Accepted version

J. P. Vtkovsk, A. Bergant, A. R. Simpson and M. F. Lambert
Closure to Systematic Evaluation of One-Dimensional Unsteady Friction Models in Simple Pipelines
Journal of Hydraulic Engineering, 2008; 134(2):284

http://doi.org/10.1061/(ASCE)0733-9429(2008)134:2(284)

Closure to, Systematic evaluation of one–dimensional unsteady friction models in simple pipelines

by

Vítkovský, J., Bergant, A., Simpson, A.R. and Lambert, M.F.

Journal of Hydraulic Engineering

Citation:
Vítkovský, J., Bergant, A., Simpson, A.R. and Lambert, M.F. (2008). Closure to "Systematic evaluation of one–dimensional unsteady friction models in simple pipelines." *Journal of Hydraulic Engineering*, American Society of Civil Engineers, Vol. 134, No. 2, February, 284.

Closure to "Systematic Evaluation of One-Dimensional Unsteady Friction Models in Simple Pipelines" by J.P Vítkovský, A. Bergant, A.R. Simpson, and M.F. Lambert.

July 2006, Vol. 132, No. 7, pp, 696-708. DOI: 10.1061/(ASCE)0733-9429(2006)132:7(696)

J.P Vítkovský[1], A. Bergant[2], A.R. Simpson[3], and M.F. Lambert[4]

[1] Hydrologist, Water Assessment Group, Department of Natural Resources and Water, Queensland Government, Indooroopilly QLD 4068, Australia.
[2] Head, Research, Instrumentation and Control Engineering Department, Litostroj E.I. d.o.o., 1000 Ljubljana, Slovenia.
[3] Head, Professor, Centre for Applied Modelling in Water Engineering, School of Civil and Environmental Engineering, University of Adelaide, Adelaide SA 5005, Australia.
[4] Associate Professor, Centre for Applied Modelling in Water Engineering, School of Civil and Environmental Engineering, University of Adelaide, Adelaide SA 5005, Australia.

In the original paper, the authors presented a mainly numerical argument, relating to different problems afflicting constant coefficient instantaneous acceleration-based (IAB) models. In addition, experimental results were shown. The main points of the paper are: (1) showing justification of the modification of the basic IAB model with respect to a series of transient flow states; (2) the inability of the IAB model to realistically model certain types of transient event (in particular, constantly accelerating flows, such as those resulting for valve opening); (3) the source of damping in the IAB model coming solely from the $\partial V/\partial x$ term; (4) non-existent (and unrealistic) evolution of the transient wave form; and (5) numerical error as a possible explanation of the variation in reported k values in the literature.

Different analyses have been known to yield different estimates of wave speed (Jönsson 2001 amongst others). The presence of viscoelastic pipe material, stress radiation into surrounding media, entrained air, air release, inertial lengths at entrances and exits to reservoirs, fluid-structure interaction, etc. can all serve to modify the apparent wave speed. It is important to note that different phenomena can cause these wave speed differences, such as wave speeds derived from timing in a viscoelastic pipe can depend on the distance from the transient

initiation point and can be very different to the wave speed derived from the frequency method. An intriguing research question is whether or not unsteady friction actually causes a change to the apparent wave speed? Many higher-order models do not predict any apparent wave speed change from unsteady friction (Zielke 1968, Vardy and Hwang 1991, Pezzinga 1999, Ghidaoui *et al*. 2002, Vardy and Brown 2003, 2004, Zhao and Ghidaoui 2006, amongst others). A quality experimental investigation is required to answer this question, where all relevant phenomenological behaviours are considered.

The discussers have contributed some of the development behind the original formulation of instantaneous acceleration-based (IAB) models. Furthermore, realisations from constant coefficient IAB models may provide some understanding of the general nature of unsteady friction. However, it is the opinion of the authors that there might not be a simple IAB-type model that can simulate all transient event types. Perhaps some evidence of this can be found in Brunone *et al*. (2004) where the coefficient *k* varies in time and space along the pipeline in a complex manner. Based on the numerical investigation and experimental data presented by the authors in the original paper weighting function-based models seem a better choice of unsteady friction model than the IAB model.

References:

Brunone, B., Ferrante, M., and Cacciamani, M. (2004). "Decay of Pressure and Energy Dissipation in Laminar Transient Flow." *Journal of Fluids Engineering*, Transactions of the ASME, 126, 928-934.

Ghidaoui, M.S., Mansour, S.G.S., and Zhao, M. (2002). "Applicability of Quasi Steady and Axisymmetric Turbulence Models in Water Hammer." *Journal of Hydraulic Engineering*, ASCE, 128(10), 917–924.

Jönsson, L. (2001). "Experimental Studies of Leak Detection Using Hydraulic Transients." *29th IAHR Congress, IAHR*, September 16-21, Beijing, China.

Pezzinga, G. (1999). "Quasi-2D Model for Unsteady Flow in Pipe Networks." *Journal of Hydraulic Engineering*, ASCE, 125(7), 676–685.

Vardy, A.E., and Brown, J.M.B. (2003). "Transient Turbulent Friction in Smooth Pipe Flows." *Journal of Sound and Vibration*, 259(5), 1011-1036.

Vardy, A.E., and Brown, J.M.B. (2004). "Transient Turbulent Friction in Fully-Rough Pipe Flows." *Journal of Sound and Vibration*, 270(1-2), 233-257.

Vardy, A.E., and Hwang, K.-L. (1991). "A Characteristics Model of Transient Friction in Pipes." *Journal of Hydraulic Research*, IAHR, 29(5), 669-684.

Zhao, M. and Ghidaoui, M.S. (2006). "Investigation of Turbulence Behavior in Pipe Transient Using a *k*–ε Model." *Journal of Hydraulic Research*, IAHR, 44(5), 682–692.

Zielke, W. (1968). "Frequency-Dependent Friction in Transient Pipe Flow." *Journal of Basic Engineering*, ASME, 90(1), 109–115.