Study, Modeling and Computing of Pressure Losses in GH2 pipelines

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INTRODUCTION

To minimise the effect of pressure, drop, various factor must be given importance that includes pipeline length, diameter, material surface roughness, friction factor, operating pressure value, volumetric flow rate and hydrogen gas properties. Besides factors that are reason for pressure drop safety precaution such as leakage and safety valves must also be considered as hydrogen is flammable.

In this research work, the pressure drops in a pipeline carrying hydrogen gas is computed by analytical and CFD analysis In addition an experimental set up at lab scale dimension with BeBlue will be developed to validate the results.

ANALYTICAL METHODOLOGY

To calculate the pressure loss, the American Gas Association equation is given by the numerical equation :

$$Q = 0.018 * \left(\frac{Ts}{Ps}\right) * E * 4 * log_{10}\left(\frac{3.7*d}{\varepsilon}\right) * \left(\frac{P_1^2 - P_2^2}{\gamma * L * Tavg * Z}\right)^{0.5} * d^{2,5}$$

PARAMETERS

Friction factor | Reynolds Number | Transmission factor | Gas velocity | Volumetric flow rate | Erosional Velocity | Elevation | Internal surface roughness | Pipe geometry effects | Gas temperature |

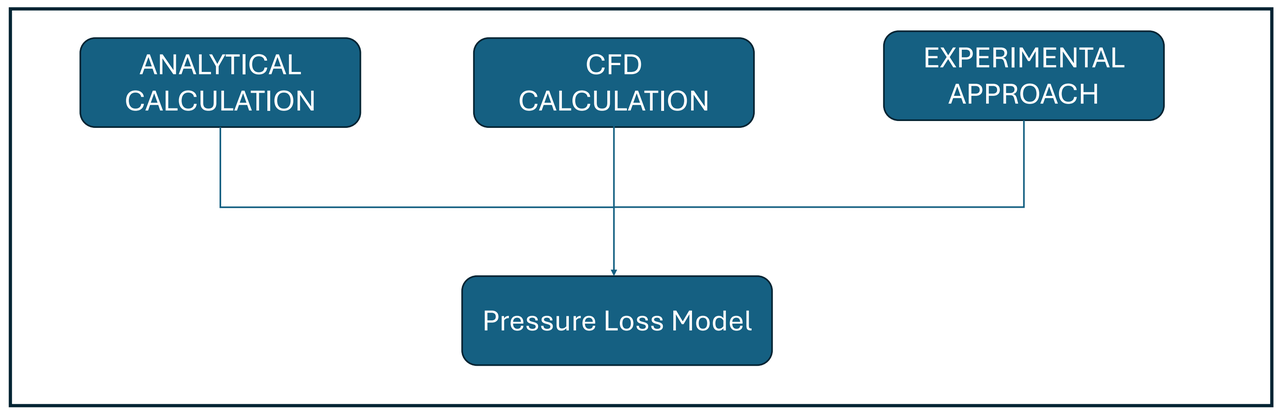
KEY INPUTS

The key inputs considered

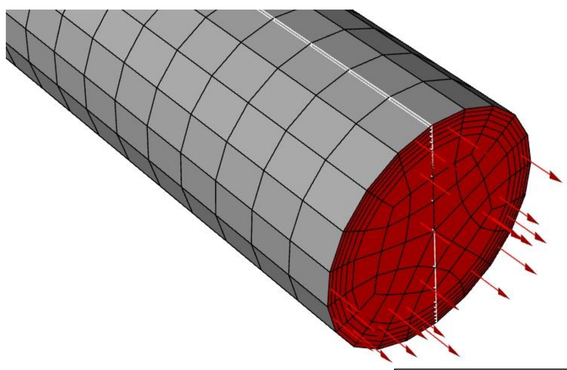
(i) Material selected API-X52:

(ii) Hydrogen gas transportation;

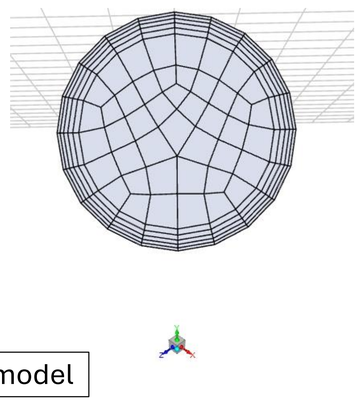
(iii) Properties of material and hydrogen

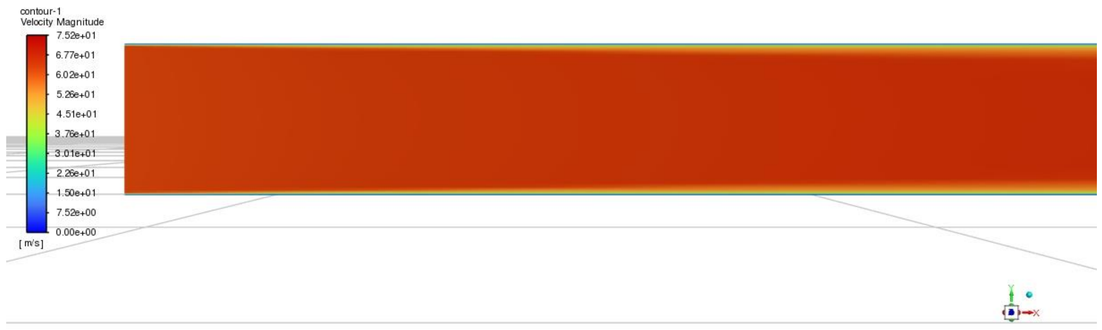


CFD ANALYSIS

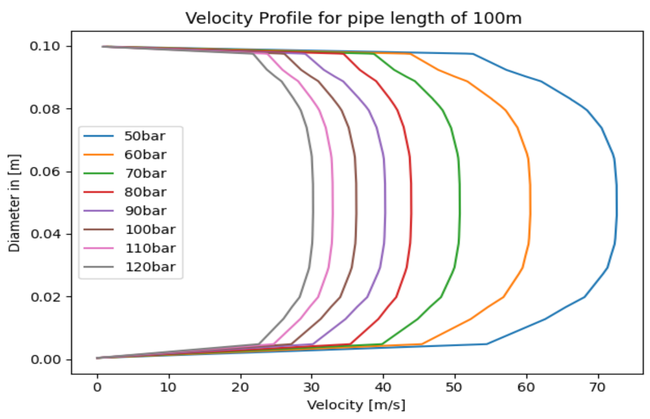


Meshing of pipeline model

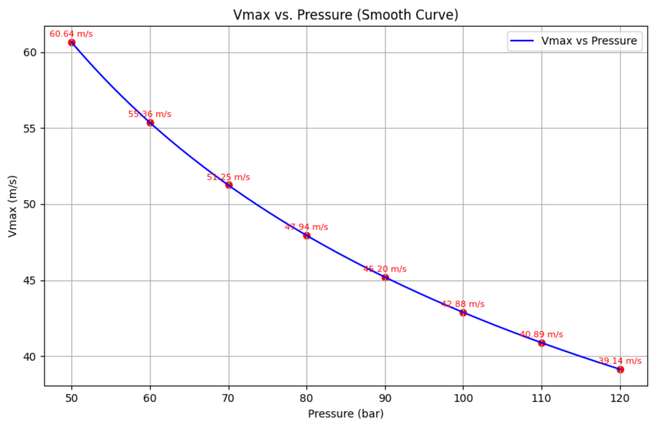




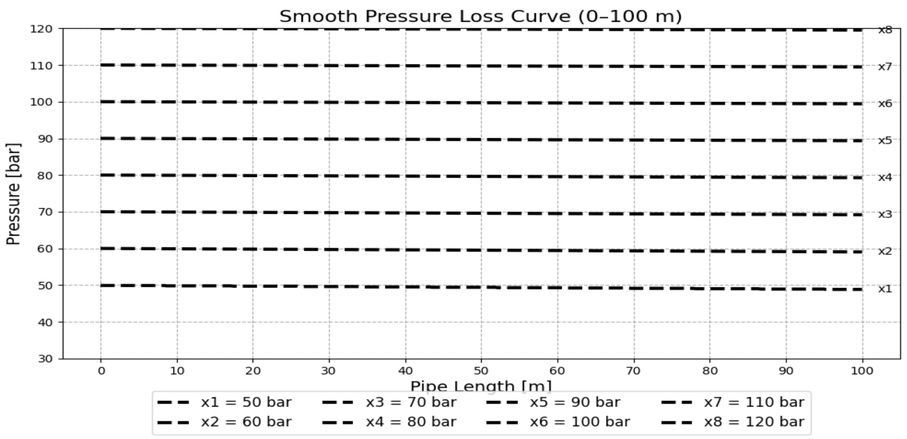
Velocity Contour



Velocity profile for operating pressure 50bar



Erosional velocity



Pressure loss along length of pipe

RESULTS

Initial Pressure P_1 [bar]	Velocity [m/s]		Pressure Loss Δ_p	
	CFD	Analytical	CFD	Analytical
50	63.32	73.72	1.15	0.50
120	26.63	30.46	0.48	0.20

SUMMARY and FUTURE WORK

This work aids understanding of pressure loss in hydrogen pipelines, combining numerical analysis CFD and experimental approaches. It develops an accredited pressure-loss model (AGA), offering significant insight into flow physics in compressible gas in high-velocity systems (30-40-50m/s).

Further applying Large Eddy Simulation (LES) turbulent phenomena and compare RANS vs. LES predictions to refine models and reduce uncertainties. To Perform parametric studies (modify roughness, diameter, flow rate, pressure) to enhance the predictive capability of the pressure-loss model. Long-term effects of gas flow on the internal pipe wall (erosion, hydrogen attack...).

Refrences

- Computational Fluid Dynamic Modeling of Methane-Hydrogen Mixture Transportation in Pipelines: Understanding the Effects of Pipe Roughness, Pipe Diameter and Pipe Bends
- Thermodynamic analysis of hydrogen pipeline transportation – selected aspects
- Assessing the pressure losses during hydrogen transport in the current natural gas infrastructure using numerical modelling