EXPERIENCE OF USE OF COMBINED CYCLONE DRYERS

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Combined cyclone dryers (CCD) [1, 2] are used as standard apparatuses for drying disperse and lumpy products of the chemical and allied industries. The "Progress" Chemical Machinery Plant at Berdichev has specialized in the production of CCD of four standard sizes, viz., KTs-500, KTs-800, and KTs-1000, in conformity with All-Union Standard 26-01-1328–75: "Combined Cyclone Dryers. Basic Parameters and Dimensions." Experience of CCD operation shows that their efficiency depends not only on the correct choice of the standard dryer size but also on the correct design, layout, and erection of the component equipment and the unit as a whole. The task of this article is to make practical recommendations for equipping the CCD production lines on the basis of the analysis of the operational characteristics of the units.

Technical Specifications of Operating CCD Units

Apparatus	KTs-320	KTs-500	KTs-600	KTs-800	KTs-1000
Product to be treated	Trial production	Piperazine adipinate	Viniflex	Polystyrene (PS)	Sodium perborate
Volume of drying chamber, m^3	0.1	0.4	0.6	1.6	3.0
Air discharge, m^3/h	200-400	1600	3000-3200	4500-6000	10000-12000
Productivity based on evaporated water, kg/h:					
actual	20-30	5-50	60-100	100-200	150-300
maximum calculated	40	60	100	180-200	to 300
Productivity based on the product, kg/h	30-80	110	200	500	1300
Pressure differential, kPa:					
in the predryer	0.1-0.5	0.65	0.9	1.1	0.6
in the cyclone dryer	1.5-2	1.65	1.30-1.5	1-2	2.5
Installed power, kW	8.5	19.5	32.8	43.47	69.6
Weight of the unit, kg	2290	6000	6500	7500	11,000

Viniflex (polyvinylformalethylal resin) production is an example of the use of the CCD type of apparatuses for drying highly moist, lumpy polymeric materials. High cohesion and unstable initial characteristics of Viniflex complicate its drying. Taking account of these properties of the product, a two-stage unit consisting of a KTs-600 dryer and a KS-3 fluidized-bed dryer with a 3 m^2 grid surface was developed, tested, and recommended for mass production for drying Viniflex to the desired moisture content.

Operational Parameters of the Unit

Productivity based on finished product, kg/h	125
Moisture content in Viniflex, %:	
initial	30-50 (up to 70)
at the exit of KTs-600	10-27
final	3
Air temperature, deg C:	
at the entry to KTs-600	up to 145
at the exit of KTs-600	40-60
at the entry to KS-3	100
at the exit of KS-3	85-90

The KTs-600 dryer (Fig. 1) includes a predryer 2 with a stirrer 7 and a cyclone dryer 9. The dryer operates as follows: the moist product is fed by a feeder 4 into the predryer, where it passes into a suspended state under the action of a heat carrier (air) entering through a nozzle 1 and the stirrer and is transported by the heat carrier through a connecting pipe 6 into the cyclone dryer, whose upper part is fed by an additional amount of fresh heat carrier; the heat carrier and the product particles pass down the cyclone dryer as a spiral stream and is directed through a pipe 8 to a settling and purification system.

Some rational solutions pertaining to both the design of the CCD and the layout of the units were found in the process of utilization of the KTs-600 dryer and other dryers of this type (KTs-500, KTs-800). In all cases it is advisable to use one- or two-worm moist product feeder, which ensures steady product feed even at an excess pressure of up to 1000 Pa in the predryer. To avoid bending, damage, and choking of the grid 12 in the predryer, the grid should be fixed with a wire to the stiffening ribs 11 welded to a flange 13. For drying thermally stable products it is advisable to use the grid No. R355-05 [All-Union State Standard (GOST) 6613–73] in place of the filter grid 72 (GOST 3187–76) supplied

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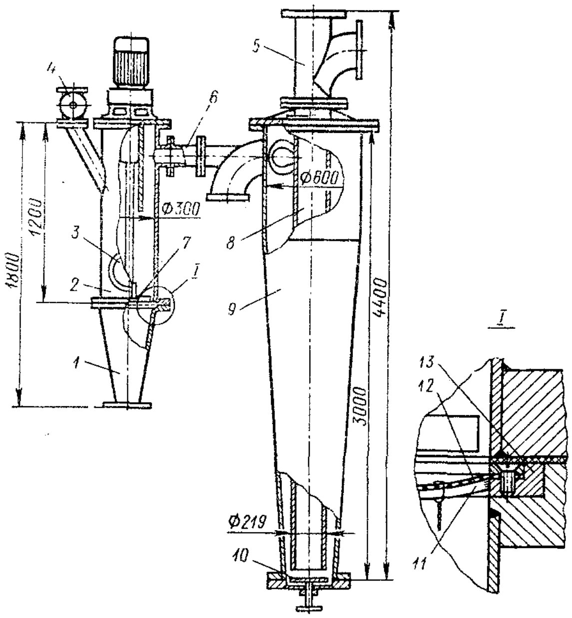

Fig. 1. KTs-600 Dryer.

by the plant. For convenience of predryer dismantling for cleaning, the flange joint at the point of grid setting should be made of hinged bolts. It was found during starting and operation that it is advantageous to have peepholes on the predryer and the dryer and to make the hatch 3 on the predryer easily detachable. The necessity for a movable false bottom 10 was not confirmed.

The efficiency and reliability of the CCD depend much on the correct design and layout of the component equipment. Leakproofness of the flange joints and the product loading–unloading points is an indispensable requirement.

For calculating the resistance coefficient of the CCD operating on a single-phase stream it is advisable to use the following relationship:

$$\xi = A\,\mathrm{Re}^n\,, \tag{1}$$

where A = 2.6, 1.76, and 55 in the calculation of ξ, respectively, for the predryer and at the entry to and the exit from the drying chamber; $\mathrm{Re} = v_g d/\nu$; v_g is the gas velocity; d is the diameter (of the predryer and of the dryer at the entry and exit); ν is the kinematic viscosity of the heat carrier; n = 0.29, 0, and 0.38, respectively, for the predryer and at the entry to and exit from the dryer; the resistance coefficient given in the manual [3] should be used for calculating the resistance at the entry to the KTs-800 and KTs-1000 dryers.

The resistance of the dryer operating with the product depends on the volume concentration and the ratio of the terminal velocity of the particles v_{ter} to the gas velocity v_g in the apparatus. At $v_{ter}/v_g \leqslant 0.3$ and the weight concentration of the product in the gas $\mu \leqslant 0.1$ the increase of the resistance can be ignored; for operational parameters exceeding these values allowance should be made for additional resistance in accordance with the empirical equation

$$\Delta p = B\left(\frac{v_{ter}}{v_g}\right)^m \mu^q \ \mathrm{Pa}\,, \tag{2}$$

where for the predryer B = 960, m = 0.93, and q = 0.8; for the dryer B = 2700, m = 0.68, and q = 1.4.

Relationships (1) and (2) verified experimentally on the pilot KTs-500, KTs-600, and KTs-800 dryers make it possible to calculate the resistance of the apparatuses with a precision of ±16% in the following ranges of the working parameters: gas velocity in the predryer 2.2-8 m/sec, at the entry to the dryer 4-17 m/sec, in the central pipe 12-32 m/sec; temperature in the dryer 40-110°C; equivalent particle diameter 0.15-1.5 mm; weight concentration up to 0.4.

The resistance of the other apparatuses of the unit and the air lines should be calculated by the methods recommended in [3, 4]. For calculating the fans it is necessary to consider their mutual influence [5], special attention being paid in the calculation to the vacuum created by the tail-end fan (the pressure in the predryer should not be above 250-300 Pa).

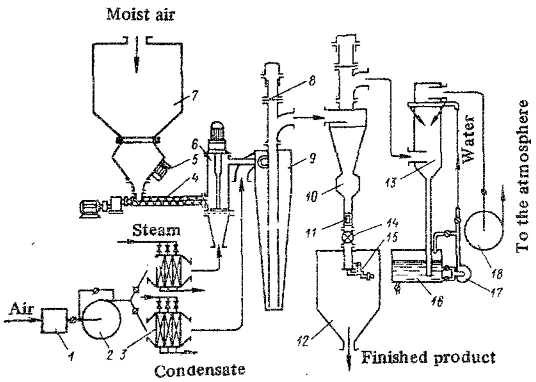

Fig. 2. Assembly of the KTs-500 dryer for piperazine production.

In the preparation of the working documents and erection drawings of the CCD units special attention should be paid to the points of loading and unloading of the finished product. The design of the moist product bin and the device to feed the material into the feeder should conform to the recommendations of the standard documents [6, 7]. Operational experience shows that unloading of the moist products from the bin is facilitated by vibrators mounted on the tapering part of the bin and by stirrers which prevent sticking of the products to the wall and breaks the dome at the point of exit of the product from the bin. A sluice feeder mounted on the bin of the cyclone was used as a device for unloading of the finished product in the CCD. The work drawings of the unit should be prepared with due regard for the leakproofness of the unloading line. Additional leakproofness of the product unloading line is necessary when the vacuum in the cyclone is above 400 Pa. The ejectors and the additional bins containing a guaranteed layer of the material operated well; installation of a single- or double-piece flap valve is the simplest solution. From the point of view of energy consumption, use of ejectors for cyclone unloading is advantageous only when the finished product has to be transported over a considerable distance.

Figure 2 is a schematic diagram of the assembly of the KTs-500 dryer operating in piperazine adipinate production. The assembly includes a predryer 6, a dryer 9, a worm feeder 4 with regulatable rotation speed, a moist-product bin with a vibrator 5, a filter 1, a forced fan 2 with a drive having a power of 7 kW, two radiator units 3, an SKTsN-34 cyclone 10 of 450 mm diameter with a bin, a TsVP-375 sanitary cyclone 13, a pump 17, a settling tank 16, and a VVD-8 exhaust fan 18 having a drive with a power of 10 kW and a rotation speed of 1700 rpm. A peephole 1, a sluice feeder 14, a flap valve 15, and a finished product bin 11 are fitted on the finished-product unloading line. The dryer and the cyclone are fitted with antiexplosion diaphragms 8.

Technical Specifications of the Assembly

Productivity (kg/h) at the initial temperature, deg C	
110	140
140	200
Air feed, kg/h	1650
Moisture content %:	
initial	up to 6
final	not above 0.5
Installed power, kW	19.5
Vapor feed under 0.3 MPa pressure, kg/h	80

Experience of operation of the test and other similar CCD units showed the necessity for maximally compact arrangement of the dryer, radiators, and cyclone with a view to conserving the heat potential of the heat carrier and eliminating the horizontal sections of the air lines containing the dusty heat carrier.

In general, all the instruments of the CCD unit are mounted on a separate panel in a central panelboard. Experience of operation of drying units shows that the following readings should be duplicated at the working site: temperature at the entry to and exit from the predryer and the dryer, the temperature of the finished product, the resistance of the predryer and the dryer, and the pressure drop after the dryer.

LITERATURE CITED

1. B. S. Sazhin and E. A. Chuvpilo, "Standard dryers with a fluidized material bed," in: Chemical and Petroleum-Refining Machinery [in Russian], Series KhM-1, TsINTIkhimneftemash, Moscow (1975), pp. 17-24.
2. B. S. Sazhin, V. A. Yatsunova, and M. N. Panfilov, "A new equipment for drying polymeric materials," in: Heat and Mass Transfer [in Russian], Vol. 6, Pt. II, Naukova Dumka, Kiev (1968), pp. 137-145.
3. I. E. Idel'chik, Handbook of Hydrodynamic Resistance [in Russian], Gosenergoizdat, Moscow–Leningrad (1960).

4. S. A. Rysin, Ventilation Systems of Machine-Building Plants [in Russian], Mashgiz, Moscow (1961).
5. M. P. Kalinushkin, Ventilation Systems [in Russian], Izd. Ministerstva Kommunal'nogo Khozyaistva, Moscow (1956).
6. Machines for Processing Friable and Pasty Materials: Album-Manual, Vol. II. Feeders and Batchers [in Russian], Severodonetsk (1975).
7. RTM (Guiding Technical Materials) 26-01-66–74: "Machines for Processing Friable Materials. Method for Selecting Optimal Type of Feeders, Mixers, and Mills" [in Russian], Introduced July 1, 1975.

ROTOR PACKING OF AN ATOMIC-POWER-STATION CENTRIFUGAL COOLING PUMP

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Centrifugal cooling pumps (CCP) have to be highly reliable because of the complex conditions under which they operate in atomic power stations (APS). Fabrication of reliable shaft packings is therefore a major task. Systems with inner and outer packings are employed for the referred operating conditions; in certain cases a sealing medium is used for this purpose. Of the known mechanical, hydrostatic, other types of face packings, the referred requirements are met best by the face packing with a self-adjusted gap [1] which was used in the VNIIAĒN as the outer packing of the rotary shaft of the CCP. Throttling is performed in it without calibrated capillary tubes.

The packing designed for pump operation in APS is shown schematically in Fig. 1. The packing is a single unit fitted on the pump shaft as a complete set and consists of two similar stages. The inner packing stage I takes up the major part of the pressure differential to be sealed. The pressure before the outer packing stage II is ensured by the throttle which restricts the organized leakages through stage I into a drainage tank. Each stage has an axial labyrinth pump, which ensures water circulation through the external heat exchangers. An auxiliary packing made in the form of a screw impeller designed for restricting leakages along the shaft due to damage of the second packing stage is provided after the second stage. The functional rings of the packing friction couples are made of siliconized graphite with the following basic design parameters: r_1 = 7 cm, r_2 = 5.5 cm, r_3 = 6 cm, Z = 24, and N = 4 (r_1 and r_2 are the outer and inner radii of the packing surfaces, r_3 is the radius of the balancing surface, Z and N are the numbers of chambers and feeding channels).

The working parameters and the design elements of the packing were worked out, and its working capacity was checked on a testing unit and directly in the pumps.

The testing unit had a horizontal shaft rotated by the drive of an MS2218-4 dc dynamometer through a belt transmission. The unit made it possible to test simultaneously two packings fitted on either side of the shaft bearings. The testing unit was used to determine the power input of the packing, the consumption characteristics of the packing stages, the admissible radial gap between the bushes of the labyrinth pump, and the working capacity of the packings at a water temperature of 143°C before the packing and with water pressure and temperature variation in variable regimes. Also determined experimentally were: the power, by measuring the frictional moment with the aid of the balancing device of the dynamometer; the leakage, by the volumetric method; and the pressure, by standard manometers.

The experimental data (Fig. 2) showed that the power input N of one packing stage, with allowance for losses due to disk friction, depends little on the pressure differential Δp to be sealed and increases substantially with increase of the rotation speed. The pressure differential in the packing also affects the volume leakage loss Q. The experimental data (Fig. 2) made it possible to choose the requisite leakages for each packing stage and to distribute the pressure and temperature in the stages.

Three versions of such a pump (Table 1) were tested for reducing the power input of the labyrinth pump [2].

The experimental relationships of the leakage Q_p and the power input N_p (Fig. 3) for the referred three versions of the labyrinth pumps made it possible to prove that at the shaft rotation speed of 3000 rpm the second variant with a radial gap of 1.1 mm is most suitable.

The working capacity of the packing units was checked under conditions approaching the real over a prolonged period (Table 2) on a testing unit at a water temperature of 40-143°C before the packings and pressures of up to 10 MPa.

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