

R.V. KOLOMIYETS

(Ukraine, Dnepropetrovsk, Institute of Technical Mechanics of NASU and SSOU)

DRYING OF THE DISPERSE MATERIAL IN THE AERO SPOUTED BED WITH HORIZONTAL MATERIAL MOVING

Introduction. Drying of materials is widespread operation in preparatory and final processes of mineral processing. A drying process intensification problems are very important in drying equipment. It is connected with that this process is quite power-intensive, in particular, about 10% of extracted fuel are spent for drying, and costs of the organization of drying have considerable part in prime cost of a product. Besides, production and quality of received products is defined substantially by the correct dehydration process organization. Now a significant amount of drying unit types is developed, that is connected with various physico-mechanical properties of materials and requirements to the final product.

Analysis of the previous researches. Now about 90% of all concentrating factory products, chemical and other productions dry in drum dryers which possess a number of shortcomings [1]: lack of humidity control and material temperature during its movement leads to uneven heating of a material layer and an overheat of separate small fractions. The drum dryer disadvantages are also small surface of a mass exchange and consequently, low drying intensity, low moisture tension (from 10 to 60 kg/m/h) that result bulkiness and high metal consumption.

On the basis of the vibro drying plant realizing the vibro boiling layer, the energy saving way of drying [2] is offered. The advanced way allows to maintain the constant critical temperature of the energy carrier during material drying and to delete the fulfilled damp energy carrier, and also to control process by change of technological parameters in each stage.

There are a number of the methods accelerating heat and mass exchange processes in the drying process and allowing to reduce the volume of drying plants, their metal and fuel consumption. The special attention is paid to pipes dryers which use for an intensification of the materials drying process containing poorly connected moisture: sulfide concentrates, coal, asbestoses ores, etc. In these devices the active aerodynamic mode is created, allowing to increase drying speed at the expense of increase in relative speeds of movement phases that is reached by increase of the energy carrier speed and by a disperse material braking. At the same time there is an increase of a material concentration in device unit of volume, hence a surface increase of a material dehydration.

Recently in industrial practice the suspended layer technology (boiling, spouted, fluidized) as one of an effective drying method of poly-dispersed materials of the different nature (grain crops, various ores and concentrates, chemical materials, etc.) has been widely used.

Introduction in the industry this new progressive technological method of firm

Зневоднення та сушіння. Водно-шламове господарство

and gas (liquid) phase interaction allows replacing some periodic processes by continuous. Besides, it is possible to reduce processing duration of these or other materials by higher speed use of material streams, and also to automate process. Thus, conducting technological processes in the boiling layer makes it possible to raise not only plant volume efficiency, but also labor productivity.

Depending on nature of grain boiling (pseudo-liquefaction) and the corresponding device designs the spouted layer subdivide into a number of the types having corresponding names: the boiling (BL), blanket and their various modifications. Due to the fluidity of BL it is called also fluidized. Circulating movement of grains and gas in a layer gave it one name – a vortex layer.

The purpose of this work – to investigate advantages and disadvantages of a boiling layer drying process and to offer the scheme of drying plant with gas dynamic material transportation of a.

Boiling layer devices with the constant or a little extending on height section, thanks to their construction simplicity, are widely used in the industry.

Disadvantages of boiling layer devices are:

- 1) Impossibility of speed increase over the value corresponding to the upper boiling layer existence bound;
- 2) Difficulty of poly disperse system processing;
- 3) Insufficiently intensive hydrodynamic mode near a lattice that leads to its fusion in high-temperature processes when poly disperses and thermolabile materials are processed and in processes with input in a liquid phase layer.

The mentioned disadvantages limit these device possibilities of productivity increase. That's why in a number of branches in the cases mentioned above, devices with the extending on height section (conic and cylindrical) are used in a spouted working mode.

Advantages of such devices are following:

- 1) explained speed change from below to the top allows to process at the same time various size firm particles, and in various intensity modes;
- 2) rather high speeds in the lower part of the device allow, especially at considerable corners of a cone solution, to process the substances which long contact with a lattice is inadmissible, being crumpled and sticking together substances, and also to enter into a liquid and paste layer.

For disperse materials the most effective are convective dryers in which there is a continuous contact of the draining agent with a surface of wood particles, peat and other materials. Depending on properties of materials, the sizes of particles use various designs of dryers: drum, tape, with a "boiling" layer, aero spouting, etc. As the drying agent heated air or combustion gases is applied. For receiving a "pure" product use of combustion gases are unacceptable therefore the drying equipment has to have the heat exchanger in which there is an outdoor air heating. Drying speed depends on the draining agent temperature, relative speed of his movement, a specific surface of dried-up particles, physical properties of a material. In an initial stage (the period of constant drying speed) humidity of a material is constant in all volume.

After a certain drying time when moisture concentration decreases owing to

Зневоднення та сушіння. Водно-шламове господарство

evaporation on a material surface, moisture starts moving from the center of particles to a surface because of a concentration gradient, there comes the period of the drying speed falling, material temperature starts growing. While moisture content decreasing in material a drying particle temperature comes nearer to draining agent temperature. Thus, there is a restriction of the applied draining agent temperature, in connection with possibility of fine fraction ignition of used material dry particles.

In difference from drum drying plants in which the draining agent temperature reaches 700 °C that quite often is the reason of drained raw material ignition, the aero spouting dryer works at a draining agent temperature of 120-250 °C that excludes danger of draining particle ignition. Besides, the drum is inert, its start demands considerable time, drying process is hardly controlled whereas the aero spouting dryer is started within several minutes, drying process is manageable and controlled. Material drying in aero spouting plant is provided with intensive mass-air exchange which is a technical solution result of this device. Also, the drying process is accelerated in connection with intensive particle friction with each other in a dense bed at a high speed movement.

Speed of the draining agent relatively material particles in the aero spouting dryer is 25-28 m/s that allows to dry wood peat, a lignin and other fine fraction materials.

Main part. During researches the aero spouting dryer design is considered. The design scheme is presented on fig. 1

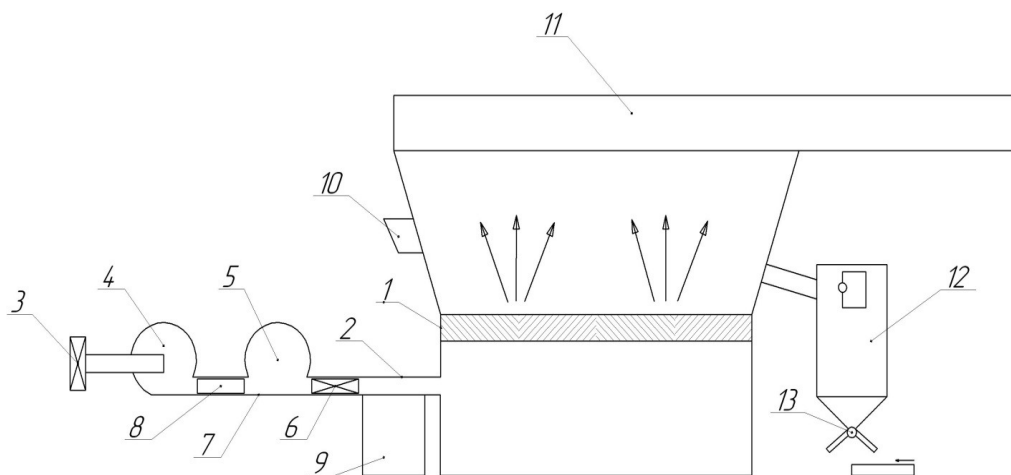


Fig. 1. Dryer "Aerofontain-STR" scheme:

- 1 – bottom grate; 2 – the pipeline; 3 – the regulation device of an air consumption;
- 4,5 – the prop fan engine; 6 – a flow-measuring site; 7 – a visualization site;
- 8 – a jet rectifier, 9 – the heating device; 10 – the device of a damp material loading;
- 11 – a vent pipe; 12 – a cyclone; 13 – the device for a dry material unloading

The drying process is following. The heated air is brought into a bottom grate 1 through the general main pipeline 2. At the beginning of the pipeline the system of air consumption regulation 3 is located. In the general pipeline chain there are two fans and two electric engines 4,5 rotating them. The general pipeline has a flow-measuring

Зневоднення та сушіння. Водно-шламове господарство

site 6 and a site of visualization 7. Before a flow-measuring site there is a jet rectifier 8 which serves for air stream straightening before its moving directly in a visualization site 7 and the air heating device 9, and then to a bottom grate 1.

Air supply is provided with the air consumption regulation device 3 in a reception pipe of the main pipeline. Process is carried out by screw giving of a working body (latch).

Air is heated at the bottom grate entrance. The bottom grate lattice blades can deviate on $\pm 15^\circ$, providing longitudinal material movement [3]. The general stand view for drying process research in a boiling layer with material transportation is presented in fig. 2.

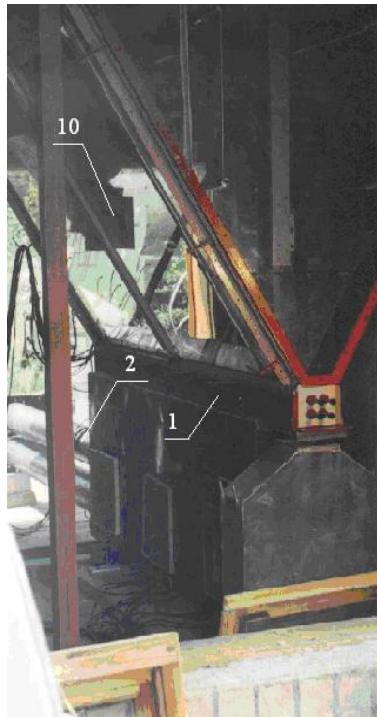


Fig. 2. Stand for research of drying process in a boiling layer:
1 – giving a lattice; 2 – the pipeline; 10 – the device of loading of a damp material

Principles of drying plant action are the following. The damp material is loaded from the loading bunker, is picked up by heated air and moves to the drying camera with a boiling layer. The product drying to its certain final humidity is realized thanks to time management which the product spends in the drying camera by a corner regulation of the bottom grate lattice blade. The moisture sated air is removed by means of a vent pipe. In the camera the material intensively circulates until material moisture level doesn't reach a certain value, after that it is carried away by gases to cyclone. There it is dust and garbage separation from the dried-up material which is removed through the cyclone bottom.

Advantages of aero spouting drying in comparison with drying drums and other types of drying plants are:

- fire safety: ignition danger is excluded because of the high material speed in

Зневоднення та сушіння. Водно-шламове господарство

the activator and the low temperature of the draining agent;

- fast start and stop, an operating mode change takes some minutes;
- high automation extent, drying parameters are regulated by the operator from the panel;
- low operational costs;
- receiving the raw materials of uniformly small fraction.
- basic development of the aero spouting dryer allows to dry up to 2 t dry product per an hour from initial moisture content of 70% to final 8-10%.

Conclusions. The carried-out analysis has allowed defining the disadvantages of existing drying plants. The offered device scheme is a working prototype of a disperse material dryer in an aero spouting layer with horizontal material moving which allows to dry up an initial material to the certain humidity value and to regulate each stage of process. Also it is possible to reduce duration of processing of disperse materials by higher speed use of material streams, and also to automate process. Thus, conducting technological processes in the boiled layer gives the chance to raise not only efficiency of hardware volumes, but also labor productivity.

References

1. Долматова М.О., Лисовая Г.К., Ермаков А.А. Интерсификация процесса сушки в трубах сушилках со вставками // Вестник УГТУ-УПИ: Серия химическая. – 2003. – №3(23). – С. 164-166.
2. Энергосберегающая технология сушки материалов / В.А. Федоскин, В.П. Франчук, Н.Н. Ерисов и др. // Збагачення корисних копалин: Наук.-техн. зб. – 2008. – Вип. 33(74). – С. 117-120.
3. Прядко Н.С. Сжигание низкосортных углей с газодинамической транспортировкой материала: Автореф. дисс. ... канд. техн. наук. – Д.: ДМетАУ, 2005. – 23 с.

© Kolomiyets R.V., 2013

*Надійшла до редколегії 25.11.2013 р.
Рекомендовано до публікації д.т.н. Л.Ж. Горобець*