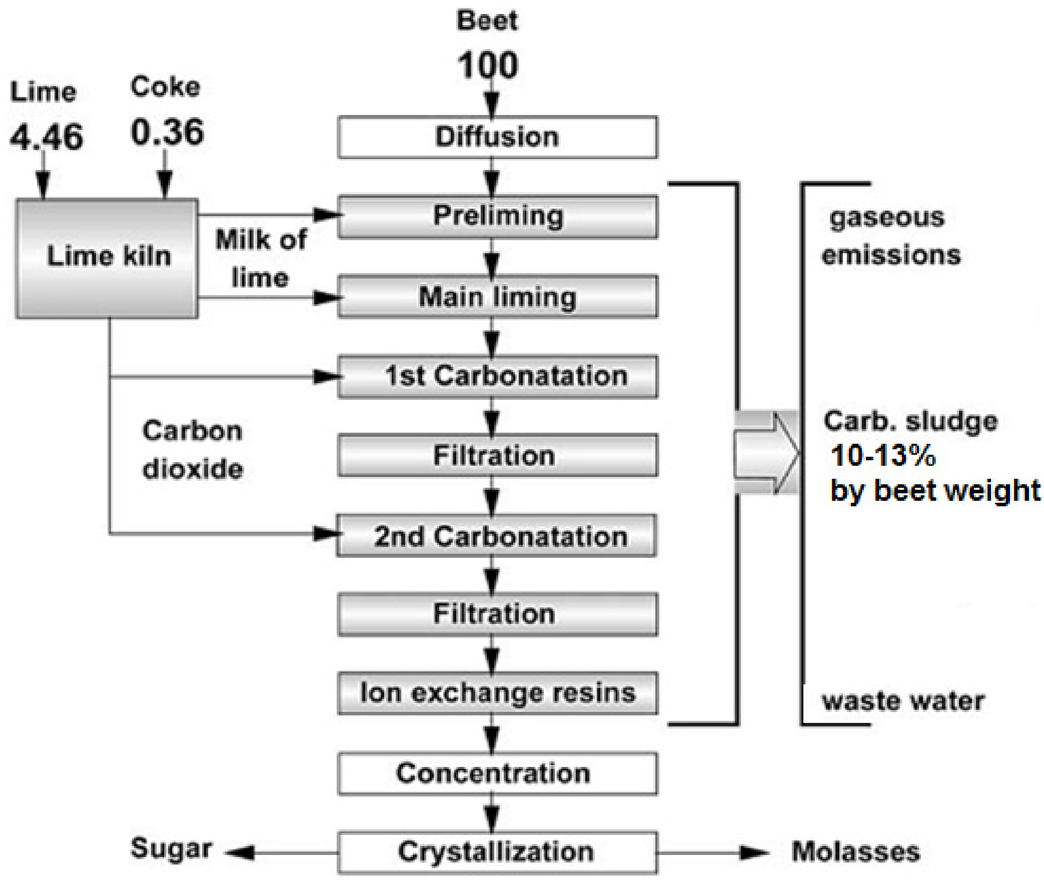

Fig. 1. A simplified scheme for production of sugar from sugar beet

Disposal of this waste is a topical problem, even if we take into consideration its suitability for use in agriculture (for soil deoxidation) [18,19].

Material and Methods

The test sample was undergone to the heat treatment with oxygen entry in the muffle furnace LOIP LF-7/13.

A laser particle-size analysis of finely dispersed powder materials was made on MicroSizer-201 by measuring particle size distributions in the disperse media.

Determination of the physical and mechanical characteristics of the fillers was carried out according to the standard methods: the content of volatile and non-volatile substances was determined in accordance with the State Standard (GOST) 10503-71 [20], compression strength was determined on a hydraulic laboratory press PSU-10, the main characteristics of the solidified mortars were determined in accordance with the State Standard 5802-86 [21].

Results and Discussion

The initial carbonation sediment is a finely dispersed, grey and yellow colored material, with moisture up to 25% and with an unpleasant odor.

The previous studies have made it possible to obtain a thermally modified carbonation sludge (TMCS) - a finely dispersed black material containing approximately 98% of $CaCO_3$ and up to 2% of amorphous carbon [22]. The resulting powder can be stored in dry conditions for a long time, without sticking together and decaying.

The heat treatment of the carbonation sludge, in accordance with the previously developed approach, is carried out at the temperature of 600 °C for 30 minutes. In this case, the dispersion of the sludge particles increases and the average diameter becomes 5-40 µm.

Based on the data of the structure and properties of the experimental dispersed material, it was suggested that it could be used in production of dry building mixtures, paints and varnishes as a filler and pigment.

Dry building mixtures are compositions which consist of a binder, an aggregate, a filler and chemical functional additives. The first three components represent a mineral base, the content of which in the total volume is more than 95% [23].

According to [24] TMCS belongs to the category of finely dispersed fillers, which corresponds to the requirements for plastering mixtures and solutions [25].

In order to prepare the experimental mixtures it was used the following formulation: portland cement - 21%; slaked lime - 5%; quartz sand - 46%; TMCS 20%.

The experimental samples were tested for compliance with the technical requirements first in the research and then in the production laboratories.

Some of the results of the building plastering mixtures tests are shown in Table 1.

Table 1. The building plastering mixtures tests results

Index	Values of indices for industrial mixtures	Mixture with TMCS
Compressive strength (MPa)	not less than 5.0	6.3
Bending tensile strength (MPa)	not less than 0.5	0.61
Adhesion (MPa)	not less than 0.5	0.58
Frost resistance (number of cycles)	not less than 75	78.0
Water vapor permeability (m^2h Pa / mg)	no more than 0.02	0.017
Wedge crack resistance, absence of cracks with layer thickness of (mm)	no more than 10	8.3

It was prepared the experimental samples of the building mixtures for flooring with complete replacement of the filler for the TMCS. The resulting dark grey mortar, after hardening, was tested for a number of indices for compliance with the standard requirements, some of which are shown in Table 2.

Table 2. The test results of the flooring building mixtures

Index	Values of indices for industrial mixtures	Mixture with TMCS
Compressive strength (MPa)	not less than 15	17.0
Bending tensile strength (MPa)	not less than 1.5	1.6
Adhesion (MPa)	not less than 0.5	0.6
Weight water absorption (%)	no more than 6.0	5.5
Wearability (g/$cm^{2)}$	no more than 0.8	0.7

On manufacturing paint and varnish products, a large number of fillers are used, which affect the color, transparency, material coverage and they reduce the oil vanish consumption.

To prepare experimental samples of oil paints the following industrial formulation was used: filler - 38%, chalk - 18.5%, siccative - 3.5%, oil vanish - 40%. The components were mixed in a beaded mill for 15 minutes, after that the paint was ready to use.

Since the TMCS was used as a filler, the resulting paint was dark grey. After preparation, it was applied over the glass plates for testing. Some indices are given in Table 3.

As a result of the studies it was found that the obtained samples correspond to the requirements for the industrial oil paints.

Thus, the thermally modified carbonation sludge is a promising material in the manufacture of building mixtures for plastering surfaces and floor leveling, as well as in the production of oil paints.

Table 3. The experimental results of the oil paint produced with the TMCS

Index	Values of indices for industrial oil paint	Paint with TMCS
Color	Dark grey	dark grey
Appearance of coating	After drying, the surface should be smooth	Corresponds to
Mass fraction of non-volatile (%)	not less than 60	71
Dilution rate (%)	no more than 20	17,5
Hardness (conventional units)	not less than 0.15	0.23
Drying time at 105ºC (minutes)	no more than 35	35
Drying time at 20ºC (hours)	no more than 24	1 h 25 min
Impact strength (cm)	not less than 50	50
Adhesion (score)	no more than 1	1
Bending film elasticity (mm)	no more than 1	1

Conclusion

The experimental dispersed material, obtained from the solid carbonate-containing byproducts of the sugar industry, has a great potential as a component in the production of dry building mixtures for various purposes and oil paints. Experiments conducted in research and industrial laboratories have shown that experimental samples manufactured using the TMCS meet the standard requirements.

The usage of the carbonate-containing byproducts as fine- dispersed filler will reduce the technogenic environmental stress and reduce the fertile land alienation, which are used for wastes storage.

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