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The Possibility of Reducing Air Consumption and Power Consumption in Pneumatic Conveying of Raw Cotton

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Abstract
In this paper work, technology that prevents external detachments from mixing with the raw cotton during the transportation of cotton with help of air as well as from destroying cotton seed is applied and new devices are created. Operation of new device is analyzed by both theoretical and experimental research.

1. Introduction

Existing constructions showed that new working elements, constructions should be simplified and their durability should be prolonged. Objective and purpose of research consists of: transporting cotton with help of air by conducting theoretical and practical research, creating the device that has opportunity to separate external elements [1], [2], [3].

In pneumatic transport separation productivity is learned theoretically by special working elements. In practical investigation experimental sample of new construction is created and prepared. In new construction experimenting and opportunity es of applying in industry is investigated. Results of practical research ar shown in the table.

Transporting raw cotton inside enterprises use mainly pneumatic transport installation suction type on Uzbekistan ginneries.

The analysis shows that raw cotton passes few times through the compressed-air in cotton ginneries. Depending on the capacity inside the factory harvesting of raw cotton, the location and distance of plant sites that is multiplicity of pneumatic transport is 4 to 6 times. This leads to a large power consumption and lower quality of produced cotton products.

Given distance of transportation in compressed-air is used mainly centrifugal fans VS-8M, VS-10M, VS-12M, with a power consumption of 30,55,75 kW/h and air flow 3.5, 5.5, 6.4 m^3/s, respectively.

As the material of the wire used pipeline steel sheet, thickness 1-3mm, with an internal diameter of 0.4 m.

Calculations show that under the current power fans and air flow speed is much higher than the minimum required of their performance. Studies conducted on cotton plants of Namangan region of Uzbekistan showed that the range of the Compressed-air about 100 m, using fans VTS-12M, the speed at the mouth of the pipeline is 20-25 m/s. This indicates a pre-defined air suction in the pneumatic transport elements-in pneumatic track (more than 3% per 10 m length of the pipe), the stone trap, a separator, which

Requires review structure connecting mechanism (coupling) Pipeline linear stone trap use din the composition and a pneumatic conveyor of the separator in terms of providing a high tightness of the system.

In addition, the study of the distribution of cotton in length and cross section of the pipe showed that during pneumatic transport of cotton to 1 m pipe length accounts for only 0.16-0.27 kg, ie 160-270 grams of raw cotton. At current size pneumotrack raw cotton takes no more than half the length and a round 5-6% of the cross-section of the pipeline.

These calculations indicate the presence of a significant amount-space that is not used during transport, ie while the bulk of the volume of the pipeline is empty. For amore effective use of the amount of space offered pneumotrack

- Apply the feeder provides a uniform power pneumatic cotton;
- To reduce the diameter of th pipeline Compressed-air to 355-315 mm, which reduces the power budget pneumatic 25-30%.

2. The Calculation and Analysis of the Main Indicators of Pneumatic Transport Using Fans with Different Power

Transportation of cotton in the cotton refineries carried pneumatic installations (1), the principle of which is base don't he movement of material by air flow, which moves due to the vacuum created by the fan inside the pneumatic elements of the installation (ie, Compressed-air).

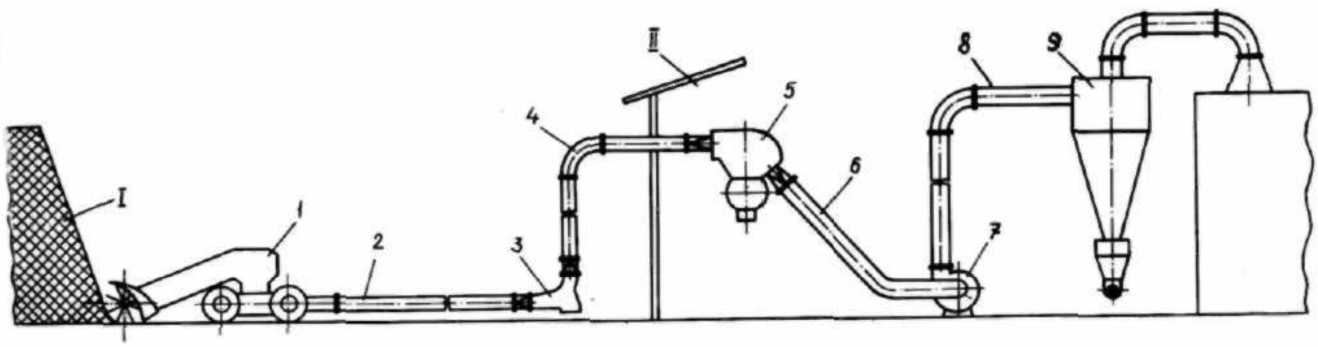

Fig. 1. *Scheme of the pneumatic installation.*

On the image I - the cottons pile, II - shop for processing cotton. 1- machine disassembly piles and filing of cotton in pneumatic transport, 2 - the pipeline of pneumatic transport 3 - separator of heavy impurities, 4 - withdrawal pipe 5 - a separator for separating cotton from the conveying air, 6 - duct (tube), 7 - the fan 8 - duct 9 - cyclone to clean the air.

When the system parses the machine 1and submits cotton in line 2, which moves the air flow. Due to the aerodynamic force of air particles cotton rush into the pipeline and begins to move with the air creating Aerosmith. Further Aerosmith will move along the pipeline passes through the trap chamber 3, which cleans cotton from heavy impurities is withdrawn 4, reaches the separator 5 which separates the cotton from the air. Further cotton leaves the pneumatic conveying, and is transmitted to the processing and the air is sucked through the tube 6 and the fan 7 is supplied through the duct 8 in to the chamber 9 air cleaning facilities (cyclone dust chamber).

The main disadvantages of pneumatic transport of cotton are high energy consumption and a negative impact of the system on the original natural (qualitative) properties of raw cotton. The reasons for these shortcomings is the high consumption of air and shorter range air installations, which leads to an increase in the multiplicity of its application.

It is known that the Q-air consumption in the pipe depends on its section Fan d the air flow speed V_B:

$$Q=F \cdot V_{в}, \quad (1)$$

F-cross-section uniformly throughout the pipe length and the air tube is determined by the known relationship. $F=0,25\pi \cdot d^2$, where d-diameter of the inner pipe. When $\pi=3,14$; $d=0.4$ m section of the pipeline will be equal to $F=0,1256m^2$.

The vacuum, created by the ventilator is passed through a separator in to the pipeline-unloaded function that performs unloading of the transported material from the pneumatic system [4], [5], [6].

During operation of the separator vacuum created in his cell causes some air suction from the outside through the suction vacuum-valve of the separator. Depending on the wear of blades vacuum-valve and the number of its revolutions air in flows is 20% of the total air flow. According to the "Paxtasanoat".

Equation (1), for reach 10 m pneumatic transport accounted additional air inflows from the outside at a rate of 3% of the total air flow rate.

If we take equal suction u% and enter coefficient taking in to account air inflows, which is equal to k=1-u/100 the air flow after the element Compressed-air installed before the fan can determine

$$Q_H = k \cdot Q. \quad (2)$$

If the number of elements is equal to n, then the air consumption before the last element will be

$$Q_H=k_1 \cdot k_2 \cdot k_n \cdot Q. \quad (3)$$

Or the same, If the elements have the same suction a mount, i.e. $k_1=k_2= =k_n$

$$Q_H = k_n \cdot Q. \quad (4)$$

Since, k<1 with in creasing the number of items (n) air consumption will decrease Q_H. Given real quantities calculate the amount of air, Compressed-air elements passed to each other.

Suction air in separator take equal u = 20%. Then, k=1-20/100 = 0.80, a flow of air after the separator:

$$Q_n=0,80Q.$$

This is in numerical value:

- WithfanVC-8M, $Q_n= 0,80 \cdot 3,5 = 2,8 m^3/s$;
- WithfanVC-10M, $Q_n= 0,80 \cdot 5,5 = 4,4 m^3/s$;
- WithfanVC-12M, $Q_n= 0,80 \cdot 6,4 = 5,128 m^3/s$.

Given the actual pipe diameter d=0.4m (1) can determine the velocity of air at the beginning (in the separator) of the pipeline:

$$Vc=\frac{Q}{F}. \quad (5)$$

Or in numerical value:

- With fan VS-8M $V_c=\frac{2,8}{0,1256} = 22.3$ m/s;
- With fan VS-10M $V_c=\frac{4.4}{0,1256} = 35,0$ m/s;
- With fan VS-12M $V_c=\frac{5.12}{0.1256} = 40.8$ m/s.

Practical interest and transportation of cotton from a long distance-from indoor and outdoor storage, which are mainly use d ventilators VS-12M. Assume that the length of transportation is 100 m (i.e.,n=10). Then the velocity of the air at this point-at the site of the pipeline, i.e.in the feeding zone is cotton:

$$V_c = \frac{5.12 \cdot (0.97)^{10}}{0.1256} = 30.06 \text{ m/s}.$$

However, when measuring air speed at ginneries received significantly lower rates. For example, a study conducted at ginneries Namangan region the Republic of Uzbekistan showed that the range of the Compressed-air about 100 m, using fans VTS-12M, the speed at the mouth of the pipeline is 20-25m/s. This indicates the presence of pre-defined elements in the air suction pneumatic conveying-in pneumatic road (more than 3% at 10 m length of pipe), stone trap, separator, which requires to reconsider the design of connecting mechanisms (couplings) pipeline, linear stone trap used as part of pneumatic conveyor systems and separator in terms of higher tightness of the system.

3. The Calculation and Analysis of Using Internal Space of Pipe sin the Pneumatic Transportation of Cotton

Many studies examined the nature of the movement of cotton-raw inside pneumatic conveying elements, including pipeline [7], [8]. Often examined the dynamic motion model aero cotton blend-some regularities are defined trajectories, speed of the transported material [9], [10].

In the present study we put a slightly different task-consider the process of transporting of cotton for practical values of the process.

Conveying performance is one of the main indicators stump installation. It is defined by:

$$P = \frac{M}{t} \quad (6)$$

where: M - is the mass of raw cotton;

t - time transportation.

Performance of the process depends on the performance of the transport of the locking element of pneumatic transport-separator that has the transmission capacity:

- Brand SS-15A - 15t/h.
- Brand SH - 22t/h.

Subsequent technological machine, for example, the dryer drum (grade 2SB-10, SBO) designed for a capacity of 10 t/h, litter cleaner 2 line UHK-12 t/h.

Due to the mismatch of technological machines in terms of performance when operated at full capacity formed overstock of cotton in workshops equipment with lower performance, which is also impractical-takes jobs created a fire hazard. According to this, the calculation of conduct for more than the average value of performance – P =10-12 t/h.

Converted the value of productivity per kg/s:

$$P = (10 \div 12) \text{ t/h} = (10 \div 12)\ 1000 \text{ kg}/3600 \text{ sec} = 2.78 \div 3.33 \text{ kg/s}.$$

The transportation time can be defined from the dependence:

$$Vm = \frac{l}{t}, \quad (7)$$

where: V_m – is the velocity of the material, m/s;

l – the length of the pipe (conveyance), m.

Whence,

$$t = \frac{l}{v_m}, \quad (8)$$

Combining (6) and (8) and it will be:

$$P = \frac{M}{l} \cdot VM, \quad (9)$$

Whence we find M:

$$M = \frac{P \cdot l}{V_м}, \quad (10)$$

We can find the mass of cotton attributable to the segment length of the pipeline.

Speed material (cotton) depends on the speed of the air flow. It is determined by experimental dependence of [2, 3];

$$V_м = (0{,}5 \div 0{,}75)V_c, \quad (11)$$

Air velocity is equal to V_c = 25 m/s. Then

$$V_м = 25 \cdot (0{,}5 + 0{,}75) / 0{,}1256 = 12.5 \div 18.75 \text{ m/s}.$$

It will analyze equation (10) under

$$P = 10 \div 12 \text{ t/h} = 2{,}78 \div 3{,}33 \text{ kg/s}.$$

We take, material velocity, equal to $V_M = 12{,}5 \div 18{,}75$ m/s. Then for P=2,78 kg/s

$$M = \frac{2{,}78 \cdot l}{(12{,}5 \div 18{,}75)} = (0{,}22 \div 0{,}15) \cdot l;$$

For P =3.33 kg/s;

$$M = \frac{3{,}33 \cdot l}{(12{,}5 \div 18{,}75)} = (0{,}27 \div 0{,}18) \cdot l.$$

For different values determine the mass of cotton M.

The results are shown in Table 1.

Table 1. *The mass distribution of the cotton along the length of the pipeline.*

Length of pipeline l, м	Weight of raw cotton M, kg			
	P=2.78, V_m=12,5	P=2.78, V_m=18,75	P=3.33, V_m=12,5	P=3.33, V_m=18,75
0.1	0,022	0,015	0,027	0.018
0.5	0,11	0,075	0,135	0,09
1.0	0,22	0,15	0,27	0,18
………				
100	22	15	27	18

These figures show that during pneumatic transport of cotton to 1 m pipe length accounts only 0.16-0.27 kg, i.e. 160-270 grams of raw cotton. It's per 10 cm 16-27 grams, or the same, if immediately stop the processing of transport in Compressed-air, with a length of pneumatic track 100 m, within the system will be about 15-27 kg of cotton, not more.

On the other hand, It is known that the mass M can be defined as the product of its γ volumetric density and volume V, that

$$M = \gamma V, \quad (12)$$

Hence, the volume of the body mass M is

$$V = M/\gamma, \quad (13)$$

When volume density of mellowed cotton $\gamma = 50$ kg/m^3, or in terms of g/sm^3

$$\gamma = 50 \text{ kg/m}^3 = 50 \cdot 1000 \text{ g}/100^3\text{sм}^3 = 0{,}05 \text{ g/sm}^3$$

And weight cotton M = 16-27 grams, the volume of the particle will be

$$V = (16 \div 27)/0.05 = (320 \div 540) \text{ sм}^3.$$

And, if this particle submit in the form of a sphere, its radius R, according to the equality

$$V = \frac{4}{3}\pi R3, \quad (14)$$

Can easily be determined by the formula

$$R = \sqrt[3]{\frac{3V}{4\pi}}. \quad (15)$$

At given values of V and π the average particle radius R is equal to

$$R = \sqrt[3]{\frac{3(320 \div 540)}{4 \cdot 3.14}} = 4.25 \div 5.06 \text{ sm}.$$

If you doublet is figure to get the diameter of the cotton particles d = 2R = 8,5÷10,12 sm. It is occupied by cotton length of the pipeline segment equal to 10 sm. It shows that for any length of the pipeline, if you build a particle of cotton in a row, it will turn out without interrupting line. But if to present a moving cotton as a continuous thread with a diameter d, then the length of the yarn per 10 cm of length of the pipeline will be equal to:

$$L = V/(0.25\pi d^2) = (320 \div 540)/(0.25 \cdot 3.14 \cdot (8{,}5 \div 10{,}12)^2) = 5.6 \div 6.7 \text{ sm}.$$

This percentage will be: ((5.6÷6.7)/10)100% = (56÷67) ≈ 62%. The projection of the particle on the longitudinal axis of the air tube is equal to the radius R, and the cross-sectional area of the pipeline-the area sphere radius R:

$$f = \pi R^2 = 3.14 \cdot (4{,}25 \div 5{,}06)^2 = (56.7 \div 80.4)\text{sm}^2.$$

Area of the cross section of the pipe radius R_p=d/2=0.4/2=0.2 m=20 sm, was determined in the m^2 and it is in sm^2

$$F = \pi R_p^2 = 3.14 \cdot 20^2 = 1256\text{sm}^2.$$

Cross section of the pipeline can be occupied to determine the cotton from the ratio:

$$\Delta f = \frac{f}{F} 100\%, \quad (16)$$

Substituting the numerical values, we have f = (4.51÷6.40)% ≈ 5,5%.

You can also calculate the volume of the pipeline occupied by the particle of cotton. The amount of tubing length 10 sm will be equal to $V_t = 0.25\pi d^2 L = 0.25 \cdot 3.14 \cdot 40^2 \cdot 10 = 12560см^3$. Then, according to (16):

$$\Delta v = (V/V_t)100\% = (320 \div 540)/12560 \cdot 100\% = 2{,}55 \div 4{,}30 \approx 3{,}5\%$$

Analyzing he obtained values, it is possible to conclude that during pneumatic transport, in the current size of pneumotrack raw cotton is 62% of the length and only 5.5% of the cross section and 3.5% of the internal volume of the pipeline.

These calculations indicate the presence of a significant amount-space that is not used during transportation, i.e. while the bulk of the volume of the pipeline is empty. If we consider that in the calculation of the rate of air flow and material have been taken much lower than the calculated values, the irrational use of pneumatic power consumption will be even more obvious. This shows the use of pipelines unreasonableness such large cross-sectional dimensions (d=0,4m), which causes high costs air, electricity, and material.

Practice justifyes the use of the existing pipeline sizes that due to un evens up ply of cotton (in the form of large lumps) of the storage formation cotton stream requires a large cross-sectional dimensions wire material since during the supply of the large size and mass of the particles may clog the throat pipe cotton, which leads to a shutdown in production. Which implies that with ensuring uniform supply of cotton in pneumatic conveying pipeline becomes possible elimination faces neck pipeline even at smaller sizes of its cross section.

When operating flow rate of 20-25 m/s, if you reduce the diameter of the pipe at least 315 mm, air flow will be Q= Fv = 0.95÷1.19 m^3/s, and if up to 355 mm Q = Fv =0.53÷0.67 m^3/s. This in turn significantly reduces the power consumption (Power consumption of the system):

- Using a fan instead of the VS-10M on VS-12M - 25 kW/h;
- Using a fan instead of the VS-8M on VS-10M - 19 kW/h.

More significant digits for saving power consumption appears to account for the multiplicity of application pneumatic cotton plants, which extends, as described above, to 6. That is, the massive use of energy saving advice is also increased by 4-6 times concerning single use.

It should be noted that the application requires smaller piping design review and other pneumatic elements equipment-stone trap, a separator as well. However, the possibility of a significant reduction in energy costs justifies such an act. This, in turn will reduce the cost of cleaning up and use the air to reduce the loss of material in its structure and provide even greater flexibility and mobility of the pneumatic installation

4. Conclusions

a). Analysis of the pneumatic transport installations at ginneries shows the presence of a number of resource s to facilitate efficient processing of cotton.

b). When using the pneumatic installation there is a substantial air suction from the environment through the pneumatic conveying elements and the connection point between them, which requires are view of the structure of these elements in terms of reducing the suction of air from the outside.

c). Analyzing the obtained values, it is possible to conclude that during pneumatic transport, in the current size of pneumotrack raw cotton is 62% of the length and only 5.5% of the cross section and 3.5% of the internal volume of the pipeline, i.e. the bulk of the volume of the inner space of the pipeline is not used.

d). For a more efficient use of space volume pneumatic track offered

- Apply the feeder provides a uniform power pneumatic conveying cotton;
- To reduce the diameter of the pipeline Compressed-air to 355-315 mm.

The main contributions of this paper are:

1. Evidence of excessive suction of air through the elements of the pneumatic installation or the same for errors in the existing method of calculation of parameters of pneumatic. This shows the need to review designs pneumatic components in terms of tightness and also conduct comprehensive fundamental and practical research to identify patterns of pneumatic transport of cotton and the development of new recommendations of the calculation.
2. Proof of in efficient use of useful volume of the pipeline in operation, which clearly over spending conveying air Compressed-air and power.
3. The proof of the possibility of using a pipeline with a diameter of 315-355 mm instead of 400 mm, which allows to reduce electricity consumption by 19-25 kW/h using a feeder provides a uniform power pneumatic cotton.

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