International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 23 (2017) pp. 13104-13107

Special Air Bed Conveyor with Pneumatic Actuator of the Nozzle Scheme Forced Induction Method

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Abstract

This article discusses how to develop a long-range design of the air bed conveyor. The author describes a methodology for calculating the basic parameters of the conveyor. Specifies the criteria for selecting the shape of the transport trough and its dimensions. The rational size of transport troughs and their comparative energy demands estimates have been established. New means have been identified and proposed to reduce air-cushion air flow rate, as well as a new air circulation scheme for air cushion conveyor, which improves the efficiency of the air cushions use.

Keywords: SABC- special air bed conveyor, air cushion, nozzle scheme, load-carrying surface.

The creation of long-range designs to allow the transportation of clumpy cargo on the reloading-free scheme is a demanding and relevant task. One of the long-range types of special conveyors is the air bed conveyor with pneumatic actuator, which provides the straight-line transportation of clumpy cargo on the reloading-free scheme in the construction and mining industries, hot and piece cargo in the enterprises of the metallurgical and engineering industries [1-5].

The use of an air cushion reduces the tractive resistance value of the load-carrying surface, increases its speed, thus reducing the energy intensity of the conveyor and thus significantly increase the flight length per a drive unit [4, 6-11]. Due to the egress of compressed air at an angle to the vertical, the load-carrying belt receives translational motion.

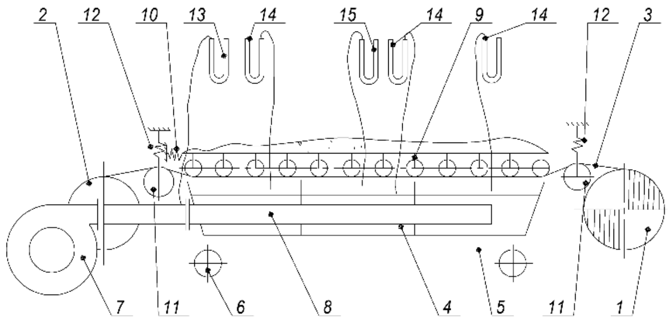

Figure 1: Diagram of the air bed conveyor with pneumatic actuator.

Figure 1 shows a diagram of the experimental installation of a special air bed conveyor. The air bed conveyor with pneumatic actuator consists of the following main nodes and elements (see Figure 1): power-drive station (1) and tension station (2) The upper, loading part of the load-carrying surface (3) moves to the air-cushion, formed underneath it in transport trough (4), which is the bearing area. Transport trough (4) is fixed to the conveyor flight between the top (3) and bottom (5) branches of the load-carrying surface. The lower branch of the conveyor's load-carrying surface (5) is supported by idlers (6). For the formation of an air-cushion under the cargo branch of the load-carrying surface of the conveyor, the air is injected with blow machine (7) on central pipeline (8) and through the elbows to the sections of the transport trough (4), then goes to the load-carrying surface, supporting it, and expires through the gap between the transport trough and the load-carrying surface into the atmosphere. The load on the top branch of the load-carrying surface (3) is created by a special stationary loading device (9), which is fasted through a plate (10) with pasted strain gauges to the fixturing. The top branch of the load-carrying surface circuits the idlers (11), suspended to plates (12) with pasted strain gauges. In central pipeline (8), after blow machine (7), there is the air flow straightener of the cancellated type and after it, at a distance of ten pipeline diameters, Pitot-Prandtl tube is built in, connecting with manometer gage (13). Each section of the transport trough (4) through the draining taps in the wall and the flex pipeline is connected to manometer gage (14). The middle section of the transport trough also has draining taps along the entire width of the reference surface, communicating with the manometer gages (15). The transmission of the driving torque from the electric motor to the conveyor's drive drum shall be carried out through two V-belt transmissions 2-3 and the ГАЗ-53 speed box, allowing to regulate the speed of the movement of the load-carrying surface from 1.56 to 11.6 m/c. The V-belt transfers significantly reduce the transmission of vibration of the power-drive station to the conveyor's flight, which increases the accuracy of the measurements. The initial tension of the load-carrying surface of the conveyor is created by a screw take-up. The reference for the top branch of load-carrying surface of the conveyor is the trapezoidal transport trough with the inclination angle of the lateral sides 25. The transport trough is located between the top and bottom branches of the on of the load-carrying surface of the conveyor and is fixed to the flight.

The operating peculiarities of this conveyor is as follows: The air jet energy under pressure is used both by air and by the driving force of the conveyor load-carrying belt.

The use of an air cushion reduces the tractive resistance value of the load-carrying surface, increases its speed, thus reducing the energy intensity of the conveyor and thus significantly increase the flight length per a drive unit [6, 7, 12]. Due to the egress of compressed air at an angle to the vertical, the load-carrying belt receives translational motion.

The calculation model of the air bed conveyor with pneumatic actuator is as follows:

Capacity Q = 3,000,000 ... 3150000 t/year; transportation length L = 100 m; belt angle β = 0 ... 300. Transported materials are the explosive substances in bags, material unit weight, γ = 0.59 t/m.

Hourly capacity is determined by the calculation method from the specified annual capacity

$$Q_r = Q_4 \cdot 300 \cdot n \cdot m \cdot k, \mathrm{T}/hours$$

Where 300 is the number of working hours per year, n = 3 is the number of work shifts per day; m = 7- is a number of working hours in shift; k = 0.45 ... 0.5- a coefficient that takes account of the conveyor use in time

$$Q_4 = \frac{Q_r}{300 \cdot 3 \cdot 7 \cdot 0{,}5} = \frac{3150000}{300 \cdot 21 \cdot 0{,}5} = 1000, T/hours$$

When transporting goods with a belt load-carrying surface on an air cushion, the maximum carrying belt speed reaches V = 2.0 ... 3.0 m/s.

Accept the speed of the belt movement equal to V = 2.0 m/s.

Define the mass per unit length of the load, by the calculated capacity, from the next ratio

$$q_{load} = \frac{Q}{3{,}6 \cdot \upsilon} = \frac{1000}{3{,}6 \cdot 2} = 138{,}9 kg/m$$

Define the mass per unit length of the belt from the following expression [20, 34]:

$$q_{mpb} = \gamma_{CT} \cdot h_P (\frac{\mathrm{B} + 2h\delta}{\ell_{PL}} + q_C) = 7800 \cdot 0{,}005 \cdot \left(\frac{1{,}0 + 2 \cdot 0{,}25}{1{,}0} + 9{,}4\right) = 68 kg/m$$

As a flexible body to connect the plates of the laminar belt, select the dismountable chain at GOST 593-84, with the number of teeth Z = 13, the link pitch of the chain t = 80 mm, and the breaking load S = 10600 kg/cm2.

For this chain, select terminal 35Л (GOST 977-85) with diameter of the pitch circle D = 667.7 mm.

Define the minimum height of the crosswall with angle setting of the conveyor $\beta = 30^0$.

$$h_{vin} = \frac{0{,}255}{2} - \frac{0{,}06 \cdot 1{,}7321}{2 \cdot 2} = 0{,}102m$$

Taking into account h $_{\min} = 0{,}102м$, β = 30 ^{0} and αmax = 255mm, define the setting increment [26.47]:

$$L_{SI.maa} = \sqrt{\frac{2 \cdot 1{,}0 \cdot 0{,}102}{0{,}5774}} = 0{,}593\ mm.$$

Finally accept 0.590 mm.

The belt filling rate when $\beta = 30$ and $\lambda = \frac{L_b}{h_b} = 5{,}8$ is $\mathrm{K}_{filling} = 0{,}65$. Accept 0.65.

Define a refined value for the belt width according to the following formula:

$$B = \frac{1000}{3{,}6 \cdot 590 \cdot [0{,}102 - 0{,}5 \cdot 0{,}59 tg(30^0 - 20^0)]} + \frac{0{,}102^2 \cdot 0{,}3249 - 0{,}0594^2 \cdot 0{,}3249}{0{,}102 - 0{,}5 \cdot 0{,}593 \cdot 0{,}0594} = 0{,}943m$$

The finally accepted belt width value is equal to $\mathrm{B}_{belt} = 1000mm = 1{,}0m$.

The width of the belt is checked by "lumpiness" from the condition of the specified productivity provision according to the following dependency:

B=1000mm>$2{,}7 \cdot 255 + 200$

$$B = 1000mm \succ 888{,}5mm, \quad B = 1{,}0m \succ 0{,}89m$$

To calculate the pneumatic actuator, some of the parameters derived from the experimental studies and design considerations are set out: Compressed air jet pressure of the compressor (blow machine) $\rho_в = 2{,}5\ kg/cm^2 =$ 245250 N/m2 [Pa] = 0, 245 MPa, height of the blade (for design considerations) is $h_{blade} 0{,}05m$; width of the blade (for design considerations) is $B_{blade} = 0{,}05m$; nozzle angle is $\alpha = 0...20$ (set experimentally); Air cushion tractive resistance value $W = 0{,}006$ from experimental studies); a= (0.2 ...) 0.3) m/s.

Define the setting increment of the blades for the horizontal and slanted position of the path: when $\beta = 0^0$

$$\ell_{blade} = \frac{2 \cdot 24525 \cdot 0{,}05 \cdot 0{,}1 \cdot 0{,}9397}{206(0{,}3 + 0{,}5 + 0{,}006 \cdot 1{,}0)}$$

Accept $\ell_{blade} = 3{,}656m$.

When $\beta = 30^0$

$$\ell_{blade} = \frac{2 \cdot 24525 + 0{,}05 \cdot 0{,}1 \cdot 0{,}9397}{206(0{,}006 \cdot 0{,}866 + 0{,}5 + 0{,}3)} = 1{,}426m$$

Accept $\ell_{blade} = 1{,}426m$.

Specify the value of compressed air jet preassure according to the following formula

$$\rho_{в}^{V} \le \frac{[(138+68)(1{,}0\cdot 0{,}006+0)9{,}81+(138+68)\cdot 0{,}3]\cdot 3{,}656}{2\cdot 9{,}81\cdot 0{,}1\cdot 0{,}05\cdot 0{,}9397} = 25320 kg/m^2$$

$$\rho_{в}^{V} = 245250 н/м^2 \prec 253200 н/м^2$$

Finally accept $\rho_{в}^{V}\, 253200 н/м^2$ Or $\rho_{в}^{V} = 2{,}58 kg/cm^2$

Refine the tractive resistance value of the load-carrying belt on the air cushion as follows:

$$\omega_{в} = \frac{2\cdot 25320\cdot 0{,}1\cdot 0{,}05\cdot 0{,}9397 - 3{,}656(138+68)(0+0{,}3)}{(138+68)\cdot 3{,}656\cdot 1{,}0} = 0{,}0056$$

Define the start time of the conveyor when $\beta = 0^0$

$$t_S = \frac{2{,}0(138+68)\cdot 3{,}656}{[2\cdot 25320\cdot 0{,}1\cdot 0{,}05\cdot 9{,}81\cdot 0{,}9397 - 9{,}81\cdot 206\cdot 3{,}656(0+0{,}006\cdot 1{,}0)]} = 66s$$

$t_S = 66c$ when $\beta = 0^0$

Define the start time of the conveyor when $\beta = 30^0$

$$t_S = \frac{2{,}0(138+68)\cdot 1{,}426}{[2\cdot 25320\cdot 0{,}1\cdot 0{,}05\cdot 9{,}81\cdot 0{,}9397 - 9{,}81\cdot 206\cdot 1{,}426(0{,}5+0{,}006\cdot 0{,}866)]} = 0{,}67s$$

$t_S = 0{,}67c$ when $\beta = 30^0$

To determine the power of the pneumatic actuator, set some parameters: air cushion clearance space is $\Delta h_{cs} = 1 мм = 0{,}001 м$, length of transportation $L = 100 м.$

Define the pneumatic actuator power first for the horizontal set conveyor according to the following dependency

$$N_{PAV} = \frac{100}{102\cdot 0{,}65}\left\{\begin{matrix}\dfrac{1{,}0\cdot(138+2\cdot 68)0{,}001}{0{,}342\cdot 0{,}664}+ \\ 2\left[\dfrac{(138+2\cdot 68)\cdot 0{,}006\cdot 1{,}0+138\cdot 0+(138+2\cdot 68)}{0{,}00102\cdot 0{,}3}\right]\end{matrix}\right\} = 7{,}05kW$$

Define the pneumatic actuator power for the angle $\beta = 30^0$

$$N_{PAV} = \frac{100}{102\cdot 0{,}65}\left\{\begin{matrix}\dfrac{1{,}0\cdot(138+2\cdot 68)0{,}001}{0{,}342\cdot 0{,}664}+ \\ 2[274(0{,}006\cdot 0{,}866)+138\cdot 0{,}5+274\cdot 0{,}00102\cdot 0{,}3]\end{matrix}\right\} = 213kW$$

When $\beta = 30^0$ and $L = 100m.$ $N = 213kW$

We are picking up the explosion-proof a.c. electric motors (asynchronous), unexposed blown out of AZ series.

When you install the conveyor horizontally, you select the electric engine of the A2-62 model, N = 7 kW, n = 750 r/min.

When installed at an angle $\beta = 30^0$, select 2 electric engines of A2-92-Z model, N=125 kW, n= 1000 r/min and a 2-91-Z, N= 100 kW, n= 1000 r/min.

The analysis of literary sources and scientific works revealed the following: The effects of the physical and mechanical properties of the goods on the formation process of the air cushion at different pressures and the air flow are defined; the need to further search for the shape of transport troughs and to determine rational values of their size was identified; the rational aerodynamic high-capacity conveyor parameters have been established;constructional decisions have been developed to reduce the aerodynamic losses in the air circulation system; the issues of improving the efficiency of the use of the air cushion in ICS have been resolved.

It has been established that air circulation open circuit requires less energy for the air cushion formation and a closed circuit can be used successfully in the transport of goods harmful to the environment.

Identified: The maintenance of the load-carrying surface of the air cushion throughout the reference surface requires less energy expenditure than the discrete; maintaining the laden and empty branches of the load-carrying surface by air flows, and creates greater hovering stability to them than a common flow, but requires large energy for the air cushion formation, and keeping both branches of the load-carrying surface of the conveyor with a common flow of air requires less expenditures in moving the flow from the load-carrying surface to the empty one, then vice versa

Specified the criteria for selecting the shape of the transport trough and its dimensions, they are: The technology of the transport trough and metal consumption, which defines capital costs; energy criteria determined by the total excess pressure and airflow required for the air cushion formation, which disclose the exploitation expenditures .

The rational sizes of transport troughs are defined and shown their comparative estimates of the energy demands required for the air cushion formation and the productivity of high-capacity conveyor.

New tools have been explored and proposed to reduce air flow at the air cushion, as well as a new air circulation scheme in the high-capacity conveyor that improves the efficiency of the use of the air cushion. The imputed dependences of the air cushion pressure and the air flow required for the air cushion formation in the high-capacity conveyor with the nozzle scheme of the forced induction are defined, and taking into account the physical and mechanical properties of the load.

Definition in any particular case, the rational shape and dimensions of the transport trough, and the choice of the appropriate width of the load-carrying surface, and the definition of the pressure for the air cushion formation, should be performed according to the specified productivity and speed of the load-carrying surface.

It has been confirmed that the high-capacity conveyor, with its nozzle scheme of the air cushion formation, has the best performance compared to the high-capacity conveyor with the camera scheme, which is determined by calculations of the rational geometrical and aerodynamic parameters for the transport of the goods with different air cushion formation schemes.

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