Opinions Regarding the Assessment of Pressure Drop in Tangential Feed Cyclones for Cleaning Industrial Dry Gases

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Abstract: *Cyclones are used to remove solid particles larger than 5 µm from impure industrial gases. They are simple constructions, without moving parts and easy to maintain. In the use of such equipment, main interest is to evaluate the pressure drop in the cyclone and the efficiency of separation. Ensuring a high value of the pressure drop involves high energy consumption, aiming to increase the separation efficiency. Many studies, exposed in the content of this work, have been carried out, in the sense of the above topic, for pressure loss assessment. The results of the empirical formulas, proposed over time, were compared, in the specialized literature, with those offered by the experimental results, obviously for practical cases of great interest.*

Keywords: *Cyclones with tangential feed, pressure drop*

1. Introduction

Cyclones are among the simplest systems used for dedusting dry gases in various industrial sectors. Among these, the ones with tangential feed of impurified gas stood out.

The design of the cyclones considers their geometry, the flowrate of the impurified gas and the number of revolutions/rotations in the downward movement. The theory developed [1] proved to be useful in the practical design of cyclones. This theory refers to the fact that the velocity profile in a cyclone does not strictly adhere to the ideal, uniform shape. Any design method is based on theories that depend on the accuracy of the evaluation of the collection efficiency and the pressure drop in the cyclone. The two characteristics represent two major criteria regarding the performance of a cyclone. Both are dependent on the dimensions of the cyclone, the height and width of the entrance ($a \cdot b$ – Figure 1), the diameter of the gas outlet D_e, the length of the outlet pipe S, the height of the cylindrical area h the height of the cyclone H and the diameter of the collected dust outlet pipe B.

Over the time, several simplified models and empirical correlations have been proposed for the design and evaluation of cyclones, the essential requirement being that of correlation with the concrete characteristics of each equipment [3]. The reference to the performance of a cyclone considered as a "*landmark*" leads, in the end, to a faulty design, since each cyclone has a specific behavior, according to the unique physical properties of the impurified gas flow [4]. The Computational Fluid Dynamics (CFD) method has become a powerful instrument in the design and evaluation of cyclones due to the rapid advances in computer technology [42]. This technique provides a great potential to predict the characteristics of the fluid flow, the trajectory of the particles and the pressure drop in the cyclone [3]. The accuracy of the numerical modeling of a turbulent flow depends primarily on the selection the appropriate turbulence model [3]. The long analysis time and therefore the high computational cost has been a major obstacle in the simulation of cyclones. In the present, thanks to the increased processing performance of computers, at a relatively low cost, it has become possible to simulate cyclones with greater precision [5, 6].

The capacity of a cyclone is determined by the value of the area of the feed pipe ($a{\cdot}b$ – Figure 1), and the inlet velocity of the gas to be cleaned. This is, mainly, in agreement with the connection between the main dimensions of the cyclone and its pressure drop.
Note: The first studies on the characterization of cyclones were carried out between 1930 and 1950 (***Alexander R. McK*** – 1949, ***Ter Linden A. J.*** – 1949) [16].

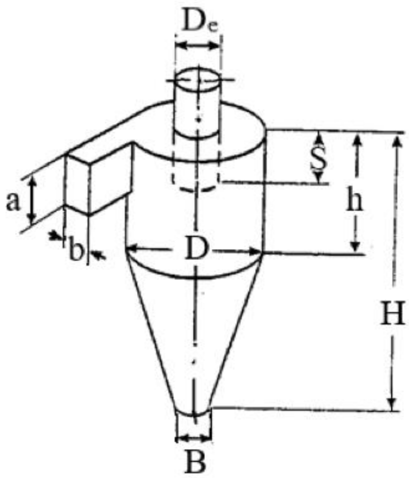

Fig. 1. Construction and characteristics of a cyclone [2]

2. Expressions for the height of the impure gas column

This characteristic (a major criterion regarding the performance of a cyclone [10]) varies with the square of the inlet gas velocity and is conveniently expressed by the height of the gas column [2]:

$$\Delta H = 2\cdot\Delta p \Big/ \left(\rho_g \cdot v_i^2\right), \tag{1}$$

where Δp is the pressure drop between the gas inlet and outlet of the cyclone, ρ_g - gas density, and v_i - the gas velocity at the cyclone inlet (the optimal input speed recommended by ***Abdel – Hadi M. A.*** – 2014 [41] is $18.5\, m/s$, respectively $18.0\, m/s$ - ***Chuah T. G., Gimbun J., Choong Y. S. T***. – 2003 [41]); the inlet velocity of the impure gas is primordial – ***Schnell K. B, Brown A. C.*** – 2002 [41].
Note: In paper [11], the density of the mixture of gas and particles ρ_{p-g} is used instead of the gas density ρ_p, a suggestion belonging to the authors ***Shepherd C. B., Lapple C. E*** (1951).
Note: In papers [13 - 16], the following relationships are indicated for the calculation of the parameter Δ H:

$\Delta H = K\cdot a\cdot b / D_e^2$ - ***Shepherd C B.*** and ***Lapple C. E.*** (1939) (2)

Note: The values of K are: $K = 16$ for cyclones with standard tangential inlet [11]; $K = 7.5$ for cyclones that have a vane at the entrance to change the geometry of the impure gas inlet section [16, 17]; $K = 12 \ldots 18$, for cyclones with tangential entry [15].

$\Delta H = 11.3\cdot\left(a\cdot b / D_e^2\right)^2 + 3.33$ - ***Casal J.*** and ***Martinez – Benet J. M.*** (1983); (2) $_1$

$\Delta H = 9.47\cdot a\cdot b / D_e^2$ - ***Coker J. K.*** (1993), (2) $_2$

configurations specified in the paper [13].

2. 1. <u>The theory of *STAIRMAND C. J.*</u> (1949)

According to this theory, the height of the gas column is calculated with [2, 9, 17, 21, 22]:

$$\Delta H = 1 + 2 \cdot \Phi^2 \cdot \left[2 \cdot \left(D - b \right) / D_e - 1 \right] + 2.548 \cdot \left(a \cdot b / D_e^2 \right)^2 , \quad (3)$$

where Φ is the ratio of the tangential velocities:

$$\Phi = \frac{\sqrt{D_e / \left[2 \cdot \left(D - b \right) \right] + 4 \cdot f \cdot A / \left(a \cdot b \right)} - \sqrt{D_e / \left[2 \cdot \left(D - b \right) \right]}}{2 \cdot f \cdot A / \left(a \cdot b \right)} , \quad (4)$$

where f is the friction coefficient, whose value, established by ***Stairmand C. J.*** (1949), is 0.005, and A is the area of the internal surface of the cyclone exposed to the spin movement of the gas [22]:

$$A = 0.785 \cdot \left(D^2 - D_e^2 \right) + 3.14 \cdot \left(D_e \cdot S + D \cdot h \right) +$$

$$+ 1.57 \cdot \left(D + B \right) \cdot \sqrt{\left(H - h \right)^2 + \left[\left(D - B \right) / 2 \right]^2} , \quad (5)$$

with the geometric notations specified in Figure 1.

2. 2. <u>The theory of *ALEXANDER R. McK*</u> (1949)

The same bibliographic sources [9, 16, 21] also present the expression of the parameter ΔH, attributed to ***Alexander R. McK*** (1949), written in the form:

$$\Delta H = 4.62 \cdot \left(\frac{a \cdot b}{D \cdot D_e} \right) \cdot \left\{ \left[\left(\frac{D}{D_e} \right)^{2 \cdot n} - 1 \right] \cdot \frac{1 - n}{n} + f \cdot \left(\frac{D}{D_e} \right)^{2 \cdot n} \right\} , \quad (6)$$

in which represents the friction factor having the expression:

$$f = 0.8 \cdot \left[\frac{1}{3 \cdot n \cdot \left(n - 1 \right)} \cdot \left(4 - 2^{2 \cdot n} \right) - \frac{1 - n}{n} \right] + 0.2 \cdot \left[\frac{1 - n}{n} \cdot \left(2^{2 \cdot n} - 1 \right) + 1.5 \cdot 2^{2 \cdot n} \right] , \quad (7)$$

in this expression n is calculated using the equations:

$$n = 0.263 \cdot R^{0,14} . \quad (8)$$

Experimentally, it was found that the exponent n can be expressed by the relation [24, 43]:

$$n = 1 - \left(1 - 0.67 \cdot D^{0,14} \right) \cdot \left(T / 283 \right)^{0,3} , \quad (9)$$

T representing the absolute temperature of the polluted gas, in K, and D - the inner diameter of the cylindrical part of the cyclone, in meters. The above relation is attributed to ***Alexander R. McK.*** (1949) [9, 11, 16, 21].

<u>Note</u>: In paper [25] a slight modification of the expression for n is presented in the form:

$$n = 1 - \left(1 - 0.50 \cdot D^{0,14} \right) \cdot \left(T / 283 \right)^{0,3} , \quad (10)$$

attributed to the authors ***Li E., Wang Y.*** (1989), where D is measured in meters; the paper [26] proposes the formula:

$$n = 1 - \left(1 - 0.016 \cdot D^{0,14} \right) \cdot \left(T / 283 \right)^{0,3} . \quad (11)$$

<u>Note</u>: In the paper [27], the equality $v_\theta \cdot R^n = v_t \cdot R^n = ct.$ is specified for the free vortex of the gas inside the cyclone, delimited by a radius a that separates it from the forced vortex ($a \langle r \langle 0.5 \cdot D = R$), D representing the inner diameter of the cyclone; for $0 \langle r \langle a$, the equality $v_t \cdot r = ct.$ is assumed. Works [16, 28, 29] present the correlation of the type $v_t = \left(R / r \right)^n \cdot v_i$, where v_i represents the velocity at de feed of the cyclone with impurified gas. ***Shephers C. B.*** and ***Lapple C. E.* –** (1939) - give the value $n = 0.5$ [28].

If the cyclone works at different temperatures, the exponent can be determined from the relationship:

$$\left(1-n_1\right)/\left(1-n_2\right)=T_1/T_2 . \quad (12)$$

The paper [17] offers the conclusions of the authors ***Miller I., Freund J. E.*** (1965) that specifies that the results obtained for the evaluation of pressure loss using the methods ***Sheperd C. B., Lapple C. E.*** (1940), ***Staimand C. J.*** (1949), ***Barth W.*** (1956) are close to other experimental research. The values obtained by ***Alexander R. McK.*** and ***First M. W.*** are less precise.

2. 3. The theory of *FIRST W. M.* (1949, 1950**)**

In the papers [9, 21] is indicated the expression of the factor ΔH written in the form attributed to ***First W. M.*** (1949, 1950):

$$\Delta H=\left(24\cdot a\cdot b/D_e^2\right)\cdot\left\{D^2/\left[h\cdot\left(H-h\right)\right]\right\}^{1/3}. \quad (13)$$

Note: In the paper [17] the following expression is indicated:

$$\Delta H=\left[12\cdot a\cdot b/\left(Y\cdot D_e^2\right)\right]\cdot\left\{D^2/\left[h\cdot\left(H-h\right)\right]\right\}^{1/3}, \quad (14)$$

where the values for the constant Y are as follows: $Y=0.5$- for cyclones with free entry of the impurified gas; $Y=1.0$ - for cyclones with fixed vane at the gas inlet; $Y=2.0$- for cyclones with adjustable vane at the gas inlet in the cyclone.

2. 4. The theory of *BARTH W.* (1956)

In accordance with this theory, ΔH is calculated with the expression [2, 17, 18]:

$$\Delta H=\left(v_t/v_0\right)^2\cdot\left(1.274\cdot a\cdot b/D_e^2\right)^2\cdot\left(\varepsilon_i+\varepsilon_0\right), \quad (15)$$

where:

$$v_t/v_0=1.57\cdot\left(D_e/2\right)\cdot\left(D-b\right)/\left[a\cdot b\cdot\alpha+\pi\cdot h^\bullet\cdot\left(D-b\right)\cdot\lambda\right], \quad (16)$$

v_t is the tangential speed of the gas vortex, v_o- the tangential speed of the gas at the exit of the cyclone, $\alpha -$ a factor characterizing the entry into the cyclone [16, 18]:

$$\alpha=1-1.2\cdot b/D, \quad (17)$$

the expression being attributed to ***Muschelnautz E.*** (1972) [16]; $h^\bullet$ – the height of the vortex in the central area of the cyclone, which depends on the cyclone's dimensions [16, 18]:

$$h^\bullet=H-S,\ \text{for}\quad D_e\leq B; \quad (18)$$

$$h^\bullet=\left(H-h\right)\cdot\left(D-D_e\right)/\left(D-B\right)+h-S,\quad \text{if}\ D_e\rangle B; \quad (19)$$

ε_i - pressure loss factor at the cyclone inlet [17]:

$$\varepsilon_i=\left(D_e/D\right)\cdot\left\{\left[1-\left(v_t/v_0\right)\cdot\left(2/D_e\right)\cdot h^\bullet\cdot\lambda\right]^{-2}-1\right\}; \quad (20)$$

ε_0 - pressure loss factor at the exit of the cyclone [17]

$$\varepsilon_0=4.4\cdot\left(v_t/v_0\right)^{-2/3}+1, \quad (21)$$

and λ is the friction coefficient (estimated by ***Barth W.*** (1956) to be $\lambda=0.02$) [16, 17]:

$$\lambda=\lambda_g\cdot\left(1+2\cdot\sqrt{c_{si}}\right);\ c_{si}\langle 1.0;\quad \lambda=\lambda_g\cdot\left(1+3\cdot\sqrt{c_{si}}\right);\ c_{si}\rangle 1.0, \quad (22)$$

where c_{si} represents the concentration of particles in the mass of gas (mass of particles/mass of gas); $\lambda_g = 0.005$ for high values of number ***Reynolds O.*** (b. 1842 – d. 1912) [16].

2. 5. The theory of *DIRGO J. A.* (1985)

This is based on the analysis of the ratios of the characteristic dimensions of the cyclones and the experimental results obtained by ***Stairmand C. J.*** (1949, 1951 [30]), ***First M. W.*** (1949, 1950), ***Swift P.*** (1969), ***Hejma J.*** (1971) and others, using dimensional analysis with the relation [2]:

$$\Delta H = K \cdot A^x \cdot B^y \cdot C^z , \tag{23}$$

where K is a constant, A, B, C are dimensionless ratios, and x, y, z – exponent calculated based on experimental data.
After processing the data, the following relationship was established [3]:

$$\Delta H = 20 \cdot \left(a \cdot b / D_e^2 \right) \cdot \sqrt[3]{ \left(S / D \right) \Big/ \left(H \cdot B \cdot h / D^3 \right)} . \tag{24}$$

Paper [31] indicates the following expression for calculating ΔH (with the dimensions provided by Figure 1), after the analysis of the constructive models proposed by ***Shepherd C. B.*** and ***Lapple C. E.*** (1940), ***Alexander R. McK*** (1949), ***First M. W.*** (1949), ***Stairmand C. J.*** (1949), ***Bart. W.*** (1956):

$$\Delta H = 19.7 \cdot \left(a \cdot b / D_e^2 \right)^{0,99} \cdot \left(S / D \right)^{0,35} \cdot \left(H / D \right)^{-0,34} \cdot \left(h / D \right)^{-0,35} \cdot \left(B / D \right)^{-0,33} , \tag{25}$$

or [31, 32]:

$$\Delta H = 20 \cdot \left(a \cdot b / D_e^2 \right) \cdot \left[\left(S / D \right) \Big/ \left(H \cdot B \cdot h / D^3 \right) \right]^{1/3} , \tag{26}$$

No significant differences between the results offered by the two expressions were obtained [31].

2. 6. The theory of *HASHEMI B. S.* (2003, 2006)

The author suggests the following relationship for the evaluation of ΔH [9, 21]:

$$\Delta H = \frac{1}{D - D_e} \cdot \left(\frac{D \cdot N_1}{cos^3 \alpha_1} + \frac{\overline{D} \cdot N_2}{cos^3 \alpha_2} \right) + \frac{N_1 + N_2}{cos^3 \alpha_3} , \tag{27}$$

where $\alpha_1, \alpha_2, \alpha_3$ represents the angle of the velocity vector for the fluid flow in the cylindrical part of the cyclone, the conical part and in the outlet pipe respectively, so that:

$$tg\,\alpha_1 = 0.318 \cdot \frac{h}{D \cdot N_1} ; \;\; tg\,\alpha_2 = \left(tg\,\alpha_1 \right) \cdot \left(sin\,\beta \right) ; \;\; tg\,\alpha_3 = 0.318 \cdot \frac{H}{D \cdot \left(N_1 + N_2 \right)} , \tag{28}$$

where (using notations from Figure 1):

$$N_1 = \frac{D^2 \cdot h - D_e^2 \cdot S}{4 \cdot a \cdot b \cdot D} ; \quad N_2 = N_1 \cdot \left[\frac{\left(H - h \right) \cdot D}{h \cdot \overline{D} \cdot \left(sin^2 \beta \right)} \right] ; \quad \overline{D} = \frac{D - B}{ln \left(D / B \right)} , \tag{29}$$

β representing the slope of the cone generator with respect to the horizontal.
<u>**Note**</u>: In the paper [16] some corrections of the parameter ΔH are proposed, with an influencing factor of the concentration of solid particles C_{pi} in the impure gas fed at the cyclone inlet, $\Delta H^{\bullet} = \Delta H \cdot k_{\Delta H}$:

$$k_{\Delta H} = 1 \Big/ \left[1 + 0.0086 \cdot \left(C_{pi} \cdot \rho_g \right)^{0,5} \right] \tag{30}$$
- ***Briggs L. W.*** (1946) ;

$$k_{\Delta H} = 1 - 0.02 \cdot \left(C_{pi} \cdot \rho_g \right)^{0,6} \tag{31}$$
- ***Smolik J.*** (1975) ;

$k_{\Delta H} = 1 \big/ \left(1 + 3.1 \cdot C_{pi}^{0,7}\right) + 0.67 \cdot C_{pi}$ - ***Baskakov A. P., Dolgov V. N., Goldovin Yu. M.*** (1990). (32)

Note: A detailed analysis of the total pressure loss in the cyclone structure is done in the papers [15, 33] – for 1D3D, 2D2D, 1D2D type cyclones and specific areas in the cyclone structure, respectively in the paper [22] – model ***Chen J.*** and ***Shi M.*** (2007).

3. Expressions of pressure drop

Note: Over time, many researchers, have suggested empirical formulas for cyclone pressure drop, such as: ***Shepherd C. B.*** and ***Lapple C. E.*** (1939), ***Alexander R. McK.*** and ***Stairmand C. J.*** (1949), ***First M. W.*** (1950), ***Bart W.*** (1956). ***Leith D.*** and ***Mehta D.*** (1973) compared through experiments and concluded that the best results were provided by the researchers: ***Shepherd C. B.*** and ***Lapple C. E.*** (1939), ***Stairmand C. J.*** (1949, 1951), ***Bart W.*** (1956), superior to the research of ***Alexander R. McK*** (1949) and ***First M. W.*** (1950) [7, 8]. The expressions proposed vary greatly in complexity and in the degree to which they are based on empiricism rather than theory [9].
In the work [39], using the Texas A&M Design (TCD) method - a simple design method for cyclones, based on an "*optimal*" speed - for 1D3D and 2D2D type cyclones [33], the dependence of the pressure drop on the speed of gas entry into the cyclone is presented experimentally.
The pressure drop total represents the difference between its value at the entry of the impure gas into the cyclone and the value of the pressure of the purified (clean) gas at the cyclone exit through the outlet pipe [40, 41].
For the domain *40 m<H<100 m* (m – meters of gas column), the relation between the pressure drop and the capacity of the cyclone is [2]:

$$\Delta p = K_1 \cdot Q^2 \cdot \rho_g \big/ D^4 , \qquad (33)$$

where K_1 is a factor that includes the effect of the friction coefficient, Q – the capacity of the cyclone (gas flow), D – the diameter of the cylindrical part of the cyclone.
If ΔH (the height of the gas column) is known, then the pressure drop in the cyclone can be determined using relation (1), after rearranging the terms, as [2, 12]:

$$\Delta p = 0.5 \cdot \rho_g \cdot v_i^2 \cdot \Delta H . \qquad (34)$$

Relation (34) for the pressure drop calculation, is applicable to all cyclones, regardless of the method of determining the height of the gas column but depending on the theories developed for the pressure drop calculation.
Note: a) In the work [22] $\Delta H = Eu$ is identified with the number of ***Euler L.*** (b. 1707 – d. 1783).

3. 1. The theory of *SHEPHERD C. B., LAPPLE C. E.* (1939)

The papers [36 - 38] offers the following relationship for the calculation of the pressure drop Δp characteristic for a cyclone with tangential feed of the impurified gas:

$$\Delta p = 8 \cdot \left[\rho_g \cdot v_i^2\right] \cdot \left(a \cdot b \big/ D_e^2\right), \qquad (35)$$

in which are present: a, b – the height and width of the cyclone inlet; D, D_e – the diameter of the cylindrical part of the cyclone, respectively of the purified gas discharge tube; ρ_g – the density of the impurified gas; v_i – gas velocity at the cyclone inlet, calculated with the expression $v_i = Q_v \big/ \left(a \cdot b\right)$, where Q_v is the volumetric flowrate of the gas entering the cyclone.

3. 2. The theory of *STAIRMAND C. J.* (1949)

In the work [23] the following relationship is presented, noting that the results refer to the case of clean gases (not contaminated with dust):

$$\Delta p = \frac{\rho_g}{203} \cdot \left\{ v_i^2 \cdot \left[1 + 2 \cdot \phi^2 \cdot \left(\frac{2 \cdot r_t}{r_e} - 1 \right) \right] + 2 \cdot v_e^2 \right\}, \quad (36)$$

where: $v_i, v_e -$ gas velocity at the entrance to the cyclone, at the exit of the outlet tube respectively; $r_t, r_e -$ the radius of the central circumference at the entrance of the gas into the cyclone, respectively the radius of the gas outlet tube; $\phi -$dimensionless pressure drop factor.

3. 3. <u>The theory of *BARTH W.*</u> (1956, 1964)

The papers [19, 20] present another expression for evaluating the pressure loss in a cyclone, in the form:

$$\Delta p = 0.5 \cdot (\xi_i + \xi_e) \cdot \rho_g \cdot v_i^2, \quad (37)$$

in which ξ_i reflects the contribution of pressure losses at the entrance to the cyclone and by friction, and ξ_e the pressure loss under the conditions of the evacuation of the purified gas:

$$\xi_i = f \cdot \left\{ 2 + 3 \cdot \left[u_t(R_e) / u_r(R_e) \right]^{4/3} + \left[u_t(R_e) / u_r(R_e) \right]^2 \right\}; \quad (37)_1$$

$$\xi_e = (R_e / R) \cdot \left\langle \left\{ 1 - \left[u_t(R_e) \cdot h_{eq} / u_r(R_e) \cdot R_e \right] \right\} \cdot \lambda \right\rangle \cdot \left[u_t(R_e) / u_r(R_e) \right]^2, \quad (37)_2$$

where (Figure 1):

- $u_r(R_e)$ radial velocity at the outer radius of the outlet pipe:

$$u_r(R_e) = w_r(R_e) = 0.159 \cdot Q_v / \left[R_e \cdot (H - S) \right]; \quad R_e = D_e / 2; \quad (38)$$

- $u_t(R_e)$- tangential speed at the inner radius of the cyclone:

$$u_t(R_e) = w_t(R_e) = v_\theta(R_e) = 0.318 \cdot \left(Q_v / R_e^2 \right) / \left[\alpha \cdot A_e \cdot R_e / (A \cdot R_\alpha) + \lambda \cdot h_{eq} / R_e \right]; \quad (39)$$

$\alpha = 1 - (0.54 - 0.153 \cdot A_e / A) \cdot (b / R)^{1/3} -$ ***Bohnet M.* –** (1984) [17] (40)

$$\lambda = 0.05 + 287.4 / R_{et}; \quad h_{eq} = 0.159 \cdot A_t / \sqrt{R / R_e}; \quad (41)$$

$$R_{et} = (2 \cdot R \cdot \rho_g / \mu_g) \cdot Q_v / \left\{ a \cdot b \cdot \left[0.089 - 0.204 \cdot (b / R) \right] \right\}; \quad R = D / 2, \quad (42)$$

where: α – correction factor; λ – friction coefficient, depending on the geometry of the impurified gas inlet and the inlet flow rate (***Muschelnautz E., Brunner K.* –** 1967 [19]); h_{eq} – the equivalent height of the cyclone; A_{tot}, $A_e = a \cdot b$, $A = 3.14 \cdot R_e^2$ – the internal area of the cyclone, the cross-sectional area of the gas section in the cyclone, the cross-sectional area of the gas outlet; $R_\alpha = R - 0.5 \cdot b$ – the average length from the gas inlet to the center of the cyclone.

<u>Note</u>: Another formulation of the pressure drop calculation is presented in the paper [37].

3. 4. Cumulative pressure drop rating

In the works [15, 33, 44] adequate details are given for the evaluation of the total pressure drop. In this sense, the corresponding sequential values are estimated for the obvious areas: the entry of the impure gas into the cyclone, the drop of kinetic energy along the descending spiral, the ascending spiral (up to the portion of the impure dust discharge tube located in the cyclone and the one up to the exit from the cyclone), as well as the pressure drop through friction between the particles and the inner surface of the cyclone. Cyclones with recognized geometry (1D3D, 2D2D, 1D2D) are considered in the respective study.

4. Conclusions

This paper presents the opinions of different researchers, elaborated over time, referring to the evaluation of the pressure loss and the efficiency of cyclones with tangential, unilateral feeding. Known as a "*dust separator*", over a hundred years ago, current cyclones have found a well-

deserved place in the field of dry dedusting of impure industrial gases. In some analyses, the density of the gas is neglected compared to that of the particles, in others it is not. Therewith, the influence of the geometry of the inlet of the impure gas in the cyclone, of the speed corresponding to the case, but also the influence of the speed at the exit through the outlet of the purified gas are specified. In the study of the kinematics of the vortex of the mixture inside the cyclone, the hypothesis of solid particles with smooth surfaces is accepted. The influence of friction with the inner surface of the cyclone is also considered, as well as the influence of temperature by means of appropriate parameters.
Article [45] recommends an interesting constructive solution, namely the presence of rectangular "evasés", respectively conical caps over the exhaust tube (radial outlet of pure gas). Such constructions can reduce the value of the total pressure drop and protect the inside of the cyclone from the effects of the weather. These structures will be of particular scientific interest for future, experimental and theoretical works.
The results of the previously specified researches can lead to new analyses, both theoretical and experimental, in possible bachelor's, master's or doctoral theses.

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