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THE ORETICAL ANALYSIS OF THE FIBER REMOVING PROCESS

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Abstract: Our scientists have been conducting research for several years to automate and improve the uniform distribution of cotton raw materials to sawing machines. This article analyzes the theoretical studies presented on the uniform distribution of air pressure and the reduction of electrical energy consumption.

Keywords: cotton, fiber, air pressure, energy, seed.

Introduction. "Air flow" means the amount of air, expressed per unit volume, passing through the duct section in question per unit time. To determine the air flow distributed to 3 engines, we will carry out the following theoretical calculations.

If the cross-sectional area of the channel under consideration is equal to S м² (for a pipe Ø400 mm) and air flows through it at an average speed of m/s, then the air flow will be as follows [1]:

$$Q = V \cdot S \text{, м}^3/\text{с}. \tag{1}$$

The air flow through the nozzle slit size is [2]:

$$Q = n \cdot \alpha \cdot S \cdot V_x , \tag{1.1}$$

here: n – number of gin stands in the battery;

α – air flow unevenness coefficient for crevice nozzles, $\alpha \approx 0{,}96$;

S – nozzle exit surface, m²;

V_x – speed of air flow leaving the nozzle, м/с.

Methodology & empirical analysis. If you substitute the values into the formula (3.2):

$$Q = 3 \cdot 0{,}96 \cdot 0{,}0128 \cdot 30 = 2{,}22 \text{ м}^3/\text{с}$$

we get.

In practice, due to resistance, suction and losses in pipes, this value is higher and is taken on average 0.8-1.0 m^3/s (2.4-3.0 m^3/s) per gin.

On the other hand, for 3 gin batteries, the total total pressure in the network is 270-475 mm water column. for removing fiber from saws and transporting it to a condenser with a capacity of 3-4 m^3/s. Centrifugal fans VTs-8M and VTs-10M are used. [2]

From an analysis of the literature it is known that the pressure of the VTs-10M fan is 3.5 m^3/s. From here, using equation (3.1), you can determine the speed of the air leaving the fan:

$$V = \frac{Q}{S} = \frac{3{,}5}{0{,}1257} = 27{,}9 \text{ м}^3/\text{с},$$

Accept $V = 30$ м³/с.

When turning the throttle valve at an α angle to the pipe axis, the cross-sectional area of the air duct $S_ў$ is determined as follows:

$$S_ў = S_{max}(1 - \sin\alpha) \tag{1.2}$$

here : S_{max} – pipe surface.

Results. It is known from production practice that even if there are 3 gin stands in the battery, they all do not work simultaneously for various reasons (repairs, saw replacement, clogging of the working chamber, insufficient cotton transfer). But the air is blown equally (in time) to all three genies.

Table 1. Air consumption when operating 3, 2 and 1 generator.

Blade rotation angle α, °	Section of the air passage in the pipe $S_ў$, m²	Air speed V, м/с	Air flow, м³/с		
			For 3 gins $Q_{3ж}$	For 4 gins $Q_{2ж}$	For 3 gins $Q_{1ж}$
0	0,1257	30	3,77	2,49	1,24
15	0,0931	30	2,79	1,84	0,92
30	0,0628	30	1,88	1,24	0,62
45	0,0368	30	1,10	0,73	0,36
60	0,0168	30	0,51	0,33	0,17
75	0,0043	30	0,13	0,08	0,04
90	0	30	0	0	0

To regulate the total air flow, a central throttle located in the central pipe is used, and individual throttles are used to regulate the flow of transmitted air for each genie. Of course, the throttle angle affects air flow. Table 1 shows the results of a theoretical calculation of air flow using formula (1.1) at an angle of inclination of the central throttle valve of 3, 2 and 1. The graph constructed based on the results obtained is shown in Figure 1.

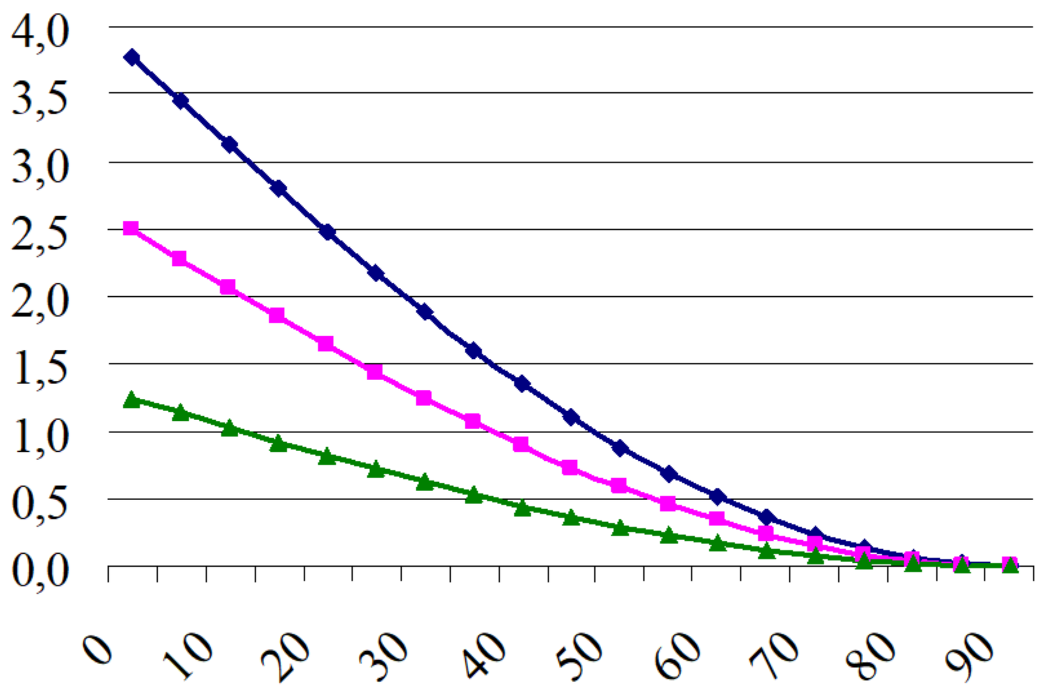

Figure 1. Graph of changes in air flow depending on the angle of rotation of the fan when operating with 3, 2 and 1 gin.

If we take the left side of the equation from equation (1) and substitute equation (2), we can find the angle:

$$S_{max}(1-\sin\alpha)=\frac{Q}{V},$$

$$\sin\alpha=1-\frac{Q}{V\cdot S_{max}}. \qquad (2)$$

Table 1 shows the values of the throttle valve rotation angle to ensure the required air flow $Q=2{,}4\div3{,}0$ m³/c for a 3-gin battery according to equation (3.4).

Table 2. Throttle angle to ensure air flow

Air flow Q, м³/с	Air speed V, м/с	Pipe cross-sectional surface S_{max}, м²	$\sin\alpha$	Blade rotation angle α, °
2,4	30,0	0,1257	0,36	21
2,5	30,0	0,1257	0,34	20
2,6	30,0	0,1257	0,31	18
2,7	30,0	0,1257	0,28	16
2,8	30,0	0,1257	0,26	15
2,9	30,0	0,1257	0,23	13
3,0	30,0	0,1257	0,20	12

So, in order to ensure the necessary air flow for a 3-gin battery, the throttle valve should be rotated 12-21°, and to increase air flow, reduce the angle of the blade.

It is known from the literature that when the speed of rotation of the fan blade changes, the air flow changes in proportion Q to the number of revolutions:

$$\frac{Q_1}{Q_2} = \frac{n_1}{n_2}; \tag{3}$$

here : Q_1 and Q_2 – respectively, the air flow supplied by the fan and the required, m³/c;

n_1 and n_2 – in the appropriate case - the number of previous and subsequent fan revolutions, rpm.

The power expended on the movement of the fan blade varies proportionally to the cube of the number of revolutions:

$$\frac{N_1}{N_2} = \left(\frac{n_1}{n_2}\right)^3. \tag{3.1}$$

here: N_1 and N_2 – respectively fan performance before and after, m³/c.

As can be seen from equations (2.1), (3) and (3.1), it is necessary to change the throttle angle or fan speed to adjust the air flow and reduce power consumption. Currently, the first method is used at cotton ginning enterprises. The disadvantage of this method is that, firstly, even when all fans are running, the throttle valve does not open completely and the air flow is artificially reduced, and secondly, even when 2 or 1 fan is running, the fans operate at full power. power, which leads to increased electricity consumption.

Table 3. Recommended fan speed.

Air flow, m³/c			Air speed V, м/с	Pipe cross-sectional surface S_{max}, м²	Maximum air flow Q_{max}, m³/c	Fan rotation speed, rpm			
For3 gins $Q_{3ж}$	For 2 gins $Q_{2ж}$	For 1 gins $Q_{1ж}$				Existence howling n_1	For 3 gins $n_{3ж}$	For 2 gins $n_{2ж}$	For 1 gins $n_{1ж}$
2,4	1,60	0,80					929	613	307
2,5	1,67	0,83					968	639	319
2,6	1,73	0,87					1007	665	332
2,7	1,80	0,90	30,0	0,1257	3,77	1460	1046	690	345
2,8	1,86	0,93					1084	716	358
2,9	1,93	0,97					1123	741	371
3,0	2,00	1,00					1162	767	383

To solve this problem, we set ourselves the task of finding opportunities to use the second method. That is, we learn to regulate the air supply to the battery by changing the fan speed without changing the position of the central throttle valve.

As a first approximation, we assume the same amount of air is used for all gins and use proportions. Using equation (3), we determine the fan rotation speed, enter the results into Table 3.3 and use them to build a graph shown in Figure 2:

$$n_2 = n_1 \frac{Q_2}{Q_1}.$$

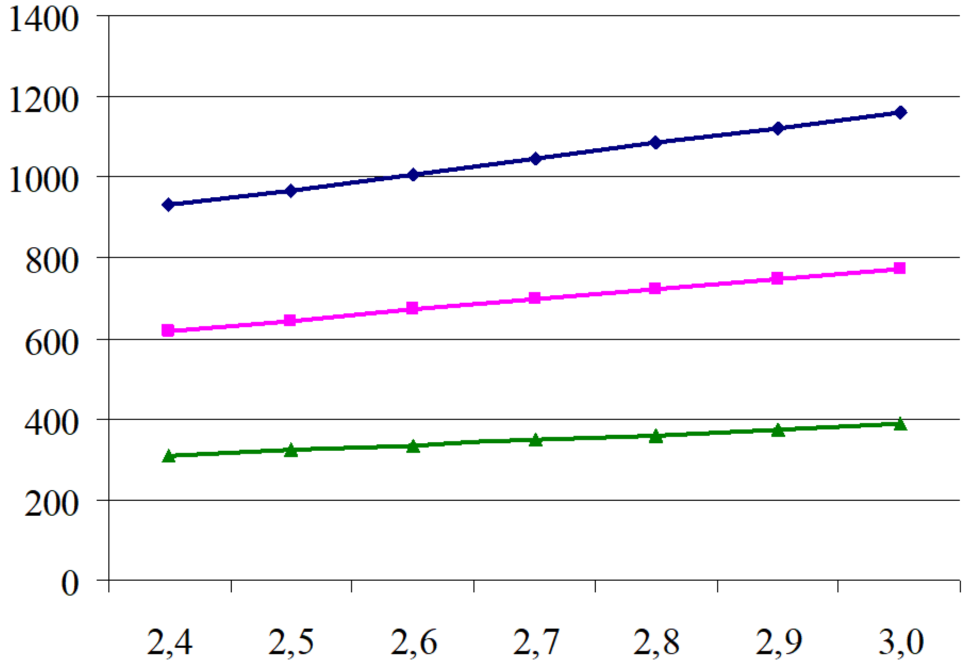

Figure 2. Graph for changing fan speed to ensure the required air flow.

Conclusion. As can be seen from Table 3 and the graph in Figure 2, the air flow of the chainsaw battery deburring system can be adjusted by changing the fan speed. There is no need for a central throttle when all gears are operating and the individual throttle valves are turned to specific (different for 1st, 2nd, 3rd gear) angles. When the engine is not running, its individual throttle valve is in the fully closed position, preventing the passage of air and, as a result, the air flow corresponds to running engines.

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