Discussion of "Economics and Statistical Evaluations of Using Microsoft Excel Solver in Pipe Network Analysis" by I. A. Oke, A. Ismail, S. Lukman, S. O. Ojo, O. O. Adeosun, and M. O. Nwude

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Analysis of few pipe networks is shown in the discussed paper where the authors conclude that the distribution of flow in a network of pipes with known topology, fixed pipe lengths and diameters, with the known and constant inputs and outputs assigned to nodes (connection between two pipes) for the chosen flow friction model (e.g. Colebrook's) depends among other on the chosen method for calculation of flow and pressure distribution in looped network of pipes. That conclusion is not sustainable. Also friction factors are used as constant which cannot be recommended.

Hydraulic analysis of the network from Figure 4 of the discussed paper (the network with five pipes and two loops) is repeated in this discussion.

Flow Friction

In the discussed paper flow friction factor is given with the constant value of f=0.02 in examples 1 and 2, and f=0.0242 in example 3 (Tables 1 and 2 of the discussed paper). It is not acceptable. Flow friction factor is being changed during the calculation between f=0.02012 and f=0.02571. Flow friction is complex variable usually determined by empirical Colebrook's equation (1) or some of its related approximations (Colebrook 1939; Brkić 2011a, 2012a, 2017):

$$\frac{1}{\sqrt{f}} = -2 \cdot \log_{10}\left(\frac{2.51}{R \cdot \sqrt{f}} + \frac{\varepsilon}{3.71 \cdot D}\right) \qquad (1)$$

It is not obligatory to use this equation. Other equations can be used but f for sure cannot be treated as a constant. As the friction factor f is not a constant and even not always in turbulent zone for which Colebrook's equation (1) is only valid, it can be even suggested to use explicit approximation of the Colebrook equation (1a) but which is in addition valid also for laminar, and the transition in between laminar and turbulent zone (Swamee 1993):

$$f \approx \left\{ \left(\frac{64}{R} \right)^8 + 9.5 \left[\ln \left(\frac{\varepsilon}{3.7 \cdot \mathrm{D}} + \frac{5.74}{R^{0.9}} \right) - \left(\frac{2500}{R} \right)^6 \right]^{-16} \right\}^{0.125} \tag{1a}$$

The relation between pressure drop "Δp" and flow "Q" through pipe is $\Delta p = r \cdot Q^2$ and with the simplification where "r" is with constant value (although it depends on variable "f"), it is similar to Ohm's law for electrical circuits which relates voltage "U" and electrical current "I" through constant thermal resistance "R_T" as $U = I \cdot R_T$; note that R in Eqs. 1 and 1a is not thermal resistance but the Reynolds number. With linearization $x = Q^2$, system of equations for pipe network in form $\Delta p = r \cdot x$ can be solved using non iterative methodology for electrical circuits. Knowing "x" for each pipe, the flow "Q" can be calculated easily. Such simplification would not produce accurate results (Liou 1998; Simpson and Elhay 2011; Brkić 2012b, 2014).

Hydraulic analysis of pipe network with loops – flow distribution through pipes for known inputs and outputs through nodes

The network used for analysis is shown in Figure 1. Pipe length, diameters and node consumption are constants. The first assumed flow pattern through pipes is chosen arbitrarily with only one condition to maintain flow balance in every node (material balance; first Kirchhoff law). The kinematic viscosity of water is prescribed as $\mu = 1.0037 \cdot 10^{-6} m^2/s$, and absolute roughness of pipes is estimated at $\varepsilon = 0.00026 m$ (Brkić 2016).

Figure 1. Network with five pipes and two loops (adapted from the discussed paper)

Following the first Kirchhoff's law, system of equations for nodes can be established (2); where $Q_{1\text{-}5}$ are flows through pipes and will be changed during calculation:

$$\left.\begin{aligned} Q_1 - Q_2 - 0.08 &= 0 \\ 0.4 - Q_1 - Q_3 - Q_5 &= 0 \\ Q_4 + Q_5 - 0.2 &= 0 \\ Q_2 + Q_3 - Q_4 - 0.12 &= 0 \end{aligned}\right\} \begin{matrix} A_{node} \\ B_{node} \\ C_{node} \\ D_{node} \end{matrix} \qquad (2)$$

For two closed paths, following the second Kirchhoff's law, systems of equations for loops can be established (3); where $\Delta p_{1\text{-}5}$ are pressure drops in pipes and their algebraic sum for each closed path in the network has to be approximately zero.

$$\left.\begin{aligned} &\Delta p_1 + \Delta p_2 - \Delta p_3 = \\ &= \frac{8 \cdot \rho}{\pi^2} \cdot \left(\frac{f_1 \cdot \mathrm{L}_1 \cdot Q_1^2}{\mathrm{D}_1^5} + \frac{f_2 \cdot \mathrm{L}_2 \cdot Q_2^2}{\mathrm{D}_2^5} - \frac{f_3 \cdot \mathrm{L}_3 \cdot Q_3^2}{\mathrm{D}_3^5} \right) \approx 0 \\ &\Delta p_3 + \Delta p_4 - \Delta p_5 = \\ &= \frac{8 \cdot \rho}{\pi^2} \cdot \left(\frac{f_3 \cdot \mathrm{L}_3 \cdot Q_3^2}{\mathrm{D}_3^5} + \frac{f_4 \cdot \mathrm{L}_4 \cdot Q_4^2}{\mathrm{D}_4^5} - \frac{f_5 \cdot \mathrm{L}_5 \cdot Q_5^2}{\mathrm{D}_5^5} \right) \approx 0 \end{aligned}\right\} \begin{matrix} I_{loop} \\ II_{loop} \end{matrix} \qquad (3)$$

First derivative of $\Delta p(Q)$; pressure drop "Δp" in function of flow "Q" as variable can be calculated as (4):

$$F' = \frac{\partial(\Delta p)}{\partial Q} = \frac{\partial \left(\frac{8 \cdot \rho \cdot f \cdot \mathrm{L} \cdot Q \cdot |Q|}{\pi^2 \cdot \mathrm{D}^5} \right)}{\partial Q} = \frac{\partial(r \cdot Q \cdot |Q|)}{\partial Q} = \frac{16 \cdot \rho \cdot \lambda \cdot \mathrm{L} \cdot |Q|}{\pi^2 \cdot \mathrm{D}^5} = 2 \cdot r \cdot |Q| \qquad (4)$$

Original version of Hardy Cross method (Cross 1936) in matrix form, accelerated version of Hardy Cross method also known as Newton-Raphson method modified by Epp and Fowler (1971) and node-loop method by Wood and Charles (1972) improved by Wood and Rayes (1981) will be used.

Accelerated Hardy Cross method

Matrix of derivatives [F'] can be established as (5); where on the main diagonal, upper term represent sum of the absolute values of the derivatives from loop I while lower term represents sum of the absolute values of the derivatives from loop II. Terms $-\left|F_3^{'}\right|$ are from the pipe 3 because that pipe is common for both loops.

$$[F'] = \begin{bmatrix} \left|F_1^{'}\right| + \left|F_2^{'}\right| + \left|F_3^{'}\right| & -\left|F_3^{'}\right| \\ -\left|F_3^{'}\right| & \left|F_3^{'}\right| + \left|F_4^{'}\right| + \left|F_5^{'}\right| \end{bmatrix} \qquad (5)$$

Correction of flow "ΔQ" will be calculated in each iteration from [F']x[ΔQ]=[Δp], where [F'] is from (5), and where [Δp] is based on (3). For the presented network it will be (6):

$$\begin{bmatrix} \Delta p_1 + \Delta p_2 - \Delta p_3 \\ \Delta p_3 + \Delta p_4 - \Delta p_5 \end{bmatrix} = \begin{bmatrix} \left|F_1^{'}\right| + \left|F_2^{'}\right| + \left|F_3^{'}\right| & -\left|F_3^{'}\right| \\ -\left|F_3^{'}\right| & \left|F_3^{'}\right| + \left|F_4^{'}\right| + \left|F_5^{'}\right| \end{bmatrix} x \begin{bmatrix} \Delta Q_I \\ \Delta Q_{II} \end{bmatrix} \qquad (6)$$

ΔQ_I and ΔQ_{II} are correction of flow which will respectfully will receive each pipe in loop I and loop II where pipe 3 common to both loops will receive both correction simultaneously following algebraic rules for that (Corfield et al. 1974; Brkić 2009).

Original Hardy Cross method in matrix form

The same procedure as for the accelerated Hardy Cross method will be used with only difference that term $-\left|F_3^{'}\right|$ in matrix (5) will be zero. With this term equalized with zero the convergence toward the balanced solution is much slower.

The node-loop method

To avoid calculation of flow "Q" through "ΔQ", Wood and Charles (1972) and Wood and Rayes (1981) introduced the node-loop method. Flow Q can be calculated using [Q]=inv[NL]x[V] where matrix [NL] and [V] are defined as (7) and (8) respectively as described in Brkić (2011b, 2016). To preserve linear independency among rows of [NL], one arbitrarily chosen node has to be omitted (in this case node D).

$$[NL]=\left[\begin{matrix} 1 & -1 & 0 & 0 & 0 \\ -1 & 0 & -1 & 0 & -1 \\ 0 & 0 & 0 & 1 & 1 \\ F_1^{'} & F_2^{'} & -F_3^{'} & 0 & 0 \\ 0 & 0 & F_3^{'} & F_4^{'} & -F_5^{'} \end{matrix}\right]\left.\vphantom{\begin{matrix}1\\1\\1\\1\\1\end{matrix}}\right\}\begin{matrix} A_{loop} \\ B_{loop} \\ C_{loop} \\ I_{node} \\ II_{node} \end{matrix} \tag{7}$$

$$[V]=\left[\begin{matrix} 0.08 \\ -0.4 \\ 0.2 \\ -\left(\Delta p_1+\Delta p_2-\Delta p_3\right)+\left(\left|F_1^{'}\right|\cdot Q_1+\left|F_2^{'}\right|\cdot Q_2+\left|F_3^{'}\right|\cdot Q_3\right) \\ -\left(\Delta p_3+\Delta p_4-\Delta p_5\right)+\left(\left|F_3^{'}\right|\cdot Q_3+\left|F_4^{'}\right|\cdot Q_4+\left|F_5^{'}\right|\cdot Q_5\right) \end{matrix}\right]\left.\vphantom{\begin{matrix}1\\1\\1\\1\\1\end{matrix}}\right\}\begin{matrix} A_{node-output} \\ B_{node-input} \\ C_{node-output} \\ I_{loop} \\ II_{loop} \end{matrix} \tag{8}$$

In [V], first three rows are with constant values during whole calculation (in every iteration).

Results

Tree methods were used for calculation, the original Hardy Cross, the accelerated Hardy Cross (Newton Raphson) and the node-loop. The final solution is reached after approximately 9 iterations using the accelerated Hardy Cross (Newton Raphson) and the node-loop and after approximately 28 iterations using original Hardy Cross method. The final results are identical and they are listed in Table 1:

Table 1. Information about the network, the flows obtained, pressure drops and related head losses

All calculations were performed in Microsoft Excel.

Conclusion

Calculation with flow friction factor treated as constant cannot be recommended. Also using the chosen flow friction model (e.g. Colebrook's), final flow distribution does not depend on the chosen method (e.g. Hardy Cross, the node-loop method, etc.) for one defined network with known and constant pipe diameters, lengths and roughness of inner pipe surface and with constant consumptions and inputs assigned to nodes (Gay and Middleton 1971).

Supplementary material:

Complete calculation using the node-loop method extracted from MS Excel is provided.

Notation

The following symbols are used in this discussion:

R – Reynolds number (dimensionless)

ε/D – Relative roughness of inner pipe surface (dimensionless)

f – Darcy (Moody) flow friction factor (dimensionless)

Q – volumetric flow (m^3/sec)

Δp – pressure drop (Pa)

ρ – water density (kg/m^3)

L – length pf pipe (m)

D – diameter of pipe (m)

π-Ludolph number, π≈3.1415

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References:

Brkić, D. (2009). "An improvement of Hardy Cross method applied on looped spatial natural gas distribution networks.", Appl. Energ. 86(7-8), 1290-1300. doi:10.1016/j.apenergy.2008.10.005

Brkić, D. (2011a). "Review of explicit approximations to the Colebrook relation for flow friction." J. Petrol. Sci. Eng. 77(1), 34-48. doi. 10.1016/j.petrol.2011.02.006

Brkić, D. (2011b). “Iterative methods for looped network pipeline calculation.”, Water. Resour. Manag. 25(12), 2951-2987. doi:10.1007/s11269-011-9784-3

Brkić, D. (2012a). “Determining friction factors in turbulent pipe flow.” Chem. Eng. (New York) 119(3), 34-39. From: www.chemengonline.com/determining-friction-factors-in-turbulent-pipe-flow/?printmode=1

Brkić, D. (2012b). “Discussion of ‘Jacobian matrix for solving water distribution system equations with the Darcy-Weisbach head-loss model’ by Angus Simpson and Sylvan Elhay.” J. Hydraul. Eng., 138(11), 1000-1001. doi:10.1061/(ASCE)HY.1943-7900.0000529

Brkić, D. (2014). “Discussion of ‘Method to cope with zero flows in Newton solvers for water distribution systems’ by Nikolai B. Gorev, Inna F. Kodzhespirova, Yuriy Kovalenko, Eugenio Prokhorov, and Gerardo Trapaga.” J. Hydraul. Eng., 140(4). doi:10.1061/(ASCE)HY.1943-7900.0000769

Brkić, D. (2016). “Spreadsheet-based pipe networks analysis for teaching and learning purpose.”, Spreadsheets in Education (eJSiE), 9(2), Article 4. http://epublications.bond.edu.au/ejsie/vol9/iss2/4

Brkić, D. (2017). “Discussion of ‘Exact analytical solutions of the Colebrook-White equation’ by Yozo Mikata and Walter S. Walczak.” J. Hydraul. Eng. 143(9). doi:10.1061/(ASCE)HY.1943-7900.0001341

Colebrook, C.F. (1939). “Turbulent flow in pipes with particular reference to the transition region between the smooth and rough pipe laws.” J. Inst. Civil. Eng. (London) 11(4), 133-156. doi. 10.1680/ijoti.1939.13150

Corfield, G., Hunt, B.E., Ott, R.J., Binder, G.P., and Vandaveer, F.E. (1974). “Distribution design for increased demand,” 63–83 [chapter 9]. In: Segeler, C.G., editor. Gas engineers handbook, Industrial Press, New York.

Cross, H. (1936). “Analysis of flow in networks of conduits or conductors.”, Urbana Champaign Univ. Ill. Bull. 286; Eng. Exp. Station, 34(22), 3–29. http://hdl.handle.net/2142/4433

Epp, R, and Fowler, A.G. (1970). “Efficient code for steady flows in networks.” J. Hydraul. Div. ASCE, 96(HY1), 43–56.

Gay, B., and Middleton, P. (1971). “The solution of pipe network problems.” Chem. Eng. Sci., 26(1), 109-123. doi:10.1016/0009-2509(71)86084-0

Liou, C. (1998). “Limitations and proper use of the Hazen-Williams equation.” J. Hydraul. Eng., 124(9), 951-954. doi. 10.1061/(ASCE)0733-9429(1998)124:9(951)

Simpson, A. and Elhay, S. (2011). “Jacobian matrix for solving water distribution system equations with the Darcy-Weisbach head-loss model.” J. Hydraul. Eng. 137 (6), 696-700., doi:10.1061/(ASCE)HY.1943-7900.0000341

Swamee, P.K.(1993). “Design of a submarine oil pipeline.” J. Transp. Engrg., ASCE, 119(1), 159-170., doi:10.1061/(ASCE)0733-947X(1993)119:1(159)

Wood, D., and Charles, C. (1972). “Hydraulic network analysis using linear theory.”, J. Hydraul. Div. ASCE, 98(HY7), 1157–1179.

Wood, D.J., and Rayes, A.G. (1981). “Reliability of algorithms for pipe network analysis.”, J. Hydraul. Div. ASCE, 107(HY10), 1145–1161.

Table 1. Information about the network, the flows obtained, pressure drops and related head losses

Pipe			r	Flow ($m^3 \cdot s^{-1}$)	Pressure drop Δp (Pa)	$K=r \cdot \rho^{-1} \cdot g^{-1}$	Head loss H (m) $H=\Delta p \cdot \rho^{-1} \cdot g^{-1}$
Number	Diameter D (m)	Length L (m)					
1	0.25	1000	16741273.11	0.170123	484523.91	1706.55	49.39
2	0.20	1500	81276026.10	0.090123	660138.41	8285.01	67.29
3	0.15	1800	442404818.12	0.050866	1144662.32	45097.33	116.68
4	0.10	1000	2083940584.61	0.020989	918078.81	212430.23	93.58
5	0.20	1200	64370456.71	0.179011	2062741.10	6561.71	210.26

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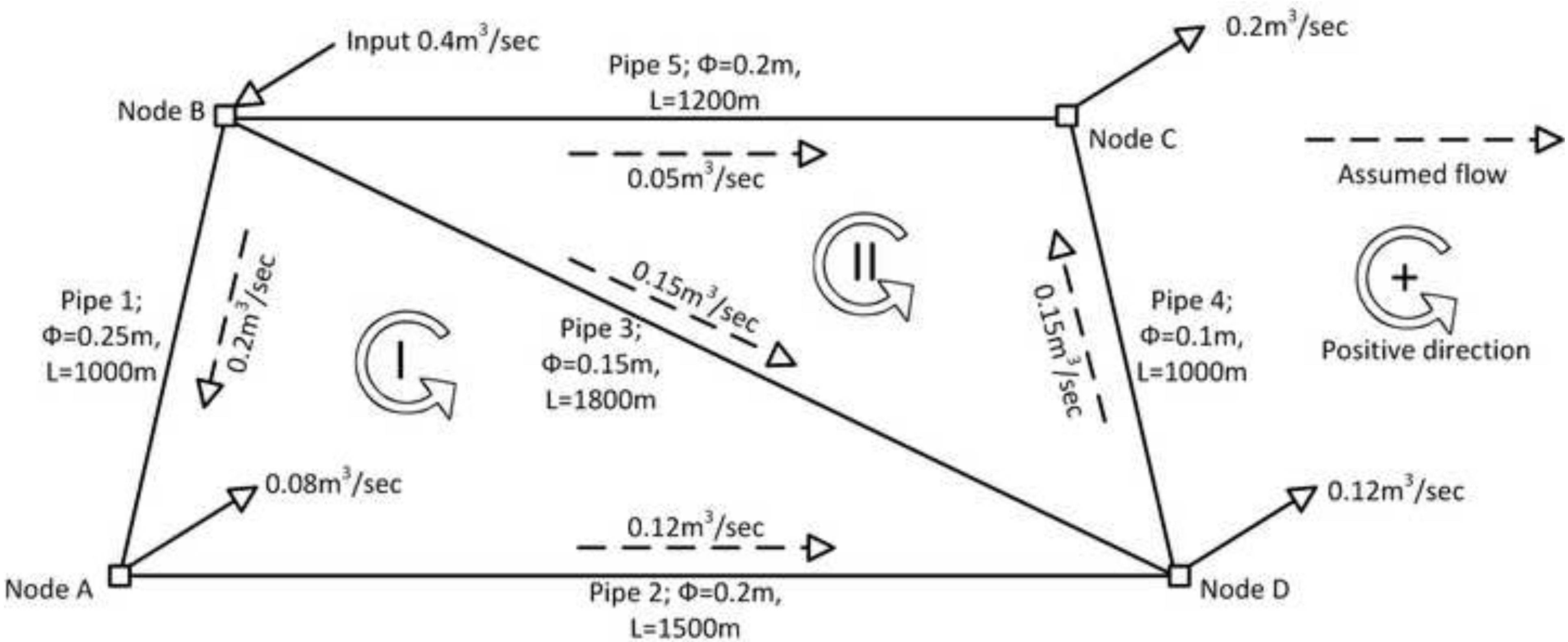

Figure caption list

Figure 1. Network with five pipes and two loops (adapted from the discussed paper)

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