Pressure and Velocity Measure in the Pipeline for Leak Detection using COMSOL Multiphysics

Neeraj, Meenakshi Nawal, Mahesh Bundele, P. K. Suri

Abstract: COMSOL Multiphysics software is multipurpose software which can be used in every field. COMSOL Multiphysics to have less work in India. I have to review many papers on COMSOL but all the papers out of India. I have decided to work on COMSOL Multiphysics. This paper presents laminar flow inside the pipeline to calculate velocity and pressure to using valve in open and close case along the pipeline. I have research on leakage detection in water supply distribution network. For this purpose I have designed a multiple size pipes and multiple size valves in AutoCAD software.

Keywords: COMSOL, Leakage.

I. INTRODUCTION

Water is necessary for every person, plants and other environment creatures in life. Firstly we save the water and store it for future. For to detected the leak in water to create a network. COMSOL Multiphysics 5.5 is element analysis and multiphysics simulation platform. In COMSOL engineers do the work at all platforms. I have done the research on leak detection in water supply distribution network. I have designed pipes in 0.5*10m”, 4*10m”, 16*10m” and valve designed 0.5*0.5” 100% open and close, 4*4”100% open and close, 6*6”100% open and close.I have also taken the three networks for simulation. Water distribution network create for different size of pipes but i have started a single pipe and after simulation to show pressure and velocity can easily to compute. Further I have taken two pipes with one valve in open status and compute the pressure. Both the network simulated easily. After this I have taken four pipes and three valves in different open conditions. First valve open 25%, second open 50%, and third open 100%. To set the laminar flow and other fluid properties. Introduction described in first section and second briefly described literature review. In third section explain COMSOL simulation and fourth to show the results. At last to include the conclusion and references.

II. LITERATURE REVIEW

Leakage in the pipelines of oils, gas and water pipeline are dangerous for health. In cities many gallon of water are waste during supply It become a problem for every person [1]. The U.S. Department to give reported that 867 gas and hazardous gallon water pipeline leakage and more pipes burst in [2]. In England 5,600 million liters of water is lost every day it means leakage and pipeline burst [5]. In water distribution networking to use the control valves which control fluid flow in pipelines and many engineering applications. It is very difficult for engineers to understand all the actual working of control valves [4]. In this design, all the parameters optimized according to the simulation and can use the magnetic flux leakage sensor. Also use permanent magnets in carbon [5].

III. METHODOLOGY

3.1 Objectivesof COMSOL: This paper to have three objectives

- Detect the pressure and velocity in pipeline to detect a leakage in pipeline network.
- Designed a pipe network to using valve between two pipes.
- Designed a pipe network to using four pipes and three valves in different condition status.

COMSOL Multiphysics to have many properties and applications in engineering. In COMSOL to select all the assumptions:

1. In COMSOL software firstly to select a model wizard 3D. You can also select 2D and 1D.
2. Physics- fluid flow-single phase flow-laminar flow
3. Study-stationary and add.
4. Global right click and set the parameters
5. Geometry- right click-labels-pipe flow. Select pipe length in inch. After this import file 1 from build in selected from AutoCAD and also import others files.
6. Material selected water and liquid.
7. In laminar flow to select wall1 and select boundary of walls.
8. Laminar flow- at inlet of pipe to select manual velocity field 0.001 and outlet select manual.
9. Mesh select manual (if error occur then free tetrahedral)
10. Study 1 then compute and find the result
In the simulation you can find out the result in 3D graph, 2D graph and 1D graph. Also can change the property according to our need.

3.2 Mathematical equation: 
Given mathematical equation to describe the time dependent in study. We can compute the pressure and flow in pipe using this time dependent formula.

\[ p \frac{u}{t} + \Delta (p (u. \Delta) u) - \Delta \left[-p t + \mu (\Delta u + (\Delta u)_{\text{r}})\right] + F \]

\[ P \Delta. (u) = 0 \]

**Table 1: Parameters of both pipes and valves**

<table>
<thead>
<tr>
<th>Name</th>
<th>Expression</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe1 length</td>
<td>10[m]</td>
<td>10meter</td>
</tr>
<tr>
<td>Pipe2 length</td>
<td>10[m]</td>
<td>10meter</td>
</tr>
<tr>
<td>Valve diameter</td>
<td>4[inch]</td>
<td>4”</td>
</tr>
<tr>
<td>Pipe1 length</td>
<td>10[m]</td>
<td>10meter</td>
</tr>
<tr>
<td>Pipe2 length</td>
<td>10[m]</td>
<td>10meter</td>
</tr>
<tr>
<td>Pipe3 length</td>
<td>10[m]</td>
<td>10meter</td>
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<tr>
<td>Pipe4 length</td>
<td>10[m]</td>
<td>10meter</td>
</tr>
<tr>
<td>Pipe diameter</td>
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<td>0.5”</td>
</tr>
<tr>
<td>Valve diameter</td>
<td>0.5[inch]</td>
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</tr>
<tr>
<td>Valve1</td>
<td>100[Percent]</td>
<td>Open</td>
</tr>
<tr>
<td>Valve2</td>
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<td>Open</td>
</tr>
<tr>
<td>Valve3</td>
<td>25[Percent]</td>
<td>Open</td>
</tr>
</tbody>
</table>

Figure 1: Single Pipeline with dimensions
In the figure 1 pipeline design in COMSOL but another pipelines design in AutoCAD then import.

3.3 Pipe network designed in COMSOL:
In the figure 1 to show the pipeline network to import the AutoCAD file in model builder. Given network can be rotate in any direction.

Figure 2: Two pipelines with one valve in 100% open status

In figure 5 four pipes are connected with three valves in a network. I have taken four pipes with 10meter ength and valves in different conditions. First valve open 100%, second open 50% and third open 25%. In pipe two show the laminar flow.

Figure 3: Two pipelines and valve with dimensions

Figure 4: Two pipelines and valve without dimensions

Figure 5: Four pipelines and three valves connected in a network
In figure 7 to show the laminar flow at all pipes after domain selection. After this to set the fluid property, initial valve, wall 1, inlet 1 and outlet 1.

IV. RESULT

In COMSOL Multiphysics can be calculated and derived all the data set, views, derived values, tables, velocity and pressure. I have detected pressure and velocity magnitude in pipeline.

4.1. Simulation result: find out the result in different graphs in 1D polar group, 2D polar group and 3D polar group.

In figure 1 to show the one valve connected between two pipes. Valves in open status. After simulation in pipeline to show the pressure in pipeline.

In the figure 2 to show the pressure in y-z direction with one valve in open status.

In figure 5 to show the velocity magnitude in line graph. Include velocity can be calculate flow in pipe.
In the figure 12 to show the 1D plot graph of pressure.

Figure 13: Surface velocity magnitude in pipeline

Figure 14: Surface velocity magnitude in pipeline

Figure 15: Pressure with dimensions

V. CONCLUSIONS

COMSOL Multiphysics is a useful tool for simulation in the research work in water supply distribution network. I also have to create a two pipeline network with a valve 100% open status and to find out the velocity and pressure. It can be analyze with laminar flow. It has also used a single pipe, two pipes with one valve. This is a success simulation result in this pipe network. In future I have create a network with different pipes means 16", 4", 0.5" and valves with 25%, 50%, 100% in open and close status and also using reducer, elbow, T joint. I have already designed all this tools in AutoCAD but only to create a network in COMSOL and simulate. COMSOL helpful to detected a leakage in water supply distribution network.

REFERENCES

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AUTHORS PROFILE
Ms. Neeraj is currently pursuing the Ph.D. degree in Computer Science & Engineering with the Poornima University, Jaipur, India. She completed B. tech in Computer Science and Engineering in 2011 and M. tech in Computer Science in 2013. She is having experience in teaching as a lecturer in Govt College. She has attended IEEE conferences, scopus conference, workshop and trainings on NS2, Wireless sensor network etc. She has published research papers in conference and journals. She is also a IEEE member. Her research interests include Wireless Sensor Network and Matlab.

Dr. Meenakshi Nawal is currently working as Associate Professor with the Poornima University, Jaipur, India. She is Gold Medalist in M.Sc (IT) from MDS University Ajmer. She has completed Ph. D (Computer Science) from Banasthali Vidyapith, Jaipur. She is having 13 years experience of Academics and Research. Her area of research is "Patient Authentication and Security measures in Remote Health Monitoring". She has attended many National and International Workshops, Conferences and Published papers in National conference. Her areas of research interest are Machine Learning, Deep Learning, Image Processing, Big Data Analytics and Software Defined Networks etc.

Professor (Dr.) Mahesh M. Bundele has completed his Bachelor’s degree in Electronics and Power in 1986 from Nagpur University and immediately joined as a Lecturer in Electronics at Babasaheb Naik College of Engineering, Pusad, Yavatmal district. He did his Master’s in Electrical Power System and Doctoral in Computer Science & Engineering with a topic “Design and Implementation of Wearable Computing System for the Prevention of Road Accidents” from Amravati University in 1990 and 2013 respectively. He has worked as Lecturer, Assistant Professor, Professor and Head of CSE & IT during 25 Years at BNCOE and guided many research projects at UG and PG level on various applications in Electrical, Electronics & Computer Sciences including city and village Wi-Fi/Wi-Max design up to 195 villages. He has worked on various govt. and industry research projects. He was also appointed as Principal of Babasaheb Naik College of Engineering, Pusad from March 2011. He has worked in various capacities such as, member Board of Studies, Chief-Valuation officer etc. at University level. He has also worked for getting ISI to Krishak Motor pumps at Amravati. He has visited US, UK, China and Malaysia for research presentations. He has published more than 50 research papers in National and International conferences and journals. He is senior member of IEEE, Life member of ISTE and IEI and the member of ACM. Presently he is working as Member, STDCOM Technical & Professional Activities, and Member Execom, IEEE Delhi Section & Secretary, IEEE Rajasthan Subsection. He is having total 34 years of teaching including 7 years of research and internship. Presently he is working as Principal & Director, Poornima College Engineering, Jaipur, India. He has also worked Dean (R&D) at Poornima University and Heading Advanced Studies & Research Center dealing Master of Technology programs and Doctoral degree programs of the University. His areas of research interest are Wearable & Pervasive Computing, Software Defined Networks, Wireless Sensor Networks, and Smart Grid Issues etc.

Prof. P. K. Suri, Dean (R & D), Chairman & Professor (CSE/IT/MCA) of HCTM Technical Campus, Kaithal, since Nov. 01, 2012. He obtained his Ph.D degree from Faculty of Engineering, Kurukshetra University, Kurukshetra and Master’s degree from IIT Roorkee(formerly). He started his research carrier from CSIR Research Scholars,AILMS. He worked former as a Dean Faculty of Engineering & Technology, Kurukshetra University, Kurukshetra, Dean Faculty of Science, KUK, Professor & Chairman of Department of Computer Sc. & Applications, KUK. He has approx 40 yrs experience in different universities like KUK, Bharakhtala University Bhopal & Haryana Agricultural university, Hisar. He has supervised 18 Ph.D. students in Computer Science and 06 students are working under his supervision. His students are working as session judge, director & chairpersons of different institute. He has around 150 publications in International/National Journals and Conferences. He is recipient of ‘THE GEORGE OOMAN MEMORIAL PRIZE’ for the year 1991-92 and a RESEARCH AWARD –“The Certificate of Merit – 2000” for the paper entailed ESMD – An Expert System for Medical Diagnosis from INSTITUTION OF ENGINEERS, INDIA. The Board of Directors, governing Board Of editors & publication board of American Biographical institute recognized him with an honorary appointment to Research board of Advisors in 1999.M.P. Council of Science and Technology identified him as one of the expert to act as Judge to evaluate the quality of papers in the fields of Mathematics/Computer Science/ Statistics and their presentations for M. P. Young Scientist award in Nov. 1999 and March 2003. His teaching and research activities include Simulation and Modeling, Software Risk Management, Software Reliability, Software testing & Software Engineering processes, Temporal Databases, Ad hoc Networks, Grid Computing, and Biomechanics.