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The Transversal Ventilator, Generating of Ideal Aerodynamic Field for Agricultural Machinery of Harvesting and Conditioning

The theoretical studies and experimental researches effects confirm that the transversal ventilator, through the structure and the quality of the aerodynamic field, which is generated, it becomes the type of ideal ventilator for agricultural machinery of harvesting and conditioned cereal mixtures.

1. General considerations

The transversal ventilator is a generator of aerodynamic field of low and medium pressure, with flowing lines after a direction which is perpendicular on the rotating axe of the rotor and a uniform distribution of the speeds on the working width of each zone of the refulation section, respectively with the possibility of modification, when necessary, of the field profile , on the vertical level of the section of the pneumatic network where it functions.

Unlike the centrifugal ventilator , which provides a spatial aerodynamic field, with components after all the three directions of the reference system, the transversal ventilator creates a rigorous bidimensional aerodynamic field.

The size of the vectors that characterize the intensity of the aerodynamic field in each zone of the coordinate of the reference system , may be influenced through constructive measures on the components of the skeleton, but also through the number, profile and installation way of the blades in the rotor, respectively through the number of rotations on which the rotor functions.

The ventilators of the combines for agricultural products and especially the combines for cereals, must create a uniform aerodynamic field on the working width and variably on the height of the refulation section, as a result of the wide fork of variation of the length of the cleaning rooms for the cereal mixture that got on their separators.

This request is satisfied only by the aerodynamic field given by the transversal ventilator, reason for which appeared on global level a series of scientific reports where there is founded the possibility of using the transversal ventilator in pneumatic networks of the agricultural machines in general and especially for building combines for harvesting straw cereals , respectively for machines of pre-cleaning of these mixtures.

Theoretical studies and experimental tests made by authors allowed the elaboration of a methodology for calculating experimental models of transversal ventilators , methodologies that are presented during this report.

2. Comparative experimental researches about the structure of the aerodynamic fields accomplished by the double absorber centrifugal ventilator and the transversal ventilator

2.1. The constructive characteristics of the double absorber centrifugal ventilator experimented

The characteristics of the double absorber centrifugal ventilator experimented are indicated in table 1, and the semnification of the notations from this table are presented in figuure 1. [6]

Table 1

d_2 mm	Dimensions in % from d_2								
	D_1	D_0	D_c	I_c	B_c	B	c	D	E
514	61,8	85,5	105,6	59,3	210	202	19,5	29,6	5,85

Table 1 continuation

d_2 mm	β_c rad	β_1 rad	β_2 rad	Nr. Blades
514	0,697 (40^0)	1,57 (90^0)	1,57 (90^0)	4

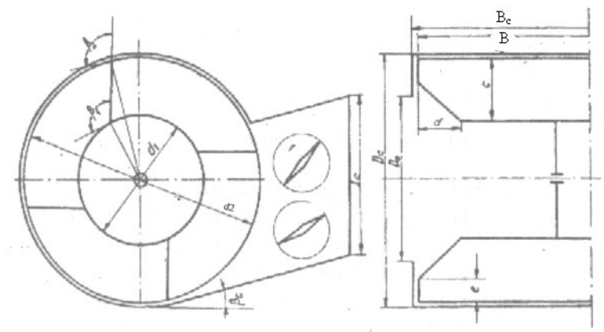

Figure 1. The semnification of the parameters notations of the double absorber centrifugal ventilator experimented

The experimented ventilator has the rotor with 4 blades,the case with circular section,and in the refulation channel there are two deflector profiles with adjustable position . In the inferior side of the aspiration zones there is also a separator with circular holes with a diameter of 12 mm, that contributes at the reduction of the aspiration sections with 19-20%.In these conditions the ratio between the total section of aspiration and that of refulation has the value of 0,89.

2.2.The experimenting of the double absorber centrifugal ventilator

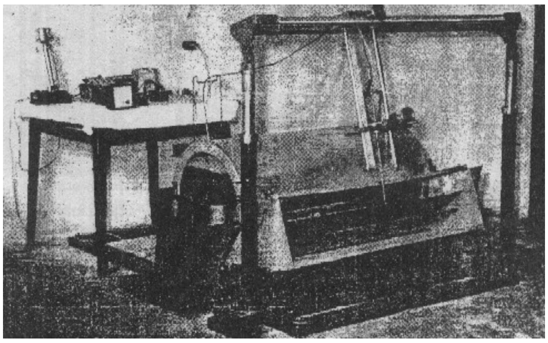

Figure 2. The experimental stand equiped with double absorber centrifugal ventilator

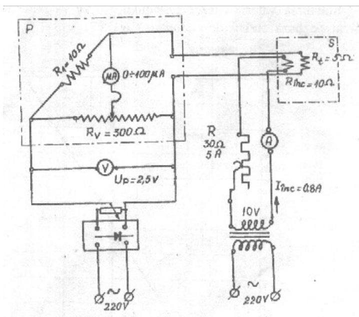

Figure 3. The scheme of the hot-wire anemometer with thermal resistance of price and necessitate a precise cost-benefit analysis to be made for each specific case.

The structure of the stand for testing the double absorber centrifugal ventilator whose constructive characteristics were presented above, is shown in figture 2.

Because the aerodynamic field realized by this ventilator was a spatial field, with deviations between –0,2443 circular measure (-14^0) and 0,26175 circular measure ($+15^0$)on horizontal level and –0,2094 circular measure (-12^0) and 0,2094 circular measure ($+12^0$) on vertical level,the measurement of the speeds of the aerodynamic field was done with the hot-wire anemometer whose skeleton is shown in picture 3. [7]
The structure of the aerodynamic field realised by this ventilator at the speed of 838 rot/min is shown in figure 4.

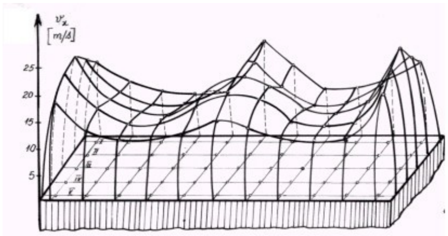

Figure 4. The structure of the aerodynamic field realised by the double absorber centrifugal ventilator at the speed of 838 rot/min

2.3. The constructive characteristics of the transversal ventilator experimented

The diagram of the transversal ventilator designed and realised in such a way that it can replace the double absorber centrifugal ventilator with the characteristics from above is shown in picture 5, and his constructive parameters are centralised in table 2.

Table 2.

D_2 mm	Dimensionsi in % from d_2													
	D_1	R_p	b	B_c	B'_c	I_c	a_c	e	r_c	R_1	R_2	R_3	Δ	L_1	L_2
340	70	17.6	298	315	270	76.5	12	14.7	67.6	208	25	140	4	57.4	65

α_a	β_c	γ			Nr of blades z_p
			δ	αc	
2.27	2.96	1.05	0.348	0.7	12

2.4. The experimenting of the transversal ventilator

The structure of the aerodynamic field made by the transversal ventilator experimented and equiped with 12 blades,set up at an angle β_2 equal with the value of 0,522 circular measure (30^0),is shown in figure 6.

Comparing the functional performances realised by the transversal ventilator experimented and respectively the double absorber centrifugal ventilator from the combine of harvesting straw cereals with medium capacity of working out,it was discovered that for the same angle speed of the rotor very close values were got for general medium speed, in the conditions of the proportion

$$\frac{d_2 t}{d_2 c} = \frac{340}{514} = 0{,}66 \tag{1}$$

Through this value it is shown the fact that for realising the same medium values of the flowing speed of the air the transversal ventilator needs a rotor with the exterior diameter much smaller than that of the equivalent centrifugal ventilator.

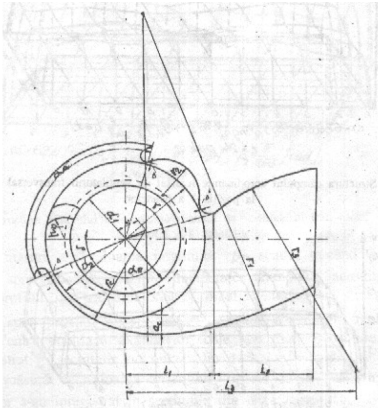

Figure 5.The diagram of the transversal ventilator tested

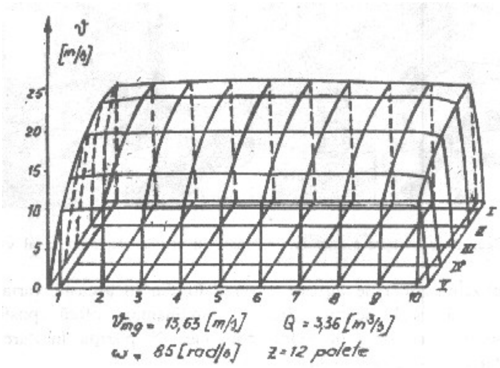

Figure 6. The structure of the aerodynamic field made by the transversal ventilator experimented

3. Contributions to the calculation and designing of the experimental model of transversal ventilator

When you don't have a prototype whose aerodynamic model and energetic characteristics satisfies from all the points of view,you use the analitical method of designing .

It is necessary to know the destination and the dimensional characteristics and that of hydraulic resistance of the pneumatic network where the designed ventilator is going to work.Also, the designing theme must impose the value of the general medium speed v_{mg} that the aerodynamic field must have ,but also the air flow Q[m^3/s],that the ventilator must realise in the final section of the air nozzle.

The medium speed of the aerodynamic field is established from technological reasons, depending on the technological effect that must be assured (elimination of undesired components, assuring of certain values for the temperature and humidity of the air, like the comfort parameters in the technological or living rooms, pneumatic transport of some components on a short distance etc.)

Knowing the necessary value for v_{mg}, from its corellation expression with the dynamic pressure H_d, regarding to whom: $v_{mg} \cong 4 \cdot \sqrt{H_d}$ [m/s], (2) the value of the working dynamic pressure is established,

$$H_d = \frac{v_{mg}^2}{16},[mm\,col.H_2O] = 9{,}81 \cdot \frac{v_{mg}^2}{16}[Pa] \quad (3)$$

For establishing the value of the total pressure that the ventilator must generate (meaning the obligatory imposed value in the designing theme),this must be higher than the resistance of H_r network ,for which N.P. Sîciugov [3] present the following calculating expression:

$$H_r = 0{,}27 \cdot \frac{Q_2}{10^4}[daN/m^2],\ respectiv\ H_r = 0{,}27 \cdot 9{,}81 \cdot \frac{Q_2}{10^4}[Pa] \quad (4)$$

Using for the calculation of the H pressure the analitical expressions (8) and (9) all the premises are created for verifying if the designed ventilator is able to realise a pressure $H>H_r$, if the parameters D_2 and n are known.

Depending on the profile imposed to the aerodynamic field that is going to be realised by the designing ventilator,angles β_1 and β_2 are adopted for fixing the blades in the border discs of the rotor, but also the value of the flow coefficient φ. For safety reasons,it is thought that may appear situations when 30% from the quantity of air drawn off the ventilator recirculates, contributing at the forming of the active swirl that naturally appear in the functioning process of this type of ventilator.That why it is adopted φ=0,7.

Imposing the working width B, respectively the height I for the rectangular section of the pneumatic network where the ventilator is going to function and knowing the medium value of the speed v_{mg} of the plenum air,the flow that must be realised by the ventilator will have the value:

$$Q = B \cdot I \cdot v_{mg}[m^3/s], \quad (5)$$

And from the expression of the flow coefficient,

$$\varphi = \frac{Q}{Bd_2 r_2 \omega} = \frac{2Q}{\omega Bd_2^2} = 0{,}7, \quad (6)$$

where ω < 85[rad/s] or ω >85[rad/s], after the number of blades Z<12 blades, or Z>12 blades.

From relation (6) results that: $d_2 = \sqrt{\frac{2Q}{0{,}7B\omega}}$, in m. (7)

The value of the B width is imposed from constructive reasons resulted from the structure of the pneumatic network where the designing transversal ventilator is going to work.

The theoretical assertion about the dependence of the aerodynamic performances of the designing ventilator on the rotor diameter, its number of revolutions and the density of the used air, imposes the using of some data got through experimental determinations like those presented in figure 7 and 8 [4]

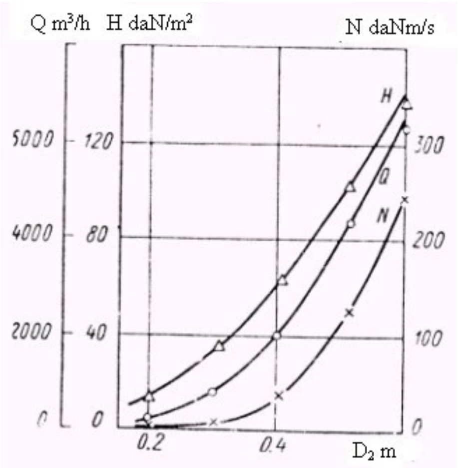

Figure 7. The evolution of the parameters H,Q N=f(D_2),for n=1170 [rot/min] and ρ=0,121 [daN.s^2/m^4]

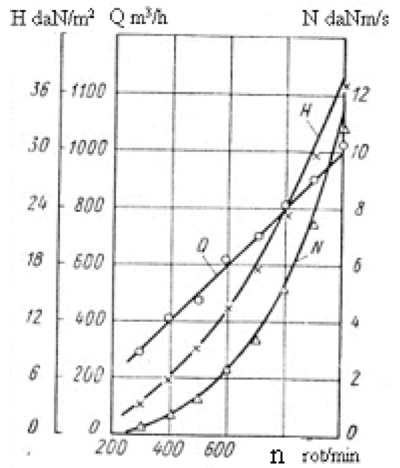

Figure 8. The evolution of the parameters Q, H, N=f(n),for D_2=0,32m; B=0,1m Z=28 blades

The analitical expressions that satisfy the evolution of the curves H, Q, N=f(D_2), respectively H, Q, N=f(n) for the experimented ventilators are:

$$\begin{cases} Q = 30900 D_2^{3,04}, \left[\frac{m^3}{h}\right]; \\ H = 382 D_2^{2,021}, \left[\frac{daN}{m^2}\right]; \\ N = 3400 D_2^{2,021}, \left[\frac{daNm}{s}\right]. \end{cases} \quad (8) \qquad \begin{cases} Q = 0,875 n^{1,023}, \left[\frac{m^3}{h}\right]; \\ H = 3,585 \times 10^{-5} \times n^{2,01}, \left[\frac{daN}{m^2}\right]; \\ N = 8,34 \times 10^{-9} \times n^{3,04}, \left[\frac{daNm}{s}\right]. \end{cases} \quad (9)$$

Regarding the constructive parameters of the case, first of all it is necessary to establish the case variant that must be adopted , with bend (unprofiled), or with the inferior wall built after the way of the logistic spiral (in spiral).

If the profile of the aerodynamic field in the final section of upsetting the air nozzle must be like that shown in figure 9b, then it is adopted the inferior wall of the bend case (unprofiled), and the superior wall with profiled limb for catching the active swirl.

If it is necessary to realise an aerodynamic field with a uniform distribution ,on horizontal and vertical plane of the final section of upsetting the air nozzle (picture 9c),it is adopted the inferior wall displayed after a logistic curve, and the superior wall has a short and unprofiled limb.

Definitely, in assuring the flows and the productive capacities wanted at the ventilators with bend inferior wall,the opening angle of the sucking window shows its influence and respectively the β_2 angle of the blades. A dependency extremely cogent on this form:

$Q = f(\lambda_{BX}, \beta_2)$ and $\eta = f'(\lambda_{BX}, \beta_2)$ is shown in figure 10

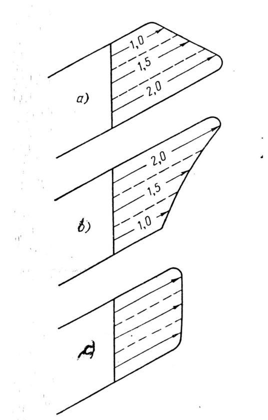

Figure 9. .Purges of the aerodynamic fields that can be realised by the transversal ventilator in the vertical plane

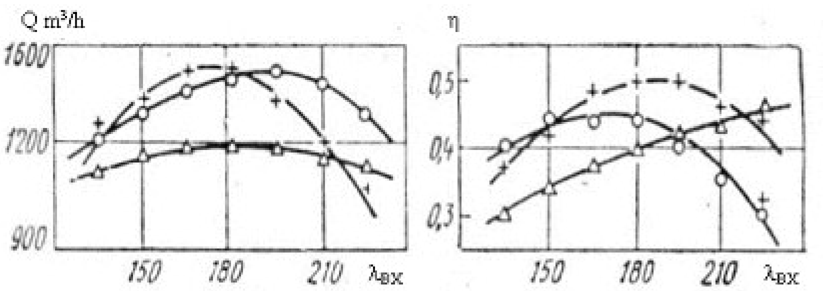

Figure 10. The influence of the variation of the opening angle of the sucking window (λ_{BX}) and of the β_2 angle of positioning the blades of the rotor on the Q flow and the productive capacity η. β_2=–Δ–Δ–20,3°;– + – + –28,1°;–O–O–39,9°; respectively, λ_{BX}=135°÷225

4. Present performances in modernizing the machines of harvesting and conditioning seeds

4.1. Examples of implementation of the transversal ventilator in the construction of harvesting machines

In figure 11 [5] it is presented a longitudinal section through the combine with axial flow made by the Case-Internaţional firm where the transversal ventilator is integrated in the units flow that assure the harvesting phases, technological transport , cleaning and single evacuation of the components.

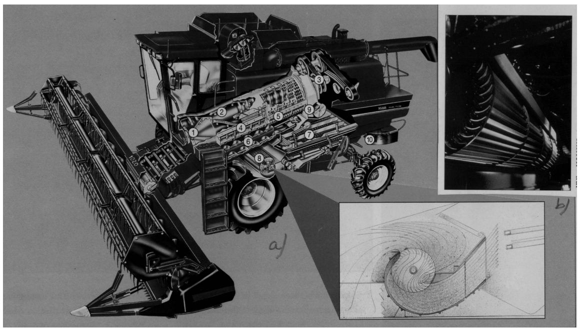

Figure 11. The Case International combine with transversal ventilator at the cleaning room a- general view, b- detail for the ventilator

4.2. Examples of implementation of the transversal ventilator in the construction of the conditioning machines

In figture 12 [7] it is presented the diagram of the technological process realised by the pre-cleaning machine MPO-50 and which has the transversal ventilator put in such a way to work on upsetting.

In figure 13 it is presented a connection between the working principle of the cylindrical separator and that of the transversal ventilator, able to execute a uniform vacuuming on all the working width of the cylindrical separator with double passing.

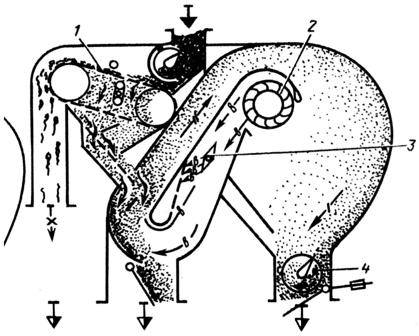

Figure 12. The diagram of the technological process realised by the MPO-50 machine with transversal ventilator that works on upsetting [7] 1. rolling separator, 2.transversal ventilator, 3.air setting key, 4.sediment eliminator

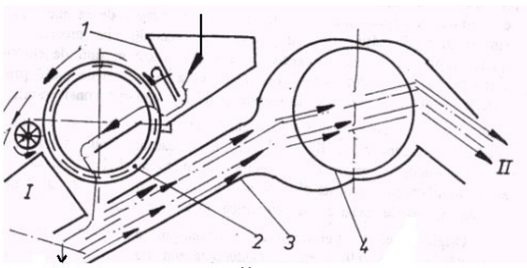

Figure 13. Machine of pre-cleaning seeds with cylindrical separator and transversal ventilator that works on vacuuming[7] 1 container for supplying with mixture, 2. cylindrical separator with double passing, 3.vacuuming zone of the transversal ventilator, 4.the rotor of the transversal ventilator

I. sorting zone for big impurities (straws,chaff), II.Upsetting zone for impurities vacuumed by the ventilator

5. Conclusion

In the present, in our country, in the construction of the machines for harvesting and conditioning agricultural products,there are mainly used the double absorber centrifugal ventilators , where the aerodynamic field is as erratic as the working width is larger. This aspect represents the basic barrier in the growing of the working ability of this category of machines .

The technical solution for overcoming this barrier is the using of the transversal ventilator that allows the growing of the working capacity of this category of agricultural machines, first of all through the enlargement of the working width.

The transversal ventilator is a technico-scientific accomplishment that can revolution the pneumatic processes from the category of the agroalimentary machines that needlow and medium pressures , and the rectangular shape of the flowing sections of the air , from vacuuming to upsetting, create the best conditions for the integration of this type of ventilator in the constructive structure of this machines category.

Its functional principle can be expanded succesfully in the processes of drying, dehidration and cooling of the agro-alimentary products,favouring the realisation of simple installations with great working capacity.

The aerodynamic field made by the transversal ventilator is plane, bidimensional,with a uniform speed on the working width and with the chance of being modelated on the height of the final section of upsetting in the network depending on the necessities imposed by the process.

For an operative application and for generalizing the using of the transversal ventilator in the processes where its functional principle is required,there are necessary own intensive and scope researches .

If under the functional aspect the working process of this type of ventilator is mostly under control,under the aspect of elaborating the building technology more researches must be done. These researches must take into consideration the finding of some quick methods for assembling and positioning the sides of the blades in the rotor in conformity with the performances that are followed, of ensuring a coresponding rigidity of the rotor and using some light and cheap materials that reduces its moment of inertia.

It is clear the fact that the transversal ventilator is more difficult to be made in comparison with the axial or centrifugal ventilator, but the functional advantages of the transversal ventilator greatly compensates this disadvantage.

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