Enhancement of the computation of diameter in Turbulent flow pipe

Imen Foual[1], Lotfi zeghadnia[2]*, Fares Laouacheria[1], Boukhari Imad[1].

[1]*Department of Hydraulic, Faculty of engineering, Badji Mokhtar university, Annaba-Algeria.*
[2]*Department of civil engineering, Faculty of sciences and technology, Souk Ahras university, Algeria.*

**Correspondence to: lotfi.zeghadnia@univ-soukahras.dz.*

Abstract

In turbulent pipe flow three kind of problem were the most targeted in Hydraulic engineer practice: the computation of the flow Q, the computation of the hydraulic energy slop J and the computation of the diameter D. Several models were proposed to improve and make these tasks easy, among them the rough model method (RMM); the goal of this paper is to improve the accuracy of the explicit formula of the third problem using RMM.

Keywords: Turbulent flow, RMM, Pipe, explicit solution.

Introduction:

Turbulent flow is the most common or the only type flow frequently encountered in water distribution net work; Turbulent flow is a fluid motion with particle trajectories varying randomly in time.

Flow in a pressurized pipe is governed by the functional relationship:

$$\varphi(Q, J, D, \varepsilon, \nu) = 0 \qquad (1)$$

Where :

Q is The discharge, J is the head loss per unit pipe length, D is the pipe diameter , ε *is* the equivalent sandgrain roughness height, *v* is the kinematic viscosity of the flowing fluid.

Among these parameters influencing the flow, only Q, D and J are of practical interest. Turbulent flow in a pipe is modeled by the universally known Darcy-Wisbach formula, in which the coefficient of friction f is evaluated by applying the Colebrook-White relationship. These relations are written:

$$J = \frac{8fQ^2}{\pi^2 g D^5} \qquad (2)$$

$$\frac{1}{\sqrt{f}} = -2log_{10}\left[\frac{\varepsilon/D}{3.7} + \frac{2.51}{R\sqrt{f}}\right] \qquad (3)$$

in which **R** = *VD/v.* the pipe Reynolds number, *V* = mean velocity; *g* = gravitational

Reference

1. Giustolisi, O.; Berardi, L.; Walski, T.M. Some explicit formulations of Colebrook–White friction factor considering accuracy vs. computational speed. J. hydro-info, IWA. 2011, 13, 401-418.
2. Sinniger, R.O. ; Hager, W.H. Constructions hydrauliques, Traité de Genie Civil Ed. Presses Polytechniques Romandes. Suisse. 1989,15.
3. Nils T. B. Turbulence Intensity and the Friction Factor for Smooth- and Rough-Wall Pipe Flow. Fluids. 2017, 2, 1–13.
4. Chandrasekhar S.V.M.; Sharma V.M., 2016, Brownian heat transfer enhancement in the turbulent regime, Facta Universitatis-series Mechanical Engineering. 2016, 14, 169 – 177.
5. Carlier, M. Hydraulique Générale et Appliquée. Eyrolles, Paris.1980.
6. Zeghadnia, L. New approach for the computation of turbulent flow. Magister Thesis.,Annaba university-Algeria.2007.
7. Mirko, D. 2012 Determination of friction coefficient in transition flow region for waterworks and pipelines calculation. Annals of faculty engineering – Inter. J. Eng. 2012, 3, 137-142.
8. Finnemore, E. J.; Franzini, J.B. 2002 Fluid Mechanics with Engineering Applications.10th ed. McGraw-Hill. New York.2002.
9. Colebrook, C.F.; White, C.M. 1937 Experiments with fluid friction in roughened pipes. Proc. Roy. Soc A Mat. 1937, 161, 367–381.
10. Sletfjerding, E.; Gudmundsson , J. S. Friction Factor In High Pressure Natural Gas Pipelines From Roughness Measurements. Journal. Energy Resour. Technol . 2003, 125, 126-130.
11. Zagarola, M.V. Mean-flow scaling of turbulent pipe flow, Ph.D. thesis, Princeton University, USA. 1996.
12. ZEGHADNIA L, Jean-Loup R, Achour B (2019) Explicit Solutions For Turbulent Flow Friction Factor: A Review, Assessment And Approaches Classification. Ain Shams Engineering Journal, Elsevier , 10(01),1-9.
13. Nikuradse, J. Gesetzmessigkeiten der turbulenten stromung in glatten rohren, In Forschungsheft 356, B. 1966. VDI Verlag Berlin. Translated in NASA TT. 1932, F-10, 359.
14. Grigson, C. Nikuradse's experiment, AIAA Journal. 1984,22, 999-1001.
15. Yang, B. H.; Joseph, D. D. Virtual Nikuradse J. Turbul. 2009,10, 1–28.
16. Zhen, S. S.; Wu, Y.; Chen, X.; Hussain, F. A. multi-state description of roughness effects in turbulent pipe flow. New J. Phys. 2012, 14, 093054.
17. Flack K, A.; Schultz, M. P. Review of hydraulic roughness scales in the fully rough regime. J. Fluids Eng. 2010, 132, 041203
18. Brkic, D. An explicit approximation of the Colebrook equation for fluid flow friction factor. Petrol. Sci. Tech. 2011, 29, 1596-1602.
19. Genić, S.; Arandjelović, I.; Kolendić, P.; Jsrić, M.; Budimir, N. A review of explicit approximations of Colebrook's equation. F.M.E. Trans. 2011, 39, 67-71.
20. Mustafa, A.; Oguz, E. T.; Mustafa, T. C. A review of non-iterative friction factor correlations for the calculation of pressure drop in pipes. Bitlis Eren University J. Sci.Tech. 2014, 4, 1-8.
21. Brkic, D.; Žarko, C. Evolutionary Optimization of Colebrook's Turbulent Flow Friction Approximations. Fluids. 2017, 2, 1–27.
22. Amir, H.; Elhameh, N.; Fatemeh, P. Explicit Determinations of the Colebrook Equation for the Flow Friction Factor by Statistical Analysis. Chem. Eng. Technol. 2015, 38, 1–11.
23. Oke, I. A.; Stephen, O.; Adeosun, O.; Olukayode. Performance evaluation for Darcy friction factor formulae using Colebrook-white as reference. J.Sci. 2015, 17,75- 86.
24. Moody, L. F. An approximate formula for pipe friction factors. Trans. ASME.1947, 69, 1005-1006.

25. Round, G.F. An explicit approximation for the friction factor-Reynolds number relation for rough and smooth pipes. Can. J. Chem. Eng. 1980, 58, 122-123.
26. Nekrasov, B. Hydraulics, Peace Publishers.Transl. by V. Talmy. Moscow.1968, 95-101.
27. Wood, D.J. An Explicit friction factor relationship. Civil. Eng.1968, 60-61.
28. Eck, B. Technische Stromungslehre. Springer, New York.1973.
29. Samadianfard, S. Gene expression programming analysis of implicit Colebrook-White equation in turbulent flow friction factor calculation. J. Petrol. Sci. Eng. 2012, 92, 48-55
30. Swamee, P.K.; Jain, A.K. Explicit equation for pipe flow problems. J. Hydr. Div.ASCE. 1976.102, 657-664.
31. Zeghadnia L.; Lakhdar, D.; Larbi, H.; Nouredin, R. New equation for the computation of flow velocity in partially filled pipes arranged in parallel. J. Water Sci.& Tech. 2014,70, 160-166.
32. Jain, A.K. Accurate explicit equation for friction factor. J. Hydr. Div.,ASCE. 1976, 102, 674–677.
33. Churchill, S.W. Friction factor equation spans all fluid-flow ranges. Chem. Eng. 1977, 84, 91-92.
34. Gurol, Y. Computer-based analysis of explicit approximations to the implicit Colebrook–White equation in turbulent flow friction factor calculation. Advances in Eng. Sofware. 2009, 40, 1183–1190.
35. Chen, N.H. An explicit equation for friction factor in pipe. Ind. Eng. Chem. Fund. 1979, 18, 296.
36. Shacham, M. An explicit equation for friction factor in pipe. Ind. Eng. Chem. Fund. 1980,19, 228 - 229.
37. Barr, D. 1981 Solutions of the Colebrook-White functions for resistance to uniform turbulent flows. Proc. Inst. Civil. Eng. 1981, 71, 529-536.
38. Zigrang, D.J.; Sylvester, N.D. Explicit approximations to the Colebrook's friction factor.AICHE J. 1982, 28, 514-515.
39. Haaland, S.E. Simple and Explicit formulas for friction factor in turbulent pipe flow. J. Fluid. Eng., ASME. 1983, 105, 89–90.
40. Serghides, T.K. Estimate friction factor accurately, Chem. Eng. 1984, 91, 63-64.
41. Tsal, R.J. Altshul-Tsal friction factor equation. Heating Piping Air Conditioning. 1989, 8, 30-45.
42. Manadilli, G. Replace implicit equations with signomial functions. Chem Eng. 1997, 104, 129-132.
43. Romeo, E.; Royo, C.; Monzón, A. Improved explicit equations for estimation of the friction factor in rough and smooth pipes. J. Chem. Eng. 2002, 86, 369-374.
44. Achour, B. ; Bedjaoui, A. ; Khattaoui, M. ; Debabeche, M. Contribution au calcul des ecoulements uniformes surface libre et en charge. J. Larhyss. 2002, 2, 7-36.[Contribution for the computation of open channel and pressurized flow. J. Larhyss.2002, 2, 7-36].
45. Chapeau,B.F., Monir, A. Evaluation of the Lambert W Function and Application to Generation of Generalized Gaussian Noise With Exponent 1/2" .IEEE Trans. Signal Processing. 2002, 50, 2160-2165.
46. Ajinkya A. M. Analytical solutions for the Colebrook and White equation and for pressure drop in ideal gas flow in pipes. J.Chem.Eng. Sci. 2006, 61, 5515 – 5519.
47. Wilkes, J.O. Fluid friction in pipes. In: Fluid Mechanics for Chemical Engineers. Prentice-Hall International Series, Englewood Cliffs, NJ. 1999, 113–159.
48. Buzzelli, D. Calculating friction in one step. Mach Des. 2008, 80, 54–55.
49. Sonnad, J.R.; Goudar, C.T. Turbulent flow friction factor calculation using a mathematically exact alternative to the Colebrook–White equation.J. Hydraul. Eng. ASCE. 2006, 132 ,863–867.
50. Rao, A.R.; Kumar, B. Friction factor for turbulent pipe flow. Div. Mech. Sci., Civ.Eng. Indian Institute of Science, Bangalore, India. 2007.
51. Avçi, A.; Karagoz, I. A novel explicit equation for friction factor in smooth and rough pipes. J. Fluids Eng. ASME. 2009, 131, 1–4.

52. Vatankhah, A.R.; kouchakzadeh, S. Discussion: Exact equations for pipe-flow problems, J. Hydr. Res. 2009, 47, 537–538.
53. Papaevangelou, G.; Evangelides, C.; Tzimopoulos, C. A new explicit relation for friction coefficient in the Darcy-Weisbach equation. Proceedings of the Tenth Conference on Protection and Restoration of the Environment. Corfu, Greece, 2010, PRE 10 July 6-09 .166, 1-7.
54. Fang, X., Xua, Y., Zhou, Z. New correlations of single-phase friction factor for turbulent pipe flow and evaluation of existing single-phase friction factor correlations. Nucl. Eng. Des. 2011, 241, 897-902.
55. Ghanbari, A.; Farshad, F.; Rieke, H.H. Newly developed friction factor correlation for pipe flow and flow assurance. J. Chem. Eng. Mat. Sci. 2011, 2, 83-86.
56. Brki, D. solutions of the CW equation for flow friction. Appl. Math. Lett. 2011, 24, 1379–1383.
57. Achour, B., Bedjaoui, A. Turbulent pipe-flow computation using the rough model method (RMM). JCES. 2012, 1, 36-41.
58. Zarko, C., Brkiç, D. Very accurate explicit approximations for calculation of the Colebrook friction factor. Inter.J. Mech. Sci. 2013, 67, 10–13
59. Vantakh, A.R. Comment on "Gene expression programming analysis of implicit Colebrook–White equation in turbulent flow friction factor calculation". J. Petroleum Sci. Eng. 2014, 124, 402-405.
60. Sonnad, J.R.; Goudar, C.T. Explicit reformulation of the Colebrook–White equation for turbulent flow friction factor calculation. Ind. Eng. Chem. Res. 2007, 46, 2593–2600.