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SMALL-SIZED BLOW TANKS RESEARCH AND ENGINEERING

Blow tank is one of the main elements of the bulk materials pneumatic conveying system. The aero disperse mixture is prepared in it, feeded into the pipeline and then it moves through the pipe primarily by means of the energy accumulated in the blow tank.

In comparison with other types of feeders (pneumatic screw, lock, etc.) the blow tank has a number of advantages such as the device simplicity, economical efficiency, absence of drive and parts rotating in the bulk material abrasive medium.

Recently pneumatic conveying systems of higher capacity and feed distance have been in demand. For systems of this type the blow tank is most acceptable as it does not have any essential limitations for increase of the pressure and the flow concentration up to the required level.

Still the blow feeder has disadvantages: cycle operation, discharge unevenness, considerable height dimensions. Herein we will review possibilities and ways of the chamber feeders downsizing.

Traditionally with the conveying system performance increase, the capacity of the blow tank and its dimensions increase as well. For single tank blow tanks charging the conveying pipeline periodically the reasons for the tradition occurrence of are obvious. The point is that after every discharge the blow tank stands idle during the period of time required for the material moving along the pipeline to the destination point. As the conveying time considerably exceeds the charging and discharging time, thus for higher capacity it is necessary to increase the quantity of the material transported during every single cycle, i.e. enlarge the tank volume.

For the double tank blow tanks supplying the material into the conveying line continuously, the duration of the transportable material movement along the pipeline is not a determinative characteristic. However the feeder of this type also has idle periods, caused by secondary operations of the air valve locks switching and pressure chambers deaeration. By means of the tanks volume enlargement the duration of the secondary operations ratio in the overall operation cycle can be reduced resulting in its capacity increase.

As an illustration of the problem under consideration the technical specifications of a number of well-known single or double tank blow tanks are given in table 1 [1].

As seen from the table, the blow tank height reaches 5m and in case if it is equipped with a feed box it can be up to 10 m and more. At the same time the height of the pneumatic screw pump NPV-110 (110 tonnes/h) is 1.2 m.

It is clear that the enlargement of the blow tank dimensions causes the increase of manufacturing and assembly costs and structure materials consumption. Taking into account the feeders height dimensions, it is necessary to increase the height of the industrial buildings and facilities, distribution lines etc.

According to foreign researchers [2] data, blow tanks manufacturing costs depends upon the tank volume and is within the range of 900 – 2700 pounds (see table 2).

For comparison it should be remarked that a pneumatic pump manufacturing cost of the same capacity is within the range of £ 11000 – 12000.

Table 1 – Blow tanks characteristics

Pump type	Manufacturer	Capacity (C), t/hour	Tank volume V_t, m^3	$\frac{V_t}{C}, \frac{m^3 \cdot hour}{t}$	Height dimension
СВ-33В (1t)	«Uglemash», Krasnogorsk	16	0,5	0,03	1,5
ТА-23А (1t)	–	30	105	0,05	2,6
ТА-29 (2t)	–	60	6,3	0,1	4,7
ТА-28 (2t)	–	100	18,6	0,2	5,4
DVF-50 (2t)	«Hitachi», Japan	50	–	–	3,3
2200-Б (2t)	«Sket», Germany	60	–	–	5,0

Table 2 – Blow tanks cost

Tank volume, m^3	Price, £
0,6	900
1,2	1440
2,4	1890
4,8	2700

Blow tanks have some other disadvantages caused by the dimensions increase.

Thus many researches [3, 4, 5] note the significant discharge unevenness of high capacity feeders causing the compressed air overconsumption and leading to the danger of the pipeline falling.

According to the researches[4, 5], in the process of bulk material discharge from tanks of large volume, holes and cavities occur in its mass through which the compressed air unproductively leaks. Furthermore bulk material arch chaotic falling into occurred hollows causes increase of pressure and two phase flow density pulsations. In practice under these conditions it is necessary to increase the compressed air consumption versus regulatory values i.e. to decrease technical and economic performance of the conveying system.

In small-sized blow tanks the discharge process is fast thus there is no time for holes occurrence in the bulk material mass, therefore discharge is carried out as a continuous flow of high concentration. By analogy with a piston compressor or hydraulic pump, a small-sized blow tank is able to provide the constant flow of fine fractional bulk material in strictly set velocity mode. In this case one of the transport process phases functions as the piston.

With the fill layer height reduction, pressure losses in in the SSBT tank decrease sharply leading to the conveying power consumption decrease.

With the aim of the small-sized blow tank (SSBT) idea implementation research and engineering works were conducted in Automobile Transport and Highway Engineering Institute of Donetsk State Technical University (ADI DonGTU) in 80-90 years and resulted in creation and testing of small-sized blow tank prototype models in industrial conditions. The conception of the device and its control, the theory of material discharge under pressure, major assemblies design and the SCF operation guidelines were developed in the research process. Some of them are outlined below.

SSBT is aimed for use in the double tank version while conveying fine fractional bulk materials through high load and long distance lines. The main technical characteristic, differing SCF from ordinary feeders is the chamber specific volume VSP:

$$V_{SP} = \frac{V_t}{C}, \frac{m^3 \cdot hour}{t},$$

where V_t – tank volume, m3:

C – the feeder capacity, tonnes/h.

For small-sized blow tank V_{SP} is no more than 0.02 units i.e. one order less than for ordinary feeders. SSBT performance maintenance is carried out by means of frequency increase of «charge-discharge» operations switch.

The SSBT sketch drawing is given in figure 1.

Two pressure tanks 1 work one at a time for the common conveying pipeline 2 and are combined by the common receiving bin 7. The tanks are equipped with quick response discharge 3 and charge 4 locks, supply 5 and compressed air discharge (6) valves.

Bulk material is supplied into the receiving bin continuously and passes to one of the tanks 1 when the lock 4 and the valve 6 are opened. For the charge process intensification the valve 6 can be connected to the vacuum aspiration system. (not showed in figure 1). After the charge the lock 4 and the valve 6 close and the valve 5 and the lock 3 open causing the tank 1 filling with compressed air forcing out the bulk material into the conveying pipeline 2. In addition all the locks and valves passage sections should not be less than the corresponding dimensions of high-capacity blow tanks reinforcements.

The bulk material is supplied to the transportation pipeline in mixture with high concentrated air. For the mixture concentration conditioning corresponding with the pipeline conveying conditions, additional amount of air is introduced to the conveying pipeline through the nozzle 8, 9

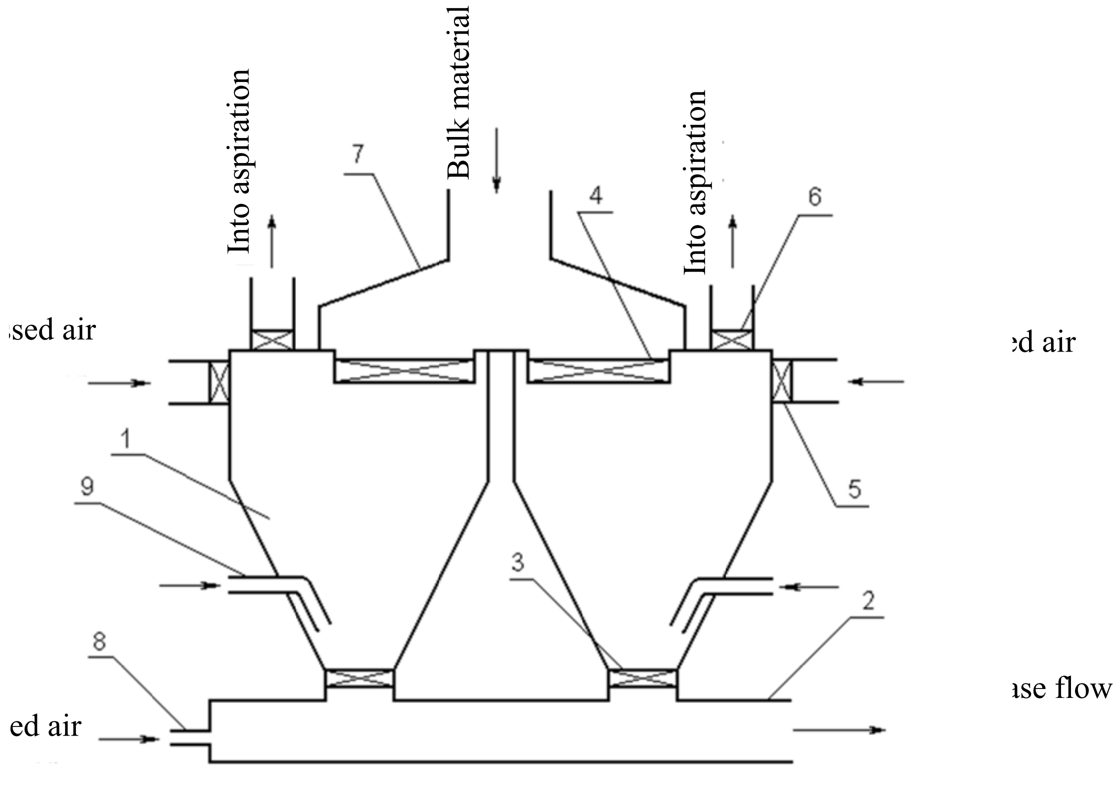

Figure 1 – Small-sized blow tank sketch drawing

The primary task of the SSBT creation is the development of charge locks of higher speed response.

As a rule blow tank charge locks are equipped with electrical and pneumatic actuators with the response time of up to 10sec or more [5]. For high-capacity feeders this value is no more than a few percent of the overall operating cycle. With the process tank volume reduction the ratio of time losses for secondary operations increases essentially and causes the device capacity decrease. Therefore reliable quick response locks creation is one of the conditions for the problem solution.

One of the suggested locks variants is given in figure 2.

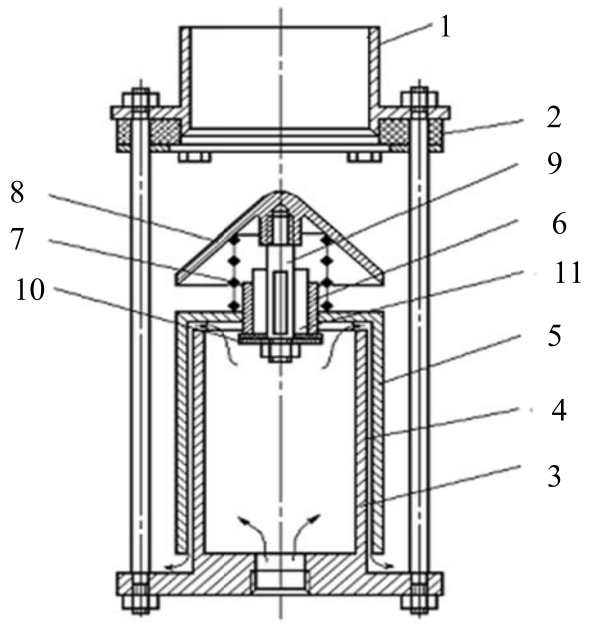

Figure 2 – Quick response pneumatic lock.

The lock [5] located under the feeder charge nozzle 1 is equipped with a support sleeve with the lift bowl 5 gapped 4 mounted on it.

In the bottom of the lift bowl 5 there is a built in coaxial guide bearing 6 with a centering in it by means of the star gear 11 stock 9 to which from one side a locking cone 8 with the spring 7 resting against the bearing 5 is fixed and from the other side – the air valve 10.

Compressed air is supplied to the tank through the support sleeve 3 of the lock. The lift bowl 5 immediately rises up to the lock cone stop position 8 at the seating 2. The lock is closed. But the bowl 5 keeps rising and compresses the spring 7. In the process the valve 10 opens, outletting the compressed air into the tank.

Thus the device combines the lock function with the control function of the compressed air supply to the tank for blow thereby the blow tank control system is simplified and the lock switch time reduces.

Another variant of the quick response lock is given in figure 3.

The device comprises the charge nozzle 1 fixed on the case 2 which is installed on the pneumatic conveying assembly 3. In the case 1 there is the coaxially built in with the charge nozzle 1 bowl 4 with the inlet air feeding nozzle 5. The shat off valve 6 with a cylindrical skirt is mounted on the bowl 4 with the possibility of vertical movement for the charge nozzle 1 shutting off and letting in a part of the compressed air from the bowl into the case 2 inner cavity. The valve 6 is equipped with a stock 7 that at the valve 6 stroke length laps over the bypass valve 8 upper part, coaxially built in the bowl 4 bottom. In the bypass nozzle 8 there is the return spring 9 fixed with the upper part to the stock 7 and with the lower one to the nozzle 8. The tap 10 for the material in the pneumatic conveying assembly 3 aeration is fixed to the nozzle 8 lower part.

As well as in the previous case it is actuated by the flow of compressed air introduced to the tank for the material unloading with the only difference that a portion of the flow passes to the aerating devices in the tank lower part with the aim of bulk materials transportability improvement [6].

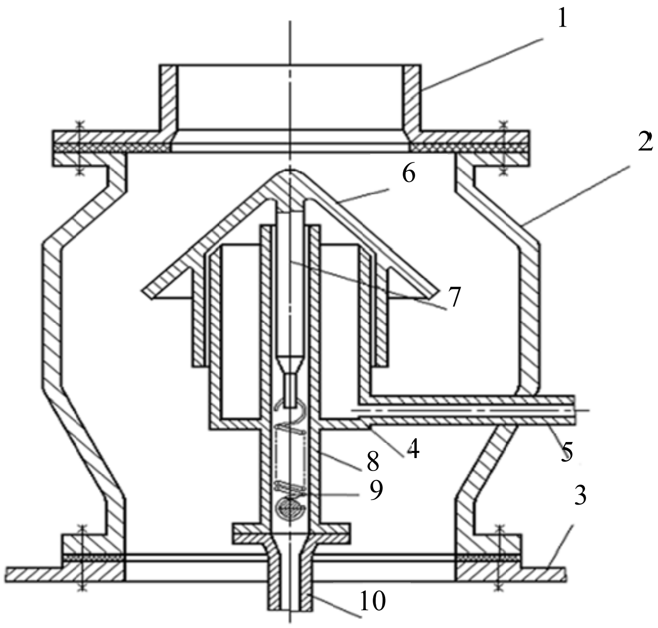

Figure 3 – Load device.

In the blow tank structure, the sketch of which is given in figure 4, the charge and discharge locks are made as one aggregate [7]. The charge lock design of the present blow tank does not differ essentially from the one given above. The support sleeve 1 with the air supply nozzle 2 is rigidly mounted in the blow tank case 3. The lift bowl 4 is gapped placed into the support sleeve, with a possibility of rising under the influence of compressed air to locking cone stop position at the charge throat 5 seating.

The discharge lock 6, resting against the nozzle seating 7 is equipped with a spring 9 stock 8.

The stock 7 upper part enters into the lift bowl 4 through the hole in its bottom and some way from the bottom the support washer 10 with the diameter exceeding the diameter of the hole in the lift bowl is mounted on it.

Normally the lift bowl of the charge lock is down positioned, the charge duct of the charge throat is opened, the blow tank charging with bulk material is carried out. At this time the discharge lock 6 is pressed to the discharge nozzle seating 7 with the spring 9, closing the outlet duct. After the tank charging compressed air is supplied to the support sleeve 1 through the nozzle 2. Under the influence of compressed air the lift bowl rises to the lock cone stop position at the charge throat seating 5. The charge lock is closed.

In the lifting process the bowl 4 grabs with its bottom the support washer 10 and with the help of the stock 8 lifts the discharge lock 6, opening the discharging duct. Compressed air is supplied to the tank for blow and aeration through the gaps between the lift bowl and the support sleeve and between the stock 8 and the lead-through nozzle of the support sleeve. The process of the bulk material discharging into the conveying pipeline is carried out. Then the cycle repeats.

The spring stiffness is designed to resist the pressure of the material-air medium in the conveying pipeline.

The discharge lock 6 rise height is determined by the gap between the lift bowl bottom and the support washer 10.

The suggested small-sized blow tank is aimed for operation in double- and multi tank pneumatic conveying systems, providing increase of their reliability and economical efficiency. Due to the high rate of charge locks response, especially under the conditions of bulk material higher temperature, the problem of reliability assurance of sealing devices gets more complicated.

The method of locks sealing without the use of elastic seal gaskets [8] for fine grained bulk materials (ash, coal dust) is developed in the laboratory of ADI DonGTU. The point of the method is in providing the sealed surfaces of the lock with ring wedge-shaped grooves. While the blow tank charging the conveyed material enters into these grooves and gets pressed at the moment of the valve being forced against the seating. For the tank discharge the compressed air is supplied under the layer of material to seal it additionally with the particles suspended by it and penetrating under the pressure into the gap between the seating and the valve.

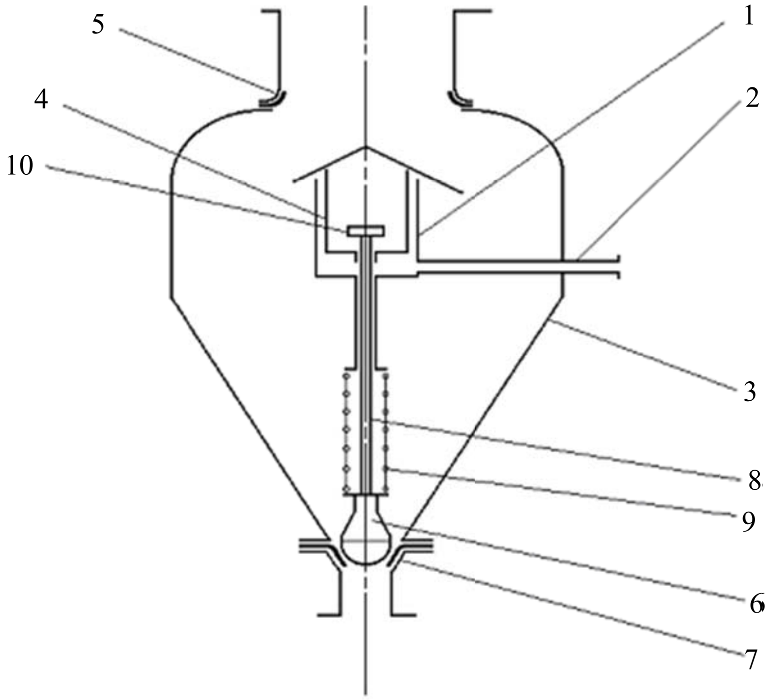

Figure 4 – Blow tank.

Small-sized blow tank prototype models, quick response reinforcements and the control equipment for them were created in Automobile Transport and Highway Engineering Institute of Donetsk State Technical University and underwent tests in the operating pneumatic ash handling systems at Kurakhovka power station, Semipalatinsk power station and in the pulverizing system of Sloviansk power station. Their use instead of pneumatic screw pumps allows reducing power consumption for 20-40 % and capital costs by 2-3 times.

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