Kalpa Publications in Engineering
Volume 1, 2017, Pages 464–469
ICRISET2017. International Conference on Research and Innovations in Science, Engineering &Technology. Selected Papers in Engineering

Numerical Investigation of Pressure-Drop in Valve Test-rig Design

G. V. Patel[1], Akash Patel[2], M. N. Makwana[3], Dr. N. K. Chavda[4]
[1] Research Scholar, Gujarat Technological Uni. Ahmedabad, India
[2] PG Scholar, University of Texas, Arlington, USA.
[3]Dept. of Mechanical Engg., Dr. Jivraj Mehta Inst. of Tech., Mogar, India
[4]Dept of Mechanical Engg., A D Patel Inst. of Technology, New V. V. Nagar, India
ergvpatel@gmail.com, akash.09.06.1995@gmail.com,
lecturer.icct@gmail.com, neeraj_chavda@yahoo.co.in

Abstract

Valves are widely used in numerous industries like Beverage, Food, Dairy, Cosmetic, Pharmaceutical and Biotech to serve various purposes. Hence, it is strongly needed that each valve must be tested thoroughly for proper functioning. The equipment used for testing of valves is known as test-rig. At present, no standard test-rig is available in the market for testing of valves. This study is a part of an attempt to develop a cost-effective customized test-rig for multiple valve testing. In present study, pressure-drop in various cross-sections of the proposed test-rig has been investigated and validated with CFD simulation.

1 Introduction

Different types of valves are used in different industries mainly beverage, food, dairy etc. to perform various operations on fluids like diversion, regulation or restriction etc. In some industries regulation of fluids become very critical. Since this kind of jobs are mainly dependent on valves, quality and performance of valves becomes vital. Therefore, it is essential that each valve must be tested under extreme conditions before actual performance. Valves are tested in some special arrangements called Test-rig. Presently, no standard test-rig is available in the market. This is a part of, a kind effort to develop valve test-rig in-house, on which variety of valves can be tested. In this paper, only pressure-drop within the pipe used in setup has been analyzed and validated by CFD simulation.

2 Analytical Calculations

Following equations are used to analyze pressure-drop in various sections of the proposed test-rig:

- Reynold's Number $\mathbf{R_e} = \frac{\rho u d}{\mu}$
- Head loss in pipe $\mathbf{h_f} = \frac{4fLu^2}{2gd}$ (Darcy-Weisbach Equation)
- Friction Factor $\mathbf{f} = \frac{0.079}{Re^{0.25}}$
- Losses at sudden enlargement $\mathbf{h_L} = \left(1 - \frac{A_1}{A_2}\right)^2 \frac{u_1^2}{2g}$
- Losses at sudden contraction $\mathbf{h_c} = 0.44 \frac{u_2^2}{2g}$
- Bend Loss $B_d = 0.5 \frac{u^2}{2g}$

A. Shukla, J.M. Patel, P.D. Solanki, K.B. Judal, R.K. Shukla, R.A. Thakkar, N.P. Gajjar, N.J. Kothari, S. Saha, S.K. Joshi, S.R. Joshi, P. Darji, S. Dambhare, B.R. Parekh, P.M. George, A.M. Trivedi, T.D. Pawar, M.B. Shah, V.J. Patel, M.S. Holia, R.P. Mehta, J.M. Rathod, B.C. Goradiya and D.K. Patel (eds.), ICRISET2017 (Kalpa Publications in Engineering, vol. 1), pp. 464–469

3 Test-rig Design

3.1 Proposed Test-Rig

As shown below, the test-rig is proposed by considering the analytical values obtained from the equations prescribed in section II.

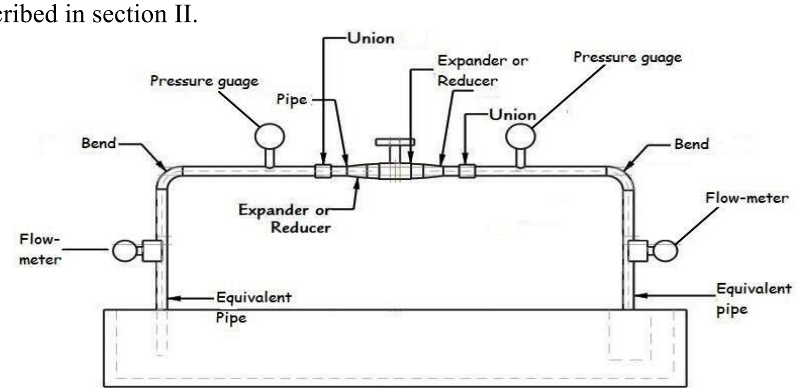

Fig. 1. 2D Drawing of Proposed Test-Rig

3.2 Modeling of Test-Rig

As the valves were having a wide range of size variations, two 3D models of test-rig, Setup 1.1 for valve dia 1” to 4” and setup 1.2 for valve dia 5” to 8” were created in modeling software by considering the proposed 2D drawing.

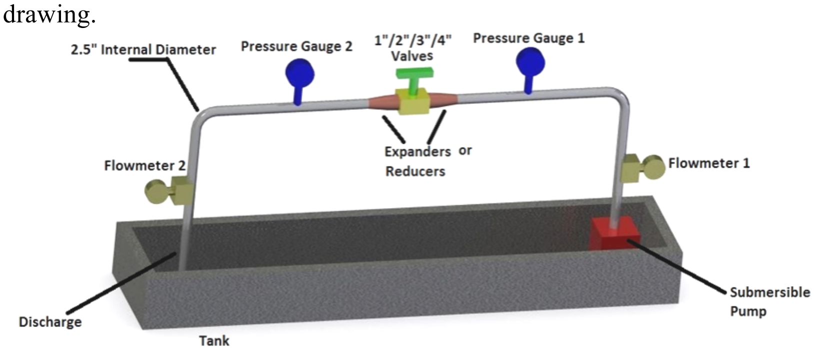

Fig. 2. 3D Model of Setup 1.1

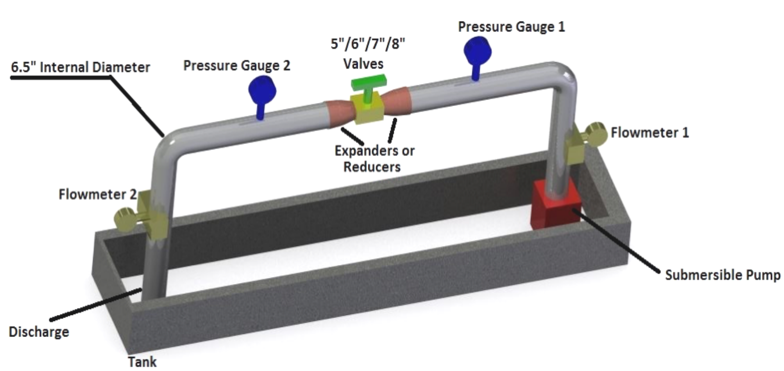

Fig. 3. 3D Model of Setup 1.2

4 CFD Simulation

The main aim to perform CFD simulation in this case was to justify the analytical exercise and also visualize the fluid flow behavior within the main pipe of the test-rig.

4.1 CFD Modeling

In this step, the fluid domain was constructed from the 3D model and different boundary conditions were applied. In this phase, various properties were also assigned to fluid.

4.2 Meshing

After CFD modeling, meshing of the interest domain was carried out.

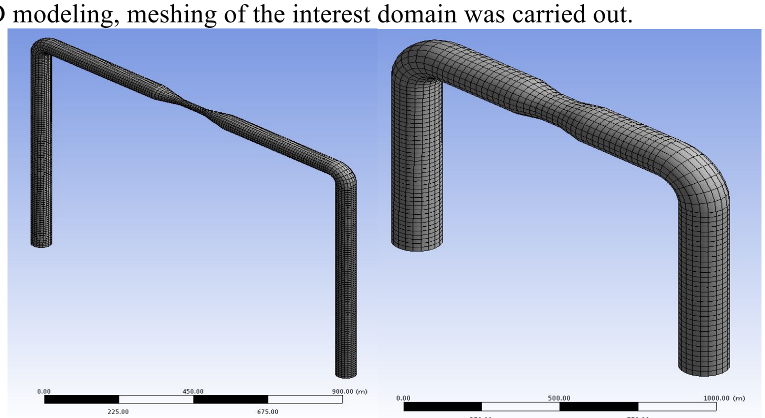

Fig. 4. 3D Meshed Model of Setup 1.1 and 1.2

Meshing was carried out for full opening of various size of valves.
Following criteria has been considered:

- Allocate an appropriate set of global mesh controls.
- Dominate the default mesh type by introducing a different mesh method.
- Dominate the global sizing or additional controls nearby on bodies, faces, edges, or vertices and the sections close to them by scoping local mesh controls.

4.3 Outputs

Following figures show pressure and velocity distributions in setup 1.1 for different flow-rates of 100, 500 and 1000 GPM for full opening of the valve of size 1”.

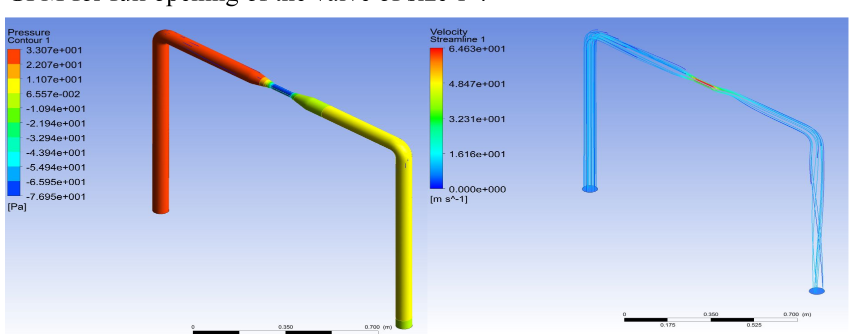

Fig. 5. Presssure and Velocity Distribution @ 100 GPM in setup 1.1

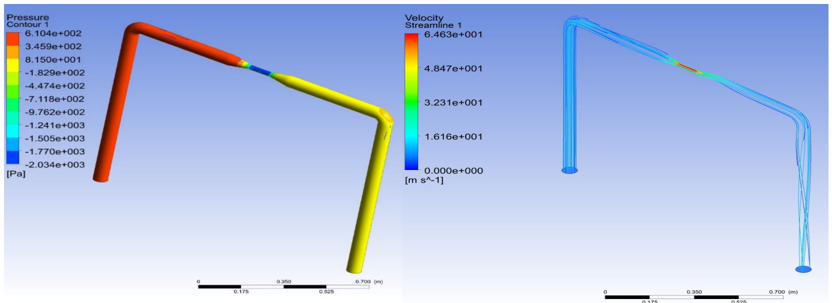

Fig. 6. Presssure and Velocity Distribution @ 500 GPM in setup 1.1

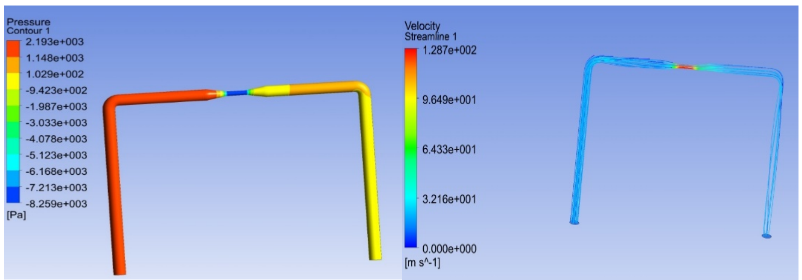

Fig. 7. Presssure and Velocity Distribution @ 1000 GPM in setup 1.1

Similar results were also obtained for full opening of the different valves of size 2”, 3” and 4”. For larger valve size, setup 1.2 was considered for which similar results were obtained. Following figures show pressure and velocity distributions in setup 1.2 for 100, 500 and 1000 GPM for full opening of the valve size of 5”.

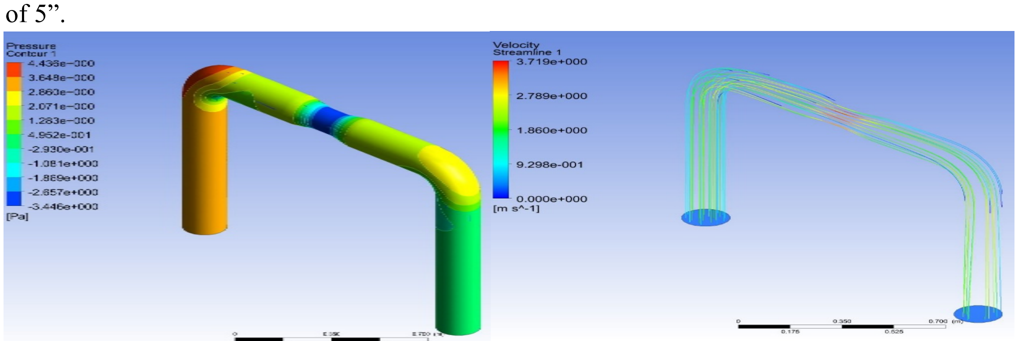

Fig. 8. Presssure and Velocity Distribution @ 100 GPM in setup 1.2

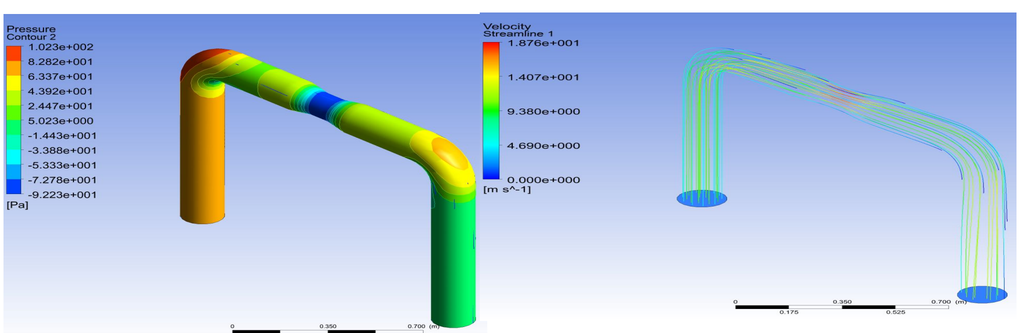

Fig. 9. Presssure and Velocity Distribution @ 500 GPM in setup 1.2

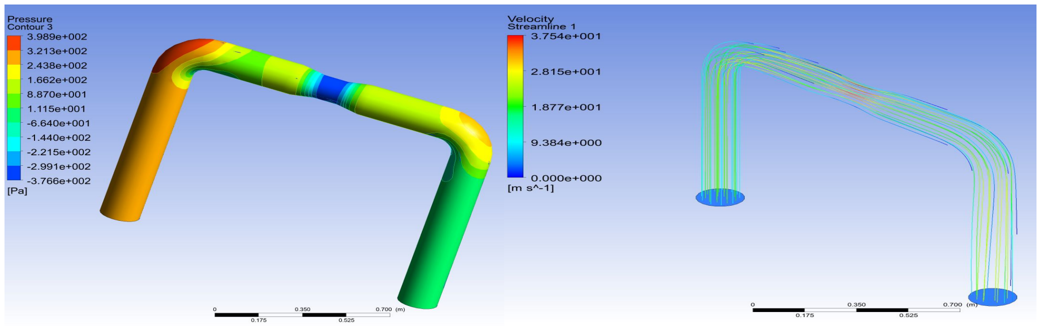

Fig. 10. Presssure and Velocity Distribution @ 1000 GPM in setup 1.2

Similar results were also obtained for full opening of the different valves of size 6”, 7” and 8”.

5 Comparison of results

Pressure-drop in various cross-sections of the proposed test-rig have been calculated analytically and by performing simulation at various flow-rates. The following figure indicates the different cross-sections of the proposed test-rig:

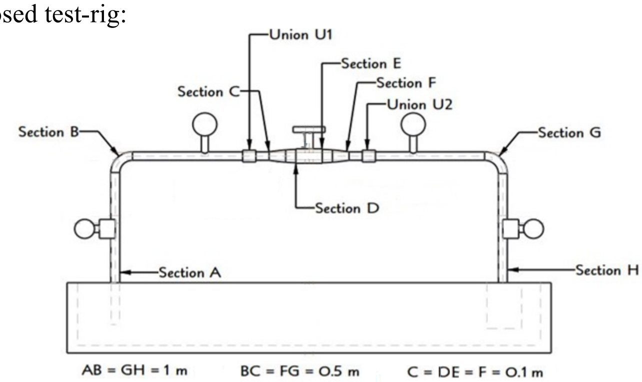

Fig. 11. Consideration of Cross-sections in Proposed Test-rig

5.1 Results Comparison for Setup 1.1

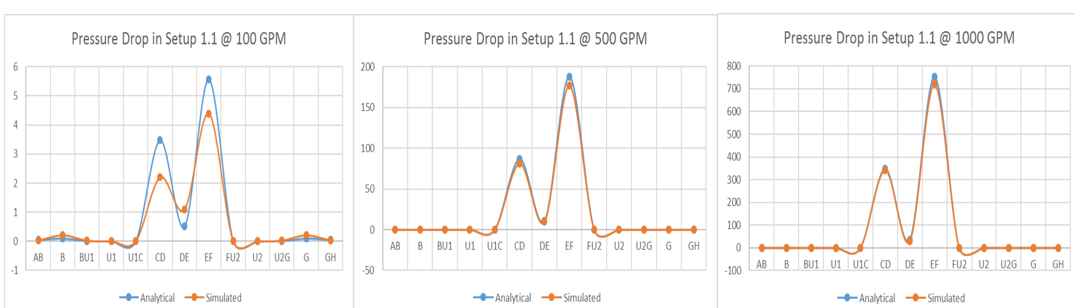

Fig. 12. Comparison of results for different flow-rates

The above results were obtained for full opening of the valve size of 1”. It was clearly observed that at higher flow rate the increase in pressure-drop was highly noticeable due to the high frictional loss in small cross-section. For 2”, 3” and 4” valve size, the analytical and simulated results were also found to be similar.

5.2 Results Comparison for Setup 1.2

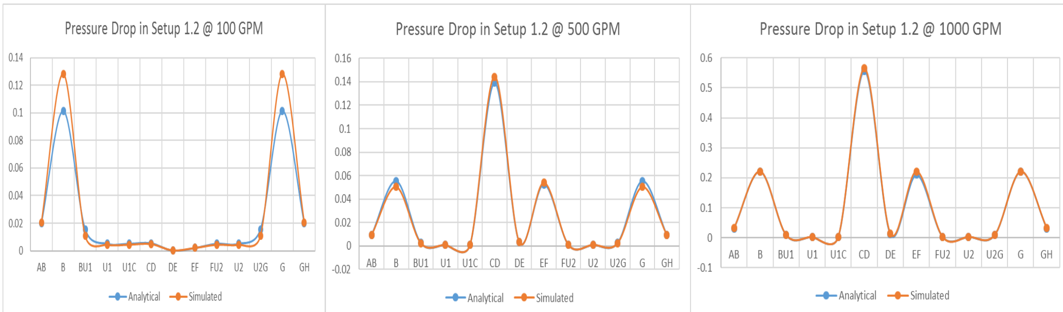

Fig. 13. Comparison of results for different flow-rates

The above results were obtained for full opening of the valve size of 5”. In this case, the value of pressure drop slightly raised with the increase in flow rate. For 6”, 7” and 8” valve size, the analytical and simulated results were also found to be similar.

6 Conclusion

From the above graphs, it is clearly observed that the values derived from analytical and simulation methods were found to be almost similar. Moreover, by analyzing the plots for overall pressure losses in setups 1.1 and 1.2, it can be concluded that losses will be minimum using flow rate of 100 GPM for both the setups. Hence, the proposed design of the valve test-rig is much appropriate for further advancement like design modification or fabrication.

Acknowledgment

The authors are enormously grateful to the Cipriani Harrisons Valves Ltd for providing valuable information of valve test-rig. The authors are also gratified to the A. D. Patel Institute of Technology, New V. V. Nagar for providing the useful resources to carry out the simulation work. The authors are grateful to the staff & students of the institute for providing their persistent efforts & support wherever desired.

References

1. Zappe R. W., Smith P., “Valve Selection Handbook”, 5th Edition, Gulf Professional Publishing, USA, 2004.
2. Tu J. Y., Yeoh G. H., Liu C, “Computational Fluid Dynamics - A Practical Approach”, 1st edition, Butterworth Heinemann, USA, 2008.
3. Patel G. V., “Design and Development of Aseptic Housing using CFD Analysis”, Charotar Institute of Technology, Changa, 2009.
4. Patel G. V., Patel R. T., “Enhanced Design Assortment of Aseptic Housing Using CFD analysis”, Proceedings of ETME-2011, GCET, V.V. Nagar, p. 160-165, 2011.
5. Patel H. P., Patel G. K., Patel G. V., Chavda N. K. “CFD Analysis of Calandria Based Nuclear Reactor: Part-I. Modeling & Analysis of Moderator”, International Journal of Research in Engineering and Technology, Vol. 03, Issue 06, p. 540-543, 2014