DEPARTMENT OF ENGINEERING AND CYBERNETICS

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Research Trends

Development of the theory and constructive framing of energy-saving resource processes of intensive operation

I. Design-engineering of high-intensity devices

a) Development of the theory and design-engineering of high-intensity devices for solving ecological problems

b) Development of new designs of mills for fine and superfine milling, classification, mixing and batching.

c) Development of the theory and design-engineering of the apparatuses of the combined action (chem.
reaction + milling + adhesion + heat exchange)

The following equipment for crushing developed at the Department of Machines and Apparatuses of Chemical Industry is introduced in a number of productions

<u>1-st group of machines</u>
Multistaged mills of shock - reflective action for dry grinding of various materials.

<u>2-nd group of machines</u>
Jet mills:
a) Mills for fine and superfine dry crushing by pulse and continuous jets in a layer of material being crushed;
б) Jet mills with flat milling chamber with developed classification of crushed materials.

<u>3-d group of machines</u>
colloidal – cavitation mills of wet grinding with developed cavitation effect on crushing materials.

<u>The equipment for classification of polydispersed and multicomponent materials:</u>
a) The centrifugal classifier of polydispersed materials with the distributed input of the products being separated;

b) The centrifugal classifier with an adjustable trajectory of movement of separated stream of particles depending on border of seperation;
c) The pneumovibrating classifier for separating fabric fibres from the mixture of rubber crumb and fibre tyre-casing grinding;
d) The electrostatic classifier of particles mixture of various polymeric materials.

Batcher of continuous action
a) Magneto - vortical batcher for pastelike materials;
b) Two-cascade batcher for poorly free-flowing bulk materials.

Mills of 1-st group

Multistaged mills of shock - reflective action can be made with horizontal and vertical in gross, with two, three and more shock steps with the advanced internal classification and without dependence on final dispersiveness of a product .

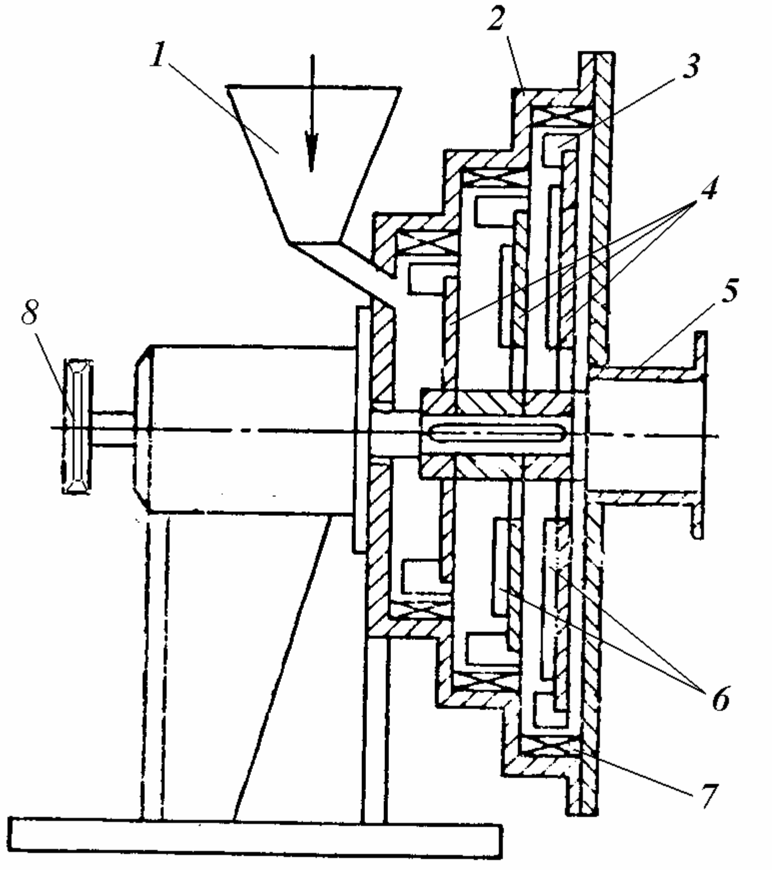

Fig. 1. Multistage mill with internal separation

1 - the bunker; 2 – the case of mill; 3 – beat; 4 – disks of rotor; 5 – branch pipe for output of fine milled product; 6 – lobes of ventilating fan; 7 – chippers; 8 - power-driven pulley

Unlike available mills of shock - reflective type of other designs, the machines developed here have very high degree of crushing i = 500 – 1100 (where $i = \frac{\overline{d}_н}{\overline{d}_к}$, $\overline{d}_н$ – the average initial size of particles, $\overline{d}_к$ – the average final size of particles) and low specific power consumption (20 – 120 kw·h/t).

Table 1

Characteristics of multistage mills of shock - reflective action

Material	Productivity, kg /h	Degree of crushing	The initial size of particles, mm	The final size, micron	Specific power consumption, kw·h/t
Chalk	1000-3000	1000	10	10	15-25
Limestone	1000-1500	330	5	15	25
Marble	1000-1500	1000	15	15	40
Graphite	1500	400	1	2,5	35
Granite	250	600	3	5	150
Sugar	1300	400	2	5	30
Talc	1500	100	0.08	0.8	30

Unlike the best foreign mills (for example of the firms Alpine, Fritch, etc.), these machines have lower specific power consumption and smaller (up to 10 times) air consumption on ton of a product. In our machines the air consumption is 200 – 250 m^3 / t, in foreign ones is 2500 – 4000 m^3 / t, what essentially affects the dimensions of the dust removal equipment .

Multistage mills of shock - reflective action have revealed themselves especially well in producing composite materials in parallel continuous batching of interacting components of the machine input.

Thus, for example, industrial introduction of these machines in the production of antifrictional and corrosion resistant fluorocarbon – coking compositions has allowed to increase durability and elastic properties of materials in 2 – 3 times, and also to increase the contents of coke (instead of expensive fluorocarbon) in 2 times in composite materials under better physicomechanical properties.

Powerful mechanoactivation of components, dosed out in machines in parallel, enabled to obtain many new materials: for example, to produce a number of new polymers – fluoroelastomers which could not be obtained earlier even under high pressure.

A number of new construction compositions has been obtained in which due to mechenoactivation, consumption of binding materials is reduced in some times under better physicomechanical characteristics of structural goods.

That is why multistage mills of shock - reflective type have been already used as highly effective mixers of continuous action, mechanoactivators and highly effective grinders.

Mills of the 2-nd group

Jet mills of dry milling with pulse and continuous jets of the energy carrier (air, vapour, gas) are intended for fine and superfine milling of pure and superpure materials (there is no pollution by products of milling in these machines). They are also used for the processes of milling and ideal mixing in turbulent jets of multicomponent materials and, naturally, for realization and a sharp intensification of chemical reactions in the systems gas – solid state. In proceeding chemical reactions of this type in the system gas – solid state, and also liquid – solid state, the intensification of heat – and mass transfer processes occurs intensively in tens, and sometimes in hundreds times, because, firstly, the resistance of diffusion of a gas or a liquid to a reacting surface of a solid phase is practically reduced up to zero, as at continuous milling, products of reaction are removed from reacting particles, a surface of reaction is renewed every time. Secondly, in destruction of particles, their superactive surfaces, which instantly react with a turbulent stream of gas or a liquid, are formed. Thirdly, in similar reactors – millers specific energy consumption for crushing itself is reduced in several times in comparison with crushing of an initial reagent in the same machines because destruction occurs, mainly, in the places of the least strength (on border of a new product – initial raw material). On border of the two hard substances: the product – initial raw material physical and chemical bonds are in tens times less than bonds at an integral initial solid reagent, therefore the energy consumption for crushing reduces in many times.

In this connection such a combining of at least two processes: chemical reaction and milling in jet devices in a layer of the same material allows to intensify both processes essentially.

The researches which have been carried out by us have shown that milling of materials with pulse energy carrier supply to a layer allows to lower energy consumption in 2 – 3 times in comparison with continuous jets. However at pulse input of the energy carrier the conditions of gravitational or rotorless centrifugal classification worsen.

Therefore, in this case the jet grinder is supplied (in analogy with grinders of Alpine) with rotor centrifugal qualifiers, on the work of which the pulse mode does not influence significantly.

<u>Jet grinders with flat grinding chamber</u> work in a continuous jet mode and unlike other jet mills (counterflow, O-shaped, with a layer of the crushed material) are able to realize good internal classification process, which strongly depends on angles of collision of crushing jets of the energy carrier and its pressure. Therefore, jet mills developed by us with flat grinding chamber allow to adjust angles of collision of crushing jets depending on the border of separation of a crushed material.

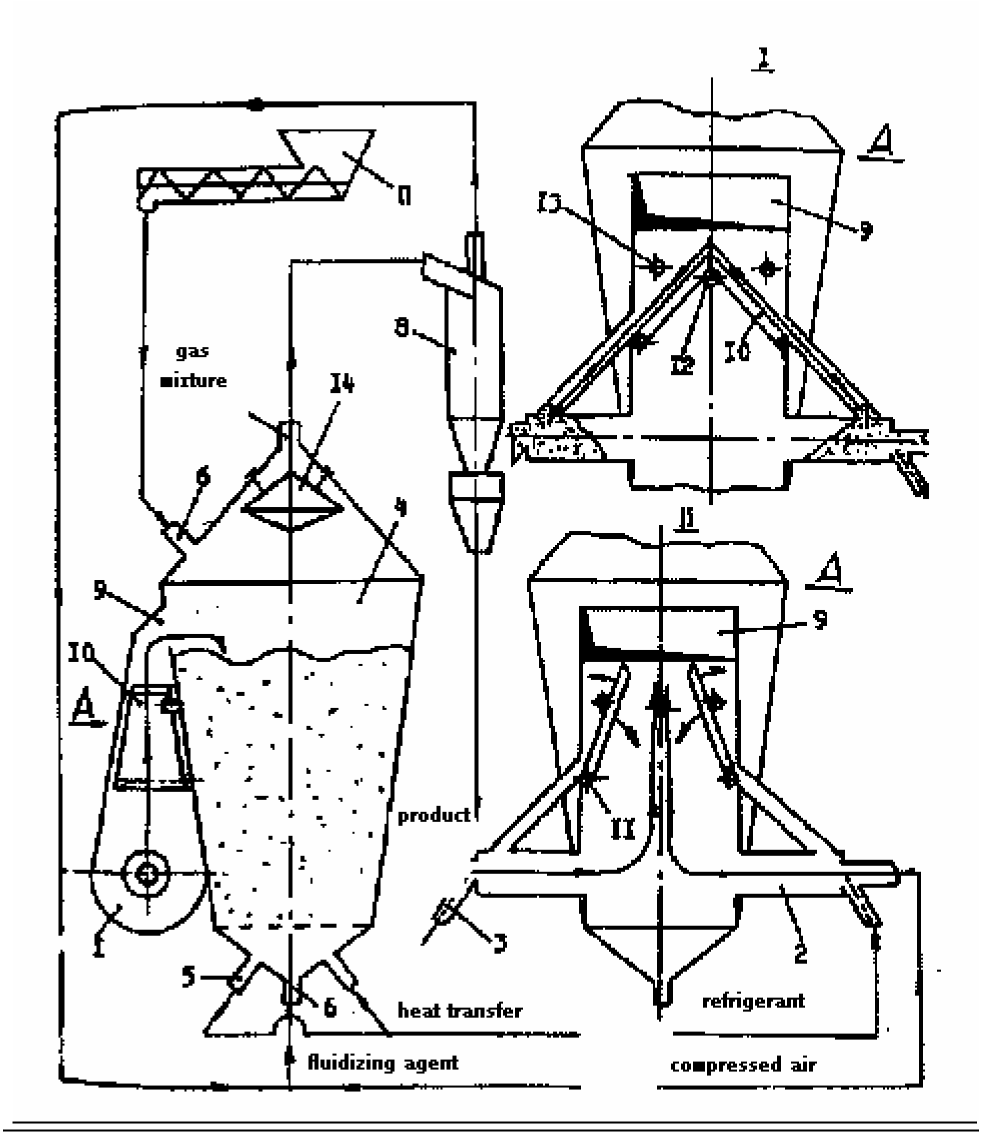

Fig. 2. The scheme of the device for combining processes with a remote zone of activation

1 - a remote zone of activation – milling; 2 - accelerating pipes;
3 - branch pipes for the pulse organization of termoloading;
4 - the basic device of the combined processes of heat and mass transfer, mixing and crushing;
5, 6 - branch pipes for of the heat-carrier; 7 – product supply;
8 - cyclone; 9 - zone of accumulation; 10 – shutter; 11 – joint;
12, 13 – clipper; 14 - breaker

THE EQUIPMENT FOR CLASSIFICATION

The centrifugal classificator of polydisperse materials with the distributed input of the materials under separating.

The general view of the classificator is presented in Fig. 3.

The classificator is intended for clear splitting of polydispersed materials into two classes on borders of separation from 20 up to 250 mkm. The border of separation is adjusted by angle of an inclination of twisting blades and by air consumption. Unlike existing centrifugal rotorless classificator, the given classificator has very clear border of separation (abrupt curve Trompfa) at high concentration of a solid phase in a stream of air m = 0,5 – 1,1 kg of a solid phase / kg of air (when in other designs m = 0,2 – 0,3), that naturally results in smaller dimensions at larger productivity of the basic device and, accordingly, to smaller dimensions of the dust removal equipment (cyclones, filters) which catches small-sized fractions.

The centrifugal classificator with an adjustable trajectory of movement of separated particles is intended for separation of polydisperse materials on borders in the range of 2 - 50 microns . The classificator differs from others in calculation and in design of trajectory with rotation of the material streams which should be shared for each material depending on density of its particles and fixed division border. The initial separated material is introduced in the device as aerosuspension with obligatory supply of pure air. At small borders of separation 2 – 10 microns for excepting turbulisation of streams of air, the top and bottom walls of separated channels are made rotating with the angular speed equal to angular speed of the twisted stream of aerosuspension.

All this allows to have an abrupt curve of separation (Trompfa’s curve) even at small borders of separation.

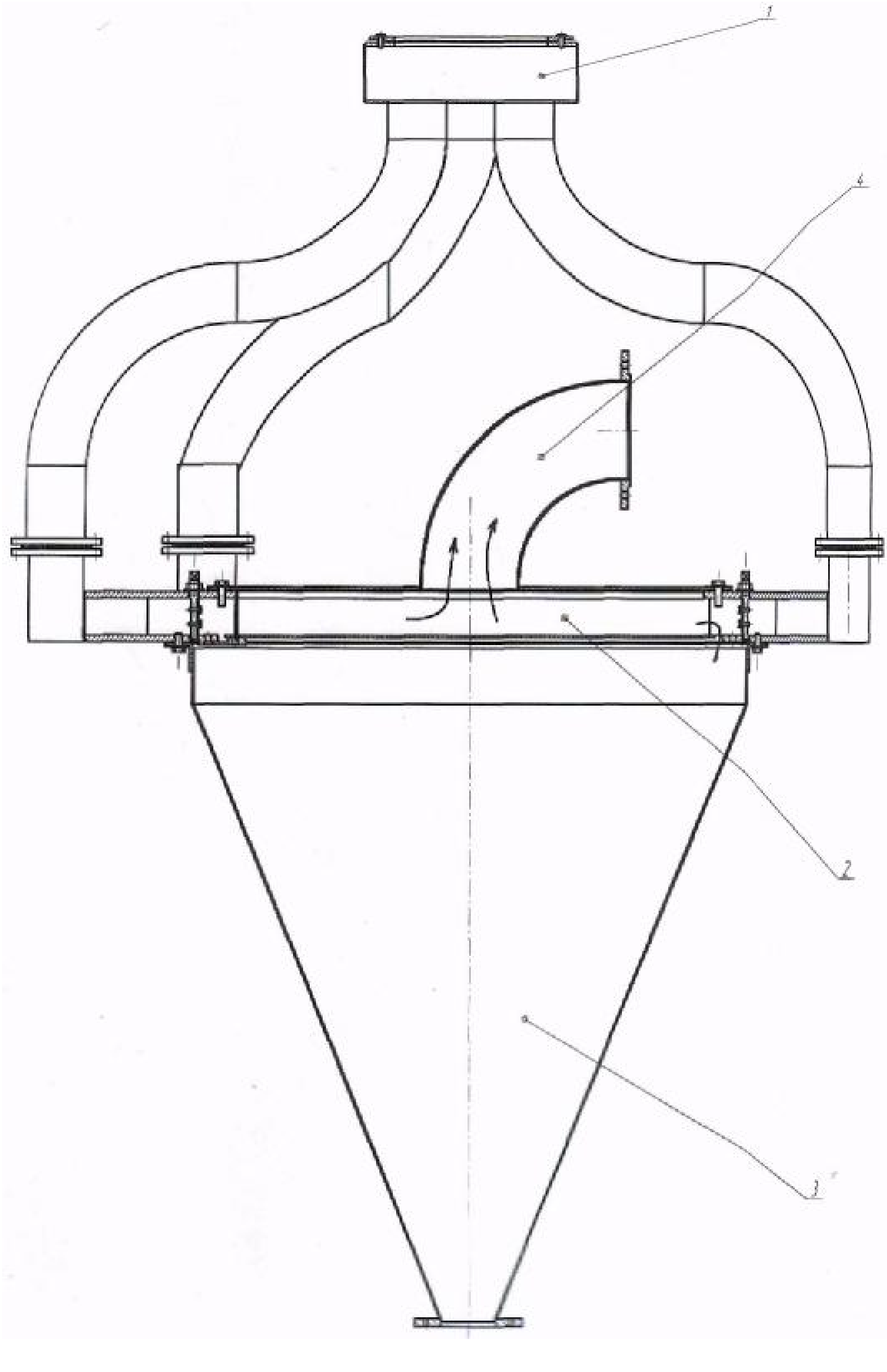

Fig. 3. The centrifugal classificator of polydisperse materials: 1 – top distributive chamber,
2 – chamber of distribution, 3 – collector of rough fraction, 4 – output of fine fraction

The pneumovibrating classificator for separating fabric fibres from rubber-fabric mixtures (Fig. 4).

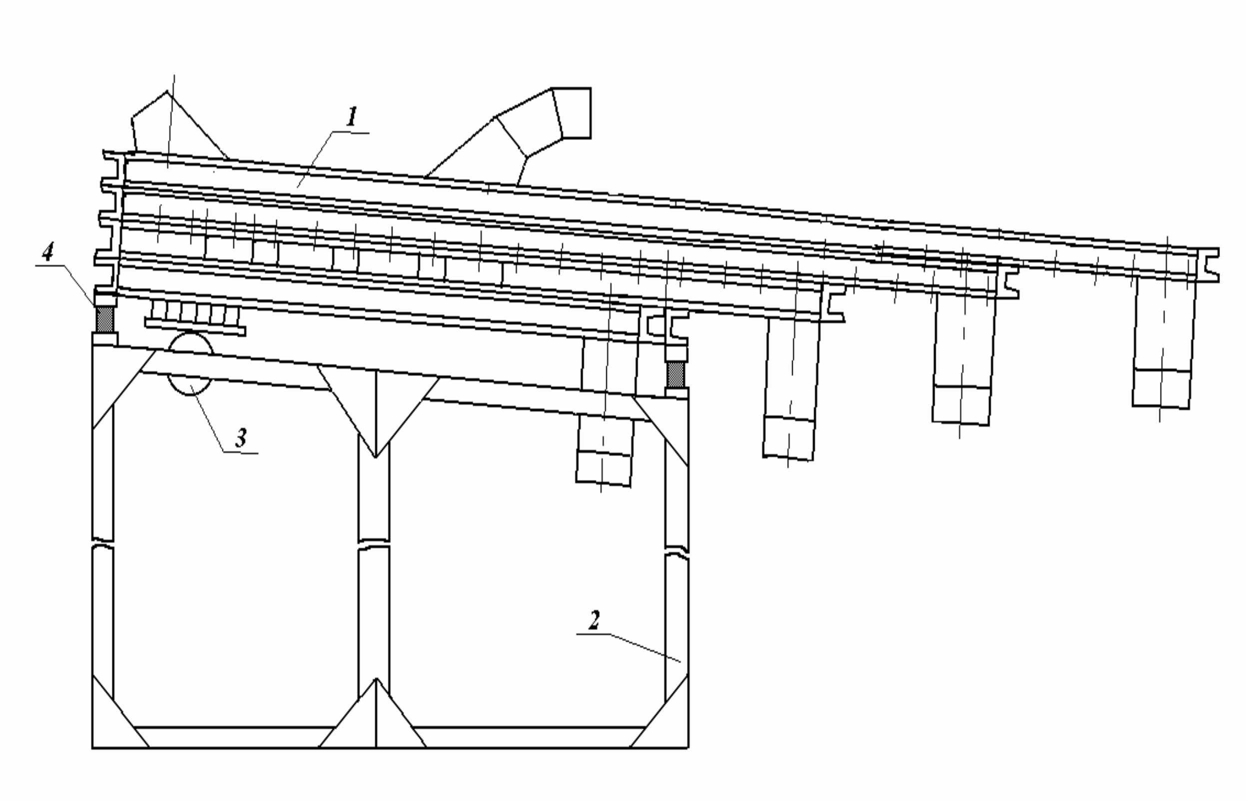

Fig. 4. The pneumovibrating classificator
1 - the case; 2 – a frame; 3 – the vibrator; 4 – vibra-supports

II. Modeling of high-intensity processes

In accordance with the system analysis strategy the mathematical modeling of combined heterogeneous systems heat treatment is carried out at the **Department of Applied Mathematics.**

The problems of heat conductivity under different boundary conditions, including conditions of moving boundary of phase transfer or chemical transformation, are solved analytically by classical and nonclassical methods of theories of heat conductivity and taking into account internal heat sources of various physical and chemical nature.
Mathematical models of processes of sublimation, annealing, drying of solid materials were developed under various hydrodynamic conditions.