International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 02 ISSUE 11 Pages: 50-59
SJIF IMPACT FACTOR (2021: 5.478) (2022: 5.636)
METADATA IF – 7.356
ISSN-2750-1396

Journal Website: http://sciencebring.com/index.php/ijasr

Research Article

DRYING OF RAW MATERIALS OF CEMENT PRODUCTION IN THE DRUM DRYER

Submission Date: November 05, 2022, **Accepted Date:** November 15, 2022,
Published Date: November 28, 2022
Crossref doi: https://doi.org/10.37547/ijasr-02-11-08

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ABSTRACT

The article investigates the drying process of the raw material component - loam, a technological line for the production of cement inLLC “Turon-ecocement group”, experimentally determined kinetic curves of drying, andchange in the temperature of the drying agent and the material being dried along the length of the drum at its various initial values.

KEYWORDS

Loam drying, kinetic curves, temperature curves, moisture content.

INTRODUCTION

The development of the production of the construction industry is inextricably linked with an increase in demand for products of the cement industry with a simultaneous increase in the requirements for the quality of the goods. One of the ways to reduce the cost of production is to reduce the most significant cost items for production, therefore, from a scientific and

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practical point of view, energy-intensive and lengthy processes are of the greatest interest. One of such technological processes in the cement industry is drying in drum dryers, where its mode is influenced by many factors that affect energy costs in different ways. Since a significant amount of heat is spent on the evaporation of the liquid, and, accordingly, significant energy costs are required, the problem of assessing the operation of existing equipment and choosing the optimal drying mode,

At present, the increasing requirements for saving fuel consumption make it necessary to process, in the dry process of cement production, raw materials with ever higher initial moisture content. On the other hand, such materials are characterized by reduced density and, accordingly, strength. Preliminary grinding of such materials is advisable to carry out in grinding mills, which allow processing raw materials with a moisture content of up to 10%. However, the raw material does not have time to dry completely, and in the future, before fine grinding and mixing of the components of the raw mixture, it is necessary to dry the raw material to a moisture content of not more than 3% in a drying drum.

Main part

The kinetics of external heat and mass transfer during the drying process is determined by a change in the concentration of moisture vapor across the boundary layer and a change in the temperature of the drying agent near the surface of the wet material. The difference in concentrations creates a vapor flow from the surface, and the temperature difference between the bulk of the drying agent and the surface of the material ensures the supply of heat to the wet material [1]. Analytical consideration of the external problem of heat and mass transfer in drying processes, taking into account the mutual influence of numerous determining factors, is currently difficult due to the complexity of determining the kinetic coefficients and driving forces of real drying processes [2].

Since drying is a heat and mass transfer process, its complete mathematical description includes differential equations for both heat transfer and mass transfer in the boundary layer [9, 92]. However, due to the complexity of such a mathematical description, the difficulty of determining and the inconsistency of the coefficients characterizing heat and mass transfer, it is not possible to complete the solution of the system of differential equations without simplifying assumptions [2, 10].

When creating a mathematical model of a drum dryer, it is natural to consider its design characteristics unchanged. Some technological parameters of the dryer, for example, the number of revolutions of the drum and the angle of inclination of the apparatus, should also be considered constant, since they change very rarely. Thus, as changing operating parameters, we take the change in temperature and moisture content of the material and air at the inlet to the dryer.

Experimental studies

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The most common raw materials for cement production in Turon-ecocement group LLC, such as loam and limestone, were used as drying objects, which in most cases are dried in a drum dryer.

Experiments to study the kinetics of convective drying of loam and limestone were carried out on a specially designed laboratory drum plant, a schematic representation of which is shown in Fig. 1.

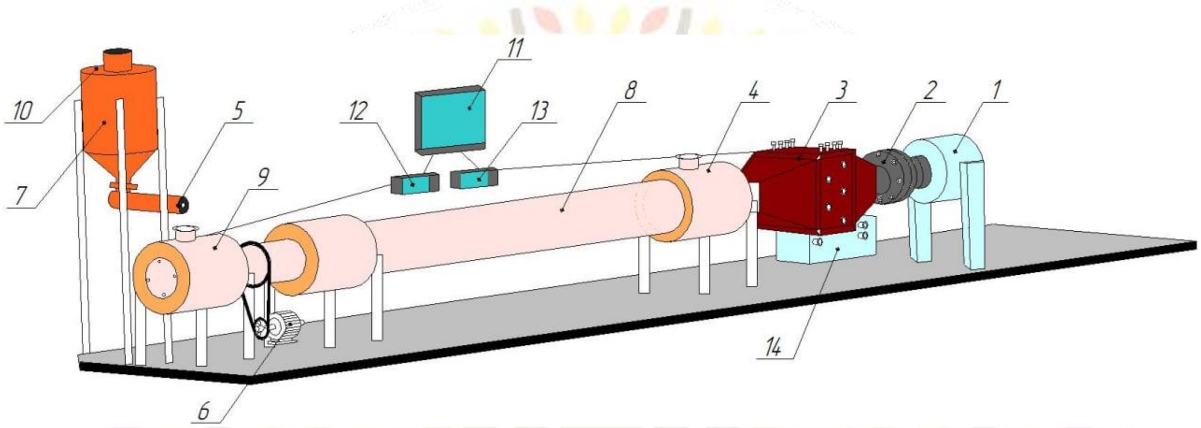

Figure 1. Scheme of the laboratory device:

1 fan; 2-diaphragm; 3-heater; 4-exit chamber; 5-screw feeder; 6-electric drive; 7-bunker; 8-drum; 9-loading chamber; 10 mixer; 11-computer; 12-heat converter; 13-temperature control device; 14 - gas reducer.

The working chamber of the installation was a rotating drum with a diameter of 0.16 m and a length of 2.00 m. At both ends of the drum there were chambers 4 and 9, one of which provides for the loading of wet material and the removal of the spent drying agent, and the other for the exit of the dried material and the entry of hot gases. The drum was driven by an electric motor 6 through a gearbox 14 with a stepwise variable speed and a chain drive. To mix the material inside the drum, nozzles were located along the entire length.

The air sucked in by the fan is used as the drying agent. Passing through the heater 3 where the air was heated due to the combustion of hydrocarbon fuel and then entered the drying drum. The preset temperature of the drying agent was maintained using an on-off controller 13, which is connected to a controller that allows you to step by step change the power of the heater 3. Thanks to this scheme, temperature fluctuations were reduced during its regulation.

The flow rate of the drying agent was measured by measuring diaphragm 2 with the measurement of the pressure drop across it using a two-fluid (kerosene-water) differential manometer, which made it possible to measure the pressure drop with an accuracy of 50 Pa.

The supply of wet material to the dryer drum was carried out from the hopper 7 by the screw 5, which was driven by a geared motor with an adjustable speed. The change in the productivity of the auger 5 was ensured by regulating the number of revolutions by changing the voltage on the rectifier 15. To ensure stable uniform operation of the dispenser, an agitator 10 driven by a gear motor was installed in the hopper.

Measurements of the temperature of the material and drying agent were carried out by thermocouples ChC (chromel-copel) through a digital six-channel temperature indicator IT-6-6 12, which has a measurement accuracy of ±0.2°C.FixiroThe temperature reading was carried out every second and transmitted to the computer via the RS-485 interface via the RSA-01 network adapter.

The appearance of the installation is shown in fig. 2.

Figure 2. Appearance of the installation.

Temperature, pressure and relative humidity of the ambient air. Before the start of the experiment, the consumption of the drying agent and its temperature was determined by the

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requiredmpowerheating and the corresponding sections of the heater were connected on the control panel. The material to be dried was pre-moistened with water to a predetermined moisture content. For faster access to the stationary mode, the drying drum was preheated. Heating was carried out at a given flow rate of the drying agent and the required temperature was established. The flow rate was monitored by a differential pressure gauge and regulated by changing the voltage at the LATR of the vacuum cleaner. The desired temperature was set using the buttons on the control panel. After the end of the heating of the drum, the wet material was loaded into the feed hopper and the rotation of the drum was turned on. The set parameters of the drying mode were finally checked, the temperature of the material was determined,

The installation was put into stationary mode. The mode was considered steady when the temperatures of the drying agent and material at the outlet of the dryer did not change. After the onset of a steady state, the temperatures of the drying agent and material were measured along the length of the drum using thermocouples fixed on the rod at a certain distance from each other. Then, using a special sampler, samples of the material were taken along the length of the drying drum and placed in glass bottles. The residual moisture content of the material was determined by the method of drying in an oven at a temperature of 105°C.Weighing was carried out on electronic scales. After the measurements were taken and the sampling of materials was completed, the supply of material, the rotation of the drum, the heating of air, its supply were turned off, and the power to the devices was turned off. The material remaining in the drying drum was collected in a separate container and weighed.

ANALYSIS

The analysis of the results of the experimental study was carried out in order to identify certain patterns of the process and to verify the adequacy of the analytical dependencies describing the kinetics of drying of dispersed materials under various drying modes.

The nature of drying studies was identified and evaluated by graphical dependencies. The results of the study of the kinetics of drying of dispersed materials upon removal of water from them were analyzed using the example of drying loam according to the calculated and experimental curves of changes in the moisture content and temperatures of the drying agent and material. The analysis of the results was carried out to identify the influence of the initial temperature and the consumption of the drying agent on the process. Let us first evaluate the effect of temperature on the nature of the drying process. 3 - 5 shows the dependence of the change in the moisture content of loam, its temperature and the drying agent on the initial temperature of the latter. The wet material had an initial temperature ranging from 20 °C to 22 °C. The initial moisture content was set equal to 20% ± 0.5%

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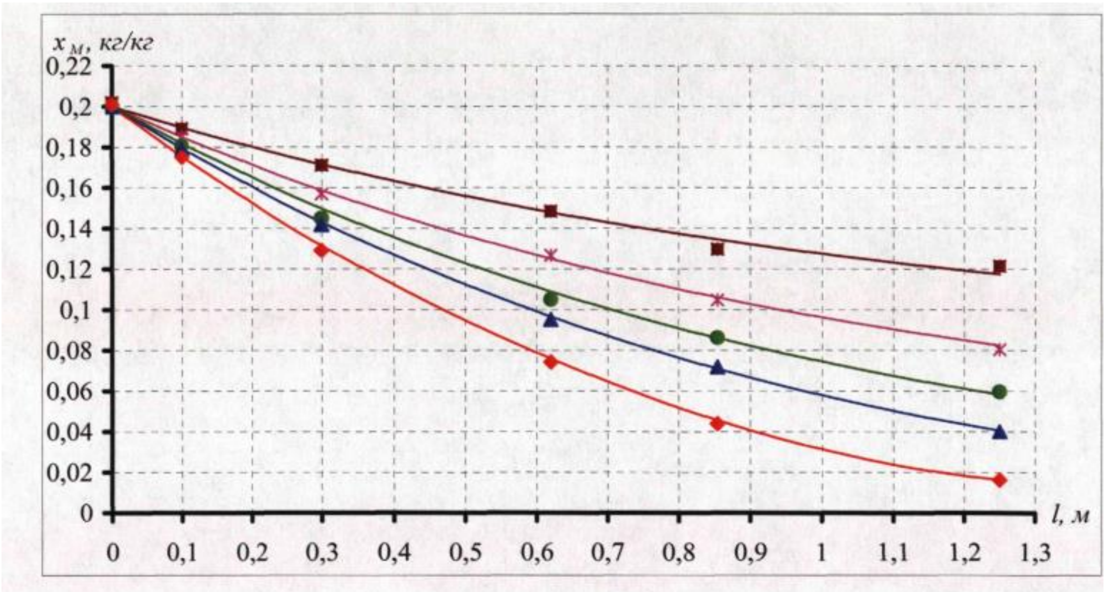

Figure. 3. Changemoisture content of the material along the length of the drum at different initial temperatures of the drying agent: 1 - 175 ℃; 2 - 150 ℃; 3 - 135 ℃; 4 - 115 ℃; 5 - 85 ℃.

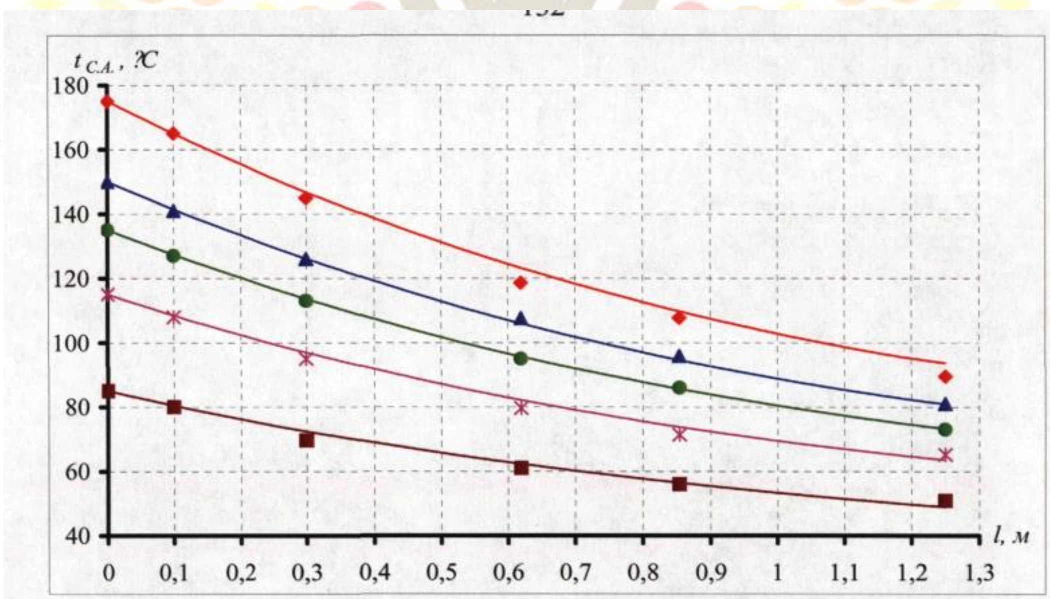

Рис. 5.5. Изменение температуры сушильного агента по длине барабана при его различных начальных значениях:
175 °C; 150 °C; 135 °C; 115 °C; 85 °C

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Figure. 4. The change in the temperature of the drying agent along the length of the drum at its various initial values: 1 - 175 ℃; 2 - 150 ℃; 3 - 135 ℃; 4 - 115 ℃; 5 - 85 ℃.

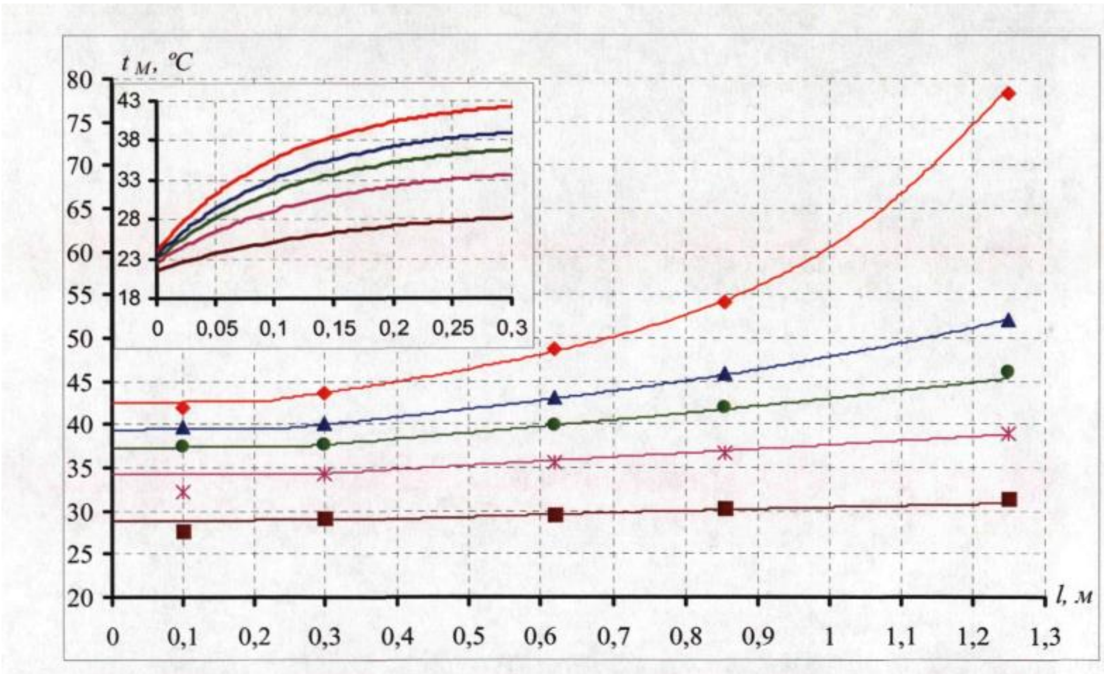

Figure. 5. The change in material temperature along the length of the drum at different initial temperatures of the drying agent: 1 - 175 ℃; 2 - 150 ℃; 3 - 135 ℃; 4 - 115 ℃; 5 - 85 ℃.

On these graphs, the points represent the results of experiments, and the lines represent the calculated dependencies obtained from the mathematical model.

The analysis presented in fig. 3-5 dependencies shows that forloam the drying process takes place mainly in the period of removal of bound moisture. Drying experimentsloam it can be noted that at a fairly high initial temperature of the drying agent, the period of removal of bound moisture is more clearly manifested, which is noticeable by a sharp increase in surface temperatureloam and slower drying.

The analysis of mathematical modeling of the heating period shows that the temperature of the material in the central layers of the particle during the drying process lags behind the temperature of its surface.

Conclusions

Comparison of experimental data with the results of mathematical modeling and graphical processing revealed a slight difference in the degree of compliance of real processes with regularities. The deviation of the experimental data from the calculated ones did not exceed 5%.

The results of the study of the kinetics of drying of dispersed materials upon removal of water from them were analyzed using the example of dryingloamaccording to the calculated and experimental curves of changes in moisture content and temperatures of the drying agent and material. The analysis of the results was carried out to identify the influence of the initial temperature and the consumption of the drying agent on the process.

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