Acta Scientific COMPUTER SCIENCES

Volume 5 Issue 4 April 2023

Research Article

Calculation of the Coefficient of Hydraulic Pressure Losses According to the Methods of Shevelev and Colebrook-White

Mykola Hirol[1], Dariusz Kowalski[1]*, Anna Girol[2], Andriy Hirol[3]

[1]*Lublin University of Technology, Faculty of Environmental Engineering, Poland*

[2]*ACI - Aquaproject Consult Ingenieurgesellschaft mbH, Dresden, Germany*

[3]*City Economy Department, Executive Committee of Rivne City Council, Ukraine*

***Corresponding Author:** Dariusz Kowalski, Lublin University of Technology, Faculty of Environmental Engineering, Poland.

Received: March 14, 2023

Published: March 19, 2023

Abstract

The work investigates the methods of Shevelev and Colebrook-White, which are widespread in the practice of water supply and sewerage in different countries of the world, for calculating the coefficient of hydraulic head losses in pipes operating in the pressure mode, provides an analysis of the conditions of their application, and shows the discrepancy in the calculation results obtained by these methods for the same constructive characteristics of technical systems. The advantage of the Colebrook-White method is substantiated and the practical expediency of introducing the Colebrook-White method into the practice of hydraulic calculations of pressure pipelines of water supply and sewage systems is demonstrated.

Keywords: Head Loss In Pipes; Colebrook-White; Shevelev; Darcy–Weisbach; Nikuradse; Blasius Equations

Introduction

The cost of water supply networks constitutes a significant share of the total cost of water supply systems, often exceeding 50%; therefore, even minor errors in their design significantly affect the economic indicators of the object as a whole [1-3]. Under such conditions, the requirements for the quality of hydraulic calculations of pipeline systems, one of the parameters of which corresponds to the hydraulic pressure losses that occur during the movement of water in the pipes, increase significantly. The method of calculating the coefficient of hydraulic friction along the length of pipes λ, proposed by Shevelev [1], has been widely adopted in the countries of the former USSR for hydraulic calculations of pipeline systems. This technique is still widespread in design [2,4,5], in the educational process [3,6,7] and in scientific research [8,9]. In the past decades, it was somewhat common in the engineering practice of Eastern European countries [10]. In global practice, and now also in Eastern European countries, the Colebrook-White mathematical expression [11] is mainly used to calculate the coefficient of hydraulic resistance of pipelines of water supply systems. The simultaneous widespread use of different methods for calculating the same parameter for the same conditions requires an analysis of their similarities and differences. The purpose of the study was to determine the features of the common methods of calculating the coefficient of hydraulic friction along the length of the pipes and to establish their influence on the final results of the technological indicators of engineering solutions in the design of the water supply network.

Materials and Methods

One of the most popular in hydraulic pressure losses (h) calculation is Darcy–Weisbach formula [1,12,13], in both laminar and turbulent modes of water movement along the length of pipes of circular cross-section:

Citation: Dariusz Kowalski*., et al.* “Calculation of the Coefficient of Hydraulic Pressure Losses According to the Methods of Shevelev and Colebrook-White". *Acta Scientific Computer Sciences* 5.4 (2023): 55-62.

$$h = \lambda \cdot \frac{l}{d} \cdot \frac{v^2}{2g}, m \qquad (1)$$

Where: λ is the coefficient of hydraulic resistance along the length of the pipe; l – pipe length, m; v – average speed of water movement in the pipe, m/s; d is the inner diameter of the pipe, m; g –free fall acceleration, m/s^2.

During such calculations, the parameters l, v, d, and g included in expression (1) are known. The parameter λ is unknown, i.e. it varies depending on the above-mentioned known parameters and the roughness of the inner surface of the pipe (k, m). Calculating the value of this particular parameter poses certain difficulties when solving engineering problems.

The method proposed by Shevelev [1] is based on the modified formula (1), which has the following form:

$$i = \frac{h}{l} = \lambda \cdot \frac{1}{d} \cdot \frac{v^2}{2g} \qquad (2)$$

To calculate the parameter λ, the author of the mentioned technique proposed a number of mathematical formulas for pipes made of different materials [1]. Hence, for non-new steel and cast iron pipes, the value the value of the kinematic coefficient of water viscosity $\vartheta = 1.3 \cdot 10^{-6}$ m^2/s, which corresponds to a water temperature in the water supply network of 10°C and under the condition

$$\frac{v}{\vartheta} \geq 9.2 \cdot 10^{-5}, 1/m \qquad (3)$$

The author of the method recommends calculating the value of the parameter λ according to the formula:

$$\lambda = \frac{0{,}021}{d^{0.3}} \qquad (4)$$

And for the conditions

$$\frac{v}{\vartheta} < 9.2 \cdot 10^{-5}, 1/m \qquad (5)$$

It is recommended to calculate the value of the parameter λ according to the formula [1,23]:

$$\lambda = \frac{0.0179}{d^{0.3}} \left(1 + \frac{0.867}{v}\right)^{0.3} \qquad (6)$$

At the same time, the empirical coefficients of the formulas (4 and 6) take into account the roughness of the inner surface of the pipes, which is characterized by the roughness coefficient (k, m), and in the method under consideration is taken as equal to k = 0.001, m [1].

For pipes made of other materials, using the described methodology for determining the parameter λ, there are a number of mathematical equations that differ slightly from formulas (4-6) [1].

On the basis of formulas (2-6), Shevelev compiled "Tables for hydraulic calculation of steel cast iron, asbestos cement, plastic and glass water pipes" to simplify the calculation of the value of the parameter h [1].

It is worth noting that there are other mathematical formulas for calculating the value of the parameter λ for the zone of turbulent water movement [12-14]. However, starting from 1952, the Colebrook-White mathematical formula [11] became widespread in world practice for calculating the value of the parameter λ in the entire area of turbulent water movement.

$$\frac{1}{\sqrt{\lambda}} = -2\log\left(\frac{k}{3.71d} + \frac{2.51}{Re\sqrt{\lambda}}\right) \qquad (7)$$

Where: k/d is the relative roughness of the inner surface of the pipes; Re is the Reynolds criterion, which can be written as:

$$Re = \frac{v \cdot d}{\vartheta} \qquad (8)$$

The Colebrook-White equation is widely used in practice for hydraulic calculations of both pipelines of drinking water supply systems [12,15,16], and calculations of pipelines of water drainage systems [17-19]. The range of changes in the Reynolds criterion in formula (7) for pipes of round cross-section can vary in a wide range - $2300 \leq Re \to \infty$ [13,14,20]. From the formula (7) it is obvious that with a significant increase in the value of the parameter Re→, its second component goes straight to $2.51/(Re\sqrt{\lambda} \to 0)$, and the formula itself takes the form of the Nikuradse formula [12-14]:

$$\frac{1}{\sqrt{\lambda}} = -2\log\left(\frac{k}{3.71d}\right) \qquad (9)$$

Such a change in formula (7) according to Re→∞ proves that in the region of hydraulically absolutely rough pipes, the parameter λ does not depend on Re and is exclusively a function of k/d. From the analysis of formulas (4), (6) and (7) and (9), it is obvious that, without paying attention to the fact that they are intended to describe the same functional dependence λ = f(Re,k,d), they are quite different in their structure: formula (6) is significantly different from formula (7), and formula (4) is significantly different from formula (9).

The research involved the selection and justification of the method of calculating the coefficient of hydraulic head losses in the pipes of water supply systems. It is based on numerical studies evaluating the results of hydraulic parameter calculations on the example of steel pipes of water supply systems, conducted according to the Shevelev and Colebrook-White methods.

The methods proposed by Shevelev and Colebrook-White for calculating the coefficient of hydraulic resistance λ along the length of metal pipes with a diameter of 50≤d≤1600 mm with a coefficient of roughness of their inner surface k = 0.001 m and the values of hydraulic parameters are recommended for practical use in engineering practice [1]. The study was carried out for the zone of turbulent water movement in pipes at Reynolds numbers of $3.5\cdot10^3 \le Re \le 1\cdot10^8$. As a mathematical description of the boundaries for evaluating the movement of water in pipes, the formula of Blasius (graph 1, figure 1) was chosen for the area of hydraulically smooth pipes, and the formula of J. Nikuradse (9) for the division of the quadratic and quadratic hydraulic resistance of rough pipes (graph 2, figure 1).

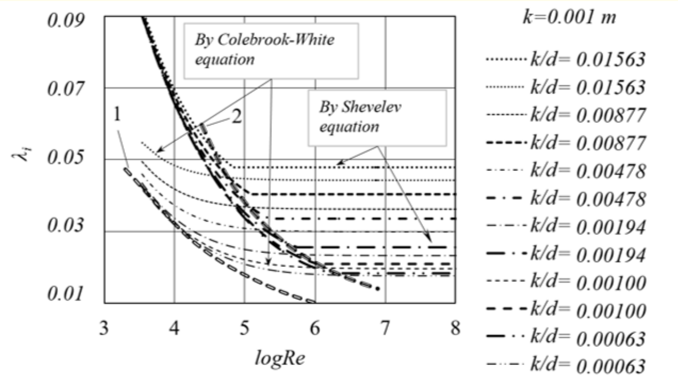

Figure 1: Patterns of changes in the parameter λ_i calculated according to the methods of Shevelev and Colebrook-White depending on the parameter Re for different values of the relative roughness of the inner surface of the pipes k/d. 1 – area of hydraulically smooth pipes; 2 – dividing line of subquadratic and quadratic hydraulic resistance of rough pipes.

Results and Discussion

According to the results of numerical studies of the dependence λ_i = f(Re,k/d), carried out according to formulas (4, 6 and 7) for steel pipes with a diameter of d = 50-1600 mm, k = 1 mm (Figure 1), it can be seen that in the entire range of changes in logRe = 3.5÷8, the values of the coefficient of hydraulic resistance along the length of the pipe λ_i obtained by using the method of Shevelev (λ_{Sh} formulas 4 and 6) are higher than the values of $\lambda_{Col\text{-}W}$ obtained by means of the Colebrook-White method. Moreover, λ_{Sh} for all values of k/d in the area of quadratic resistance are significantly distant from graph 1 (Figure 1) and are mainly concentrated along graph 2 (Figure 1). The value of the difference between λ_{Sh} and $\lambda_{Col\text{-}W}$, calculated according to the methods of Shevelev and Colebrook-White ($\Delta\lambda = \lambda_{Sh} - \lambda_{Col\text{-}W}$) is observed to be significantly greater for small values of logRe and k/d numbers. Moreover, for this range of motion, a larger value of Δλ is characteristic for smaller values of k/d. Therefore, for logRe = 4 and k/d = 0.00063, the value of Δλ≈0.033, with an increase in k/d to 0.01563, with an unchanged value of logRe, a decrease in Δλ to 0.021 is observed. As logRe increases to 4.5, the difference between the values of Δλ for k/d = 0.00063 is Δλ≈0.022, and for k/d = 0.01563 - Δλ≈0.0083. That is, the difference between the value of λ_{Sh} and $\lambda_{Col\text{-}W}$ in the area of quadratic resistance for all values of k/d is significant and decreases with increasing k/d and logRe. However, with the growth of logRe and k/d values, the value of $\Delta\lambda$ does not disappear, but has certain constant values in the field of quadratic hydraulic resistance (Figure 1).

The value of the ratio $\lambda_{Sh}/\lambda_{Col\text{-}W}$ in the region of the quadratic resistance for $0.00063 \leq k/d \leq 0.001563$ varies in the range $1.03 < \lambda_{Sh}/\lambda_{Col\text{-}W} < 2.15$, and larger values of the value $\lambda_{Sh}/\lambda_{Col\text{-}W}$ are characteristic mainly for small values of logRe (logRe = 3.5) and k/d (k/d<0.002) (Figure 2).

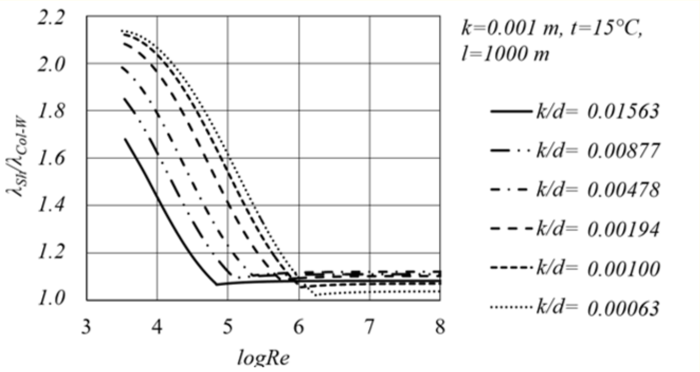

Figure 2: Patterns of changes in the ratio of parameters $\lambda_{Sh}/\lambda_{Col\text{-}W}$, calculated according to the methods of Shevelev and Colebrook-White in the range of changes in the logarithm of the Reynolds criterion $3.5 \leq \log Re \leq 8$ for steel pipes with a diameter of d = 64-1600 mm and k = 1 mm.

An increase in the value of the logRe parameter in the region of the quadratic resistance is accompanied by a decrease in the value of $\lambda_{Sh}/\lambda_{Col\text{-}W}$; however, at the maximum value of logRe, which is close to the limit of changes in the patterns of resistance, this pattern changes, and in the region of the quadratic resistance, larger values of $\lambda_{Sh}/\lambda_{Col\text{-}W}$ are characteristic of larger of k/d values. Therefore, if for logRe = 3.5 and k/d = 0.00063, the value of $\lambda_{Sh}/\lambda_{Col\text{-}W} = 2.15$, and as k/d = 0.01563 increases, it decreases to $\lambda_{Sh}/\lambda_{Col\text{-}W} = 1.55$, then with the approach of logRe to the limit of the change in the regularity of the resistance (graph 2, Figure 1) for k/d = 0.00063, the value of $\lambda_{Sh}/\lambda_{Col\text{-}W} = 1.03$, then the increase in k/d = 0.01563 is not accompanied by a decrease, as it is was in the first case, and its growth was $\lambda_{Sh}/\lambda_{Col\text{-}W} = 1.07$. This ratio $\lambda_{Sh}/\lambda_{Col\text{-}W}$ is observed in almost the entire range of quadratic resistance (Figure 2).

The difference in the values of the parameter λ_i calculated according to alternative methods –Shevelev and Colebrook-White – in the entire range of changes of the studied parameters ($3.5 \leq \log Re \leq 8$ and $0.00063 \leq k/d \leq 0.01563$) indicates the possibility of obtaining different values of calculated pressure losses, calculated according to the Darcy–Weisbach equation (1) that includes the specified parameter λ, which, in turn, affects the quality of engineering solutions for the construction of hydraulic tubular systems, including water supply and drainage systems.

In the practice of water supply and sewage management, many systems have been designed, the hydraulic calculations of which were carried out using the two of the studied methods. In both variants, the resulting structural characteristics of the pipeline are the same, but with different values of λ_{Sh} and $\lambda_{Col\text{-}W}$. Obviously, as a criterion for evaluating the choice of the method, it would be appropriate to accept the method by which it is possible to obtain smaller values of λ_i, and therefore lower pressure losses in the pipe (h_i), since this will lead to the need for pressure equipment with lower energy costs, which will contribute to the increase in the efficiency of the system as a whole.

The value of the difference in head loss ($\Delta h = h_{Sh} - h_{Col\text{-}W}$), calculated according to expression (1) using the value of the parameter λ_i, calculated according to different methods, is a non-constant value and depends on the values of logRe and k/d, whereas the largest values of Δh are inherently a larger value of the mentioned values, that is, for a certain value of logRe, the largest value of Δh is observed for the pipes with the largest value of k/d (Figure 3).

An increase in the value of the logRe parameter for each value of k/d is accompanied by an increase in the value of the Δh parameter (Figure 3).

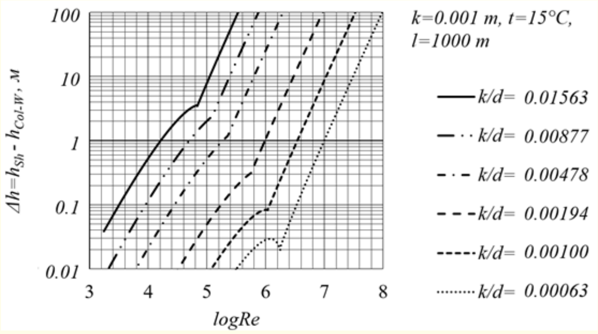

Figure 3: Patterns of changes in the difference in head losses ($\Delta h = h_{Sh} - h_{Col\text{-}W}$), calculated by the Darcy-Weisbach formula and λ_{Sh} and $\lambda_{Col\text{-}W}$, determined by the methods of Shevelev and Colebrook-White in the range of changes in the logarithm of the Reynolds criterion 3≤logRe≤ 8 for steel pipes with a diameter of d = 64-1600 mm, k = 1 mm, l = 1000 m, and t = 15°C.

During the hydraulic calculations of the pipes of linear or circular water supply systems, the correspondence of the calculated values of pressure losses with their actual values is an important factor. However, from the above (Figure 2), it is obvious that in the entire range of changes of 3.5≤logRe≤8 and 0.00063≤k/d≤0.01563, the ratio of parameters $\lambda_{Sh}/\lambda_{Col\text{-}W}$ exceeds 1.0. Such a ratio of parameters $\lambda_{Sh}/\lambda_{Col\text{-}W}$ according to formula (1), all other conditions being equal, also determines the formation of the ratio $\lambda_{Sh}/\lambda_{Col\text{-}W} > 1.0$, that is, for the same diameter and length of the pipeline, the value of head loss (h_{Sh}) calculated taking into account formulas (4,6) exceeds the head losses ($h_{Col\text{-}W}$), calculated using formula (1) taking into account $\lambda_{Col\text{-}W}$, calculated using formula (7) (Figure 3). Exaggeration of head loss h_{Sh} in relation to $h_{Col\text{-}W}$ leads to an overestimation of the energy characteristics of the water supply system as a whole; however, it is better to make a quantitative assessment of this phenomenon by the absolute values of the difference of the obtained results, i.e. $\Delta h = h_{Sh} - h_{Col\text{-}W}$, rather than the relative indicators of $\lambda_{Sh}/\lambda_{Col\text{-}W}$.

In the practice of water supply, in order to achieve the highest efficiency of water supply systems, there are recommendations regarding the limit of change in the speed of water movement in pipes, which depends on a number of factors and is within v = 0.7-3.0 m/s, and in some cases the upper limit of this speed can reach higher values [1,4,21]. The presence of a range of changes in the parameter v indicates the existence for a known k/d of a certain range of changes in the logRe parameter, and therefore, the change in the parameter Δh will also occur in a narrower range. Taking this remark into account, let us plot graph 3 in the coordinates Δh = f(v,d) (Figure 4).

For the changes in the speed of movement in the range of 0.7-3.0 m/s for d = 64 mm, the discrepancy between the results of calculations according to the studied methods varies within Δh = 3-25 m, that is, under the mentioned conditions and the conditions indicated in Figure 4 for d = 64 mm, a piezometric line for a water supply made of steel pipes (k = 1 mm) with a length of 1000 m at its end point, built according to the results of calculations according to the method of Shevelev, should be located 25 m higher than the piezometric line at the same point, constructed based on the results of calculations using the Colebrook-White method. The higher location of the piezometric line indicates the need to select the pressure equipment capable of raising water to an additional height (Δh = 25 m), caused by exceeding the results of λ_{Sh} calculations for d = 64 mm, k = 1 mm, l = 1000 m, and t °C = 15°C above the results of the $\lambda_{Col\text{-}W}$ calculations obtained for the same conditions using the Colebrook-White method.

As the diameter of the investigated pipes increases, the value of Δh decreases in the same range of movement speed (v = 0.7-3.0 m/s) of the water in them. Therefore, for pipes with a diameter of 209 mm and v = 0.7 m/s, the value of Δh is significantly smaller than it was for a pipe d = 64 mm (Δh = 3 m), and is Δh = 0.7 m, and according to v = 3.0 m/s increases only to Δh = 8.0 m, which is smaller than the same parameter for d = 64 mm (Δh = 25 m). However, even the value of Δh = 8.0 m for a pipe with a length of 1000 m is quite significant and needs to be taken into account when selecting pumping equipment. That is, in this case (d = 209 mm by k = 1 mm, l = 1000 m, and t°C = 15°C), the pumping equipment for raising water to the mark calculated using the Shevelev method has a higher pressure than the pumping equipment selected based on the results of calculations using the Colebrook-White method, which in this case requires significant additional energy costs. For pipes with large diameters d>500 mm, the difference between the results of λ_{Sh} and λ_{Col-W} calculations has a smaller effect on the value of Δh, and, yes, already for a pipe d = 1000 mm and v = 0.7 m/s, the value of Δh = 0.07 m, increasing along with v = 3.0 m/s only up to Δh = 0.20 m.

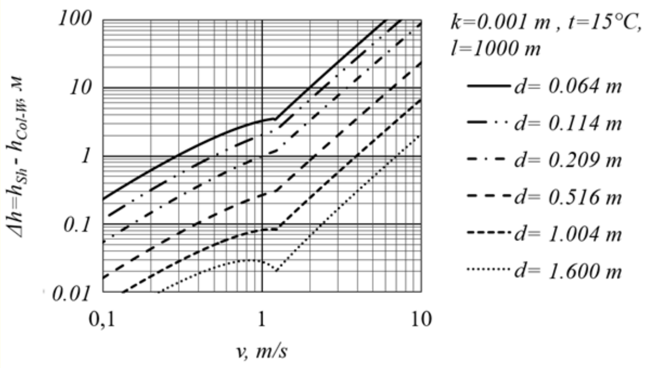

Figure 4: Patterns of changes in the difference in head loss ($\Delta h = h_{Sh} - h_{Col-W}$), calculated according to the Darcy-Weisbach formula as well as using λ_{Sh} and λ_{Col-W}, determined according to the methods of Shevelev and Colebrook-White in the range of changes in the speed of water movement in the pipe 0, 1≤v≤10 m/s, for steel pipes with a diameter of d = 64-1600 mm for k = 1 mm, l = 1000 m, and t = 15°C.

The statistical evaluation of the calculated value of the coefficient λ according to the Shevelev and the Colebrook–White equations was carried out according to the following procedure:

- For all studied formulas (6-7), the pattern of change of independent parameters Re and k/d in the entire range of studies was the same.
- The correspondence of the coefficient λ_i, calculated according to formulas (6) to the value of the same parameter λ_{Col-W}, calculated under the same conditions, according to formula (7), was chosen as an evaluation parameter.
- All calculations were performed using Microsoft Excel.
- On the basis of the analysis of calculation results using various methods of the coefficient λ, the justification of the mathematical equation was carried out, which allows obtaining the most accurate results.

The following criteria were chosen for the evaluation of calculation equations:

Average relative deviation;

$$\mathrm{Rel} = \frac{1}{n}\sum_{i=1}^{n} \frac{\lambda_{Col-W} - \lambda_i}{\lambda_{Col-W}} \tag{10}$$

Maximum relative deviation;

$$\mathrm{Rel}_{max} = \frac{\lambda_{Col-W} - \lambda_i}{\lambda_{Col-W}} \tag{11}$$

Minimum relative deviation;

$$\mathrm{Rel}_{min} = \frac{\lambda_{Col-W} - \lambda_i}{\lambda_{Col-W}} \tag{12}$$

Mean square deviation;

$$\mathrm{SD} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} \left(\frac{\lambda_{Col-W} - \lambda_i}{\lambda_{Col-W}}\right)^2} \tag{13}$$

Average linear deviation;

$$\mathrm{MD} = \frac{1}{\mathrm{n}}\sum_{\mathrm{i}=1}^{\mathrm{n}}\left|\frac{\lambda_{\mathrm{Col-W}} - \lambda_{\mathrm{i}}}{\lambda_{\mathrm{Col-W}}}\right| \quad (14)$$

$\lambda_{\text{Col-W}}$ is the value of the parameter λ calculated according to the Colebrook–White equation (1); λ_i is the value of the parameter λ, calculated according to formula (6); n is the number of calculated values.

It should be noted that the criteria of average values Rel, SD, MD carry a qualitative assessment of the average values of the studied parameters in a wide range of changes in Re and k/d, while the evaluation criteria $\text{Rel}_{\min}$ and $\text{Rel}_{\max}$ allow identifying the range of deviations of specific values of λ_i from $\lambda_{\text{Col- W}}$, for certain values of Re and k/d. This feature of the evaluation criteria $\text{Rel}_{\min}$ and $\text{Rel}_{\max}$ allows, depending on the requirements of engineering practice, determining the areas of rational application of this or that mathematical equation under study.

Results of statistical calculations of λ according to formulas (10-14) for $3.6\cdot 10^3 \leq \text{Re} \leq \infty$ and $0 \leq \text{k/d} \leq 2\cdot 10^{-2}$.

Rel = −3.4·10−1, $\text{Rel}_{\max} = -1.1\cdot 10^{-2}$, $\text{Rel}_{\min} = -1.1\cdot 10^{\pm 0}$, MD = 3.4·10−1, $\text{SD} = 4.7\cdot 10^{-1}$.

Note: the “minus” sign in front of the numerical value of the evaluation criterion specified in the table indicates a smaller calculated value of λ_i calculated by formula (6) compared to the value of $\lambda_{\text{Col-W}}$ calculated by formula (7).

The value of the evaluation criterion Rel for formulas (6-7) (F. Shevelev) is −3.4·10−1 for $\text{Rel}_{\max} = -1.1\cdot 10^{-2}$ and $\text{Rel}_{\min} = -1.1\cdot 10^{\pm 0}$. From the above it follows that, under certain conditions, the results of calculations according to formula (6) are close to the results of calculations according to formula (7), but the significant value of the values of the evaluation criteria SD = 4.7·10−1, $\text{MD} = 3.4\cdot 10^{-1}$ and $\text{Rel}_{\max} = -1.1\cdot 10^{\pm 0}$ for formula (6) reduce the value of its practical application.

From the materials of the conducted studies, it is obvious that there is a noticeable excess of the values of the parameter h calculated by formula (1) taking into account formulas (4 and 6) over the values of h calculated by formula (1) taking into account formula (7) for the same diameter pipes in the entire range of changes in the recommended speed of water movement in the pipes (v = 0.7-3.0 m/s) is accompanied by a noticeable excess of the energy characteristics of the system as a whole. At the same time, the wide and effective use of the Colebrook-White method in the world practice of designing water supply systems indicates the feasibility of introducing this method in the practice of hydraulic calculations of water supply systems in other countries, which will contribute to reducing their energy intensity.

Conclusion

The method of calculating the coefficient of hydraulic friction along the length of pipes λ, proposed by Shevelev, has become widespread in the practice of hydraulic calculations of pipeline systems in the countries of the former USSR. In global practice, and now also in Eastern European countries, the method based on the Colebrook-White mathematical expression is mainly used to calculate the coefficient of hydraulic resistance λ of pipelines of water supply systems.

The difference between the value of the coefficients of hydraulic resistance (λ_{Sh} and $\lambda_{\text{Col-W}}$), calculated according to the methods of Shevelev and Colebrook-White in the entire range of changes in logRe (3.5≤logRe≤8) of the zone of turbulent water movement in a pipe of different relative internal roughness its surface 0.00063≤k/d≤0.01563, is significant. A special difference in the results of the calculations of the coefficients λ_{Sh} and $\lambda_{\text{Col-W}}$ is observed in the area of quadratic resistance.

The results of calculations of head losses (h) according to formula (1) taking into account the values of the parameter λ_{Sh} and $\lambda_{\text{Col-W}}$ within the limits of the speed of water movement in pipes common in the practice of water supply and sewage systems (v = 0.7-3.0 m/s) in the entire range of changes in the value of the relative roughness of their inner surface k/d (0.00063≤k/d≤0.01563) showed significantly lower values of the parameter h for the option using the values of the parameter $\lambda_{\text{Col-W}}$ compared to the option using λ_{Sh}. Under the above-mentioned conditions, the value of the difference in head loss calculated for both options changes ($\Delta h = h_{\text{Sh}} - h_{\text{Col-W}}$) within 25>Δh>0, which, when applying λ_{Sh}, leads to a noticeable increase in the energy characteristics of the system as a whole. In addition to the above, the wide and effective use of the Colebrook-White method in the global practice of designing water supply systems indicates the feasibility of introducing this method in the practice of hydraulic calculations of water supply systems in other countries, which will contribute to reducing their energy intensity.

Bibliography

1. Shevelev F.A. “Tables for hydraulic calculation of steel cast iron, asbestos cement, plastic and glass water pipes”. Ed. 5th Stroyizdat, (1973).
2. SNiP 2.04.02-84 standard “Water supply External networks and constructions”. M: FSUP CPP (2006).
3. Somov MA. “Water supply systems and structures: Textbook. For universities”. Stroiizdat, (1988).
4. DBN V.2.5-74:2013 standard. “Water supply. External networks and structures. Basic provisions of design”. Ministry of Regional Development, Construction and Housing and Communal Economy of Ukraine (2013).
5. SP 31.13330.2010. “Code of water supply rules. outdoor networks and constructions”. Water supply. Pipelines and portable water treatment plants. Updated edition. SNiP 2.04.02-84 (2013).
6. Mediolanskaya MM., *et al*. “Designing water networks: Textbook”. Vologda VTU (1999).
7. Shadura VO and Kravchenko NV. “Water supply and drainage: a study guide. – Rivne”. NUVHP (2018).
8. Matyash OV and Novokhatniy VG. “The state of the supply and distribution complex of the city’s water supply system”. Communal management of cities (2019), 1 (147): 169-174 (in Ukrainian).
9. Nguyen HK. “Improvement of the calculation and optimization of the water supply system of large cities taking into account the wear and tear of pipelines”. Dissertation for the degree of Candidate of Technical Sciences. Voronezh State Technical University. Voronezh (2019).
10. Szpindor A. “Zaopatrzenie w wodę i kanalizacja wsi”. Arkady. Warszawa (1998).
11. Colebrook CF and White CM. “Experiments with Fluid Friction in Roughened Pipes”. *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences* 161.906 (1937): 367-381.
12. Orzechowski Z., *et al*. “Fluid mechanics in environmental engineering”. WNT, Warsaw (2009): 622.
13. Kiseleva PG. “Handbook of hydraulic calculations”. Energy (1972).
14. Altshul AD., *et al*. “Examples of hydraulic calculations. Textbook for universities”. Stroyizdat (1977).
15. Twort AC., *et al*. “Water supply”. Fifth Edition. Elsevier Ltd. Butterworth-Heinemann (2000).
16. Chin D.A. “Water-Quality Engineering in Natural Systems”. John Wiley and Sons, Florida (2006).
17. Hydraulische Dimensionierung und Leistungsnachweis von Abwasserleitungenund – kanälen. Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V. Arbeitsblatt DWA-A 110 (2006).
18. Pecher R., *et al*. “Hydraulik der Abwasserkanäle in der Praxis”. Paul Parey, Berlin (1991).
19. Bischof W. “Abwassertechnik”. Springer, Stuttgart, Leipzig (1998).
20. Posypanov SV. “Hydraulic calculations of external water pipes: teaching and methodical manual”. 2nd ed. Lomonosov University, Arkhangelsk, (2014).
21. Tkachuk OA and Shadura V.O. “Water supply networks: Study guide”. NUVHP, Rivne (2010).

Citation: Dariusz Kowalski*., et al.* “Calculation of the Coefficient of Hydraulic Pressure Losses According to the Methods of Shevelev and Colebrook-White". *Acta Scientific Computer Sciences* 5.4 (2023): 55-62.