PROJECT REPORT

"CFD Simulation of Valve Leakage and Pressure Retention Using SolidWorks Flow Simulation

Submitted by: ARJUN

Course: B.TECH Mechanical engineering

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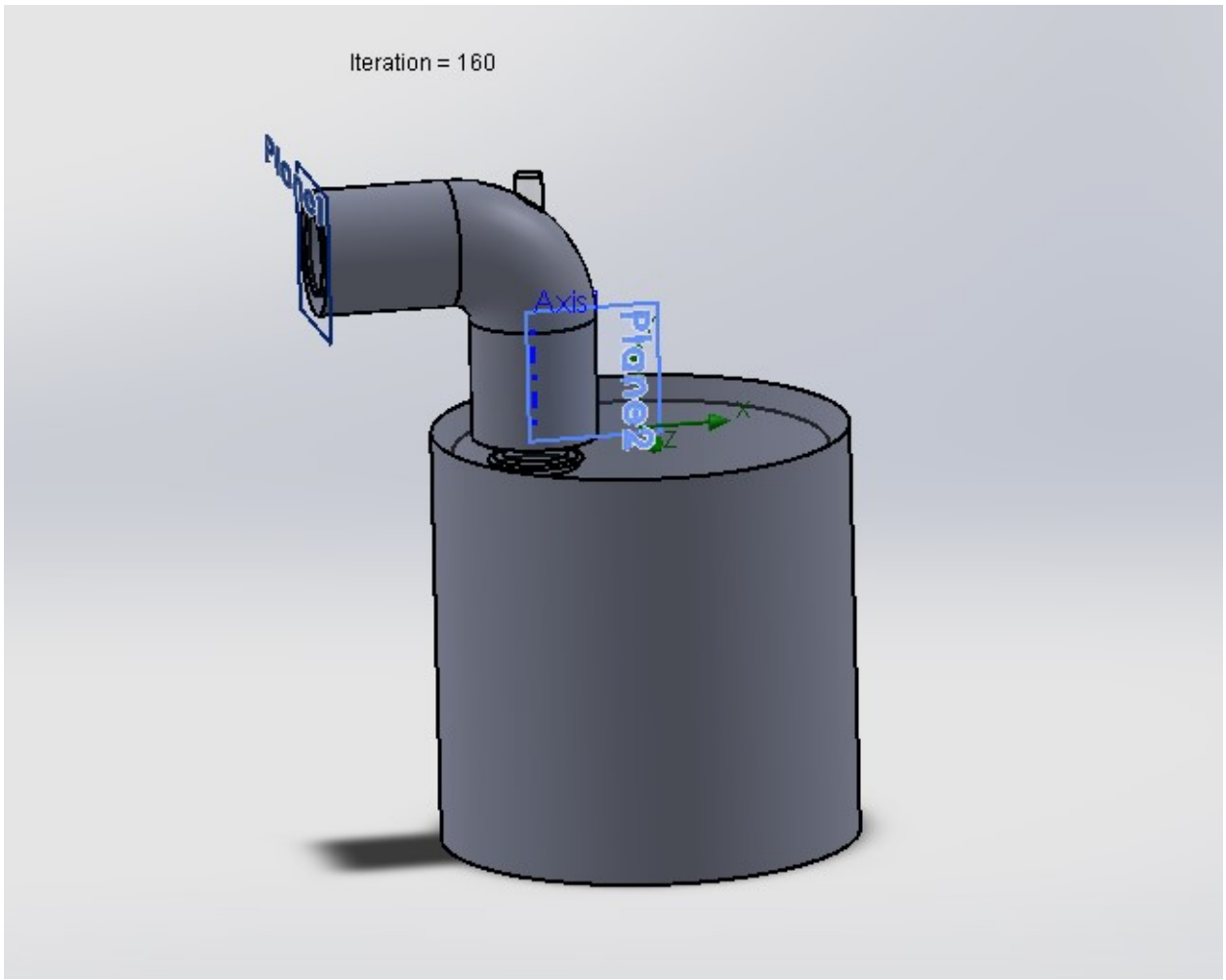
Software Used: SolidWorks Flow Simulation



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Objective:

To analyze air leakage through a valve using CFD simulation and evaluate pressure loss and mass flow rate, validating the valve's effectiveness in retaining pressure.

Problem Description:

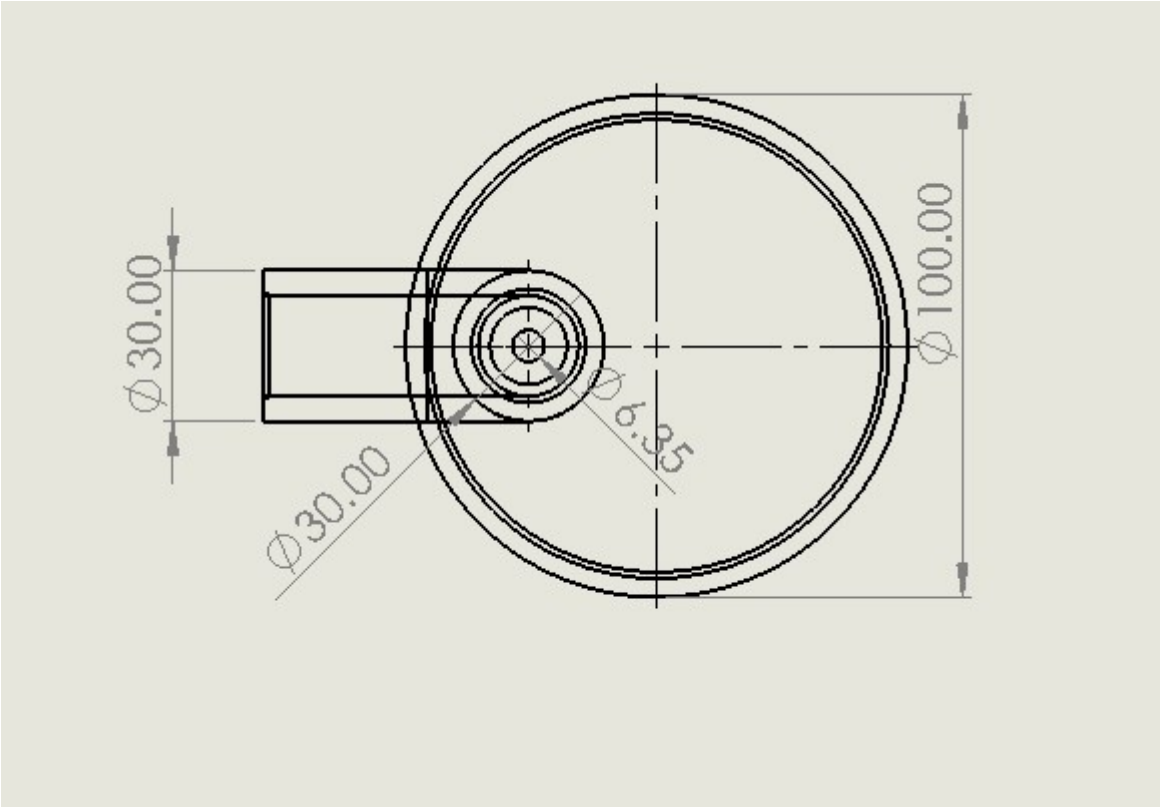
A **steady inlet pressure of 600,000 Pa** is applied to a sealed cylindrical chamber through an inlet. A valve is placed at the outlet end of the chamber to **restrict or block the flow**. However, a small amount of **leakage occurs past the valve**. The objective of this analysis is to:

✅**Determine the pressure retained** behind the valve (i.e., how much pressure is effectively held back).

✅**Quantify the mass flow leakage rate** through the valve.

✅**Evaluate the valve's effectiveness** in sealing the chamber by measuring the leakage performance.

. CAD Model Overview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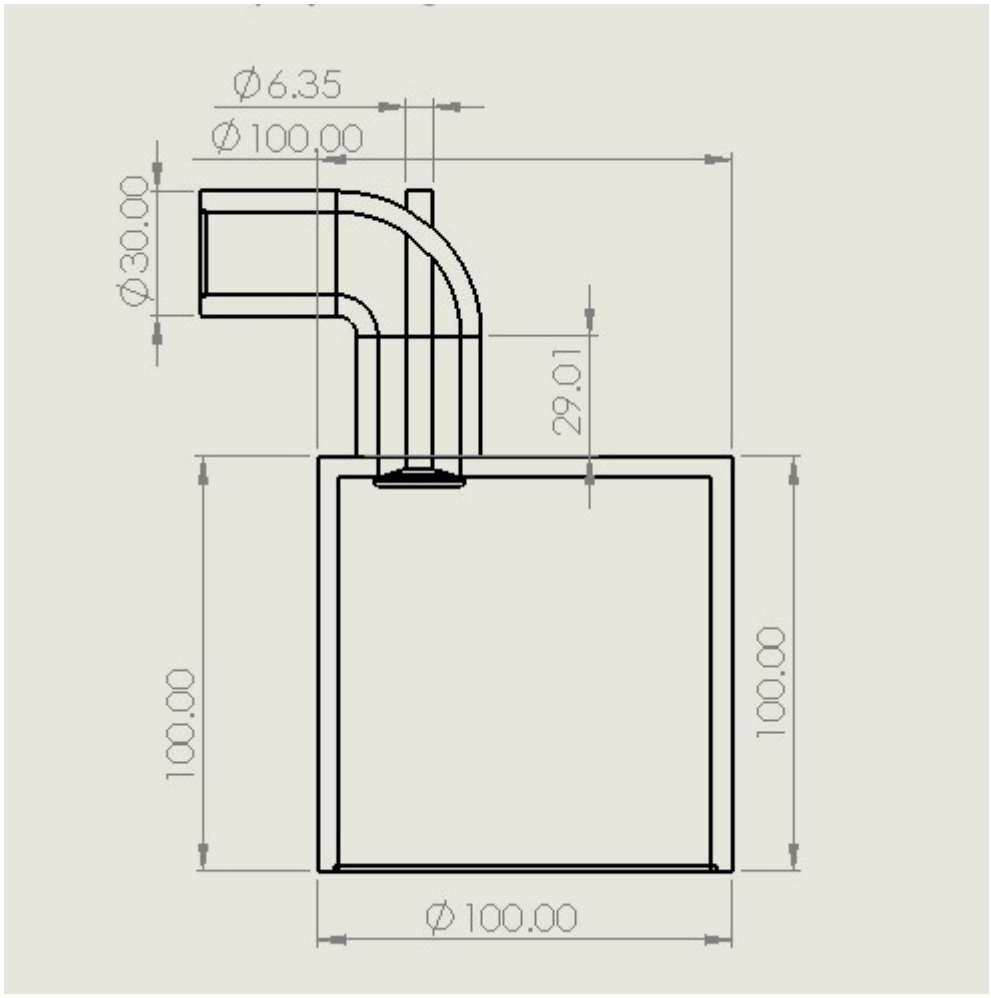
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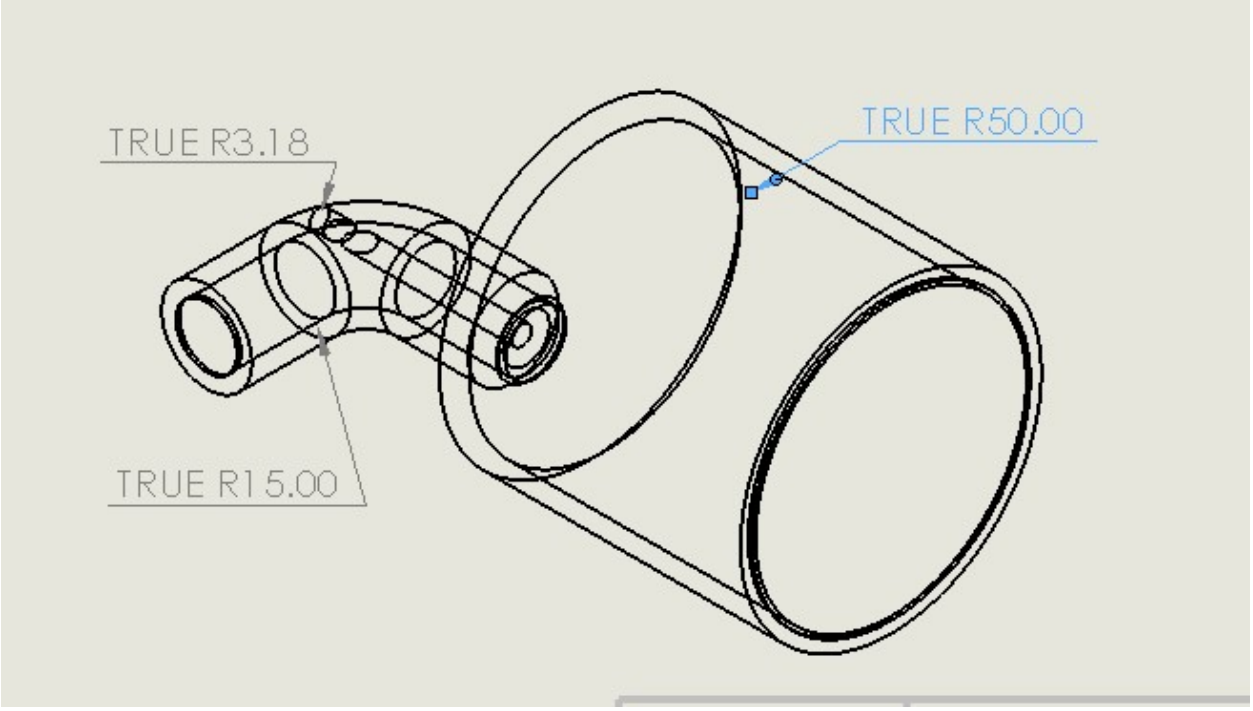


Simulation Setup

- **Type:** Internal Flow (Steady-State)
- **Fluid:** Air (Ideal Gas)
- **Inlet Boundary Condition:** Total Pressure = 600000 Pa, Temperature = 293.2 K
- **Outlet Boundary Condition:** Static Pressure = 0.001 Pa, Temperature = 293.2 K

Goal Name	Quantity	Unit	Averaged Value	Min Value	Max Value	Progress (%)	Remarks
SG1	Avg. Static Pressure (Inlet)	Pa	535,726.80	494,162.45	586,079.98	100	Fully Converged
SG2	Mass Flow Rate (Inlet)	kg/s	0.0352	-0.1787	0.1148	80	Nearing Convergence
SG3	Volume Flow Rate (Inlet)	m^3/s	0.0096	-0.0142	0.0162	100	Fully Converged
SG4	Avg.	Pa	12,657.51	547.27	16,692.44	9	Not

	Static Pressure (Outlet)						Converged
SG5	Mass Flow Rate (Outlet)	kg/s	-0.1525	-0.2248	-0.1284	32	Needs Mesh Refinement
SG6	Volume Flow Rate (Outlet)	m³/s	-21,143.4921	-438,323.5008	287.4781	52	Likely Numerical Instability

Results and Analysis

1. Pressure Loss Calculation

The average static pressure at the inlet was recorded as 535,726.80 Pa and at the outlet as 12,657.51 Pa. The pressure loss across the valve due to leakage can be calculated as:

Pressure Loss = Inlet Pressure - Outlet Pressure

Pressure Loss = 535,726.80 Pa - 12,657.51 Pa = 523,069.29 Pa

This pressure loss indicates the extent to which the valve is able to retain pressure inside the cylinder.

2. Pressure Retention by Valve

To evaluate how effective the valve is at retaining pressure, the percentage of retained pressure was calculated:

Pressure Retention (%) = [(P_inlet - P_loss) / P_inlet] × 100

= [(600000 - 523069.29) / 600000] × 100 ≈ 97.63%

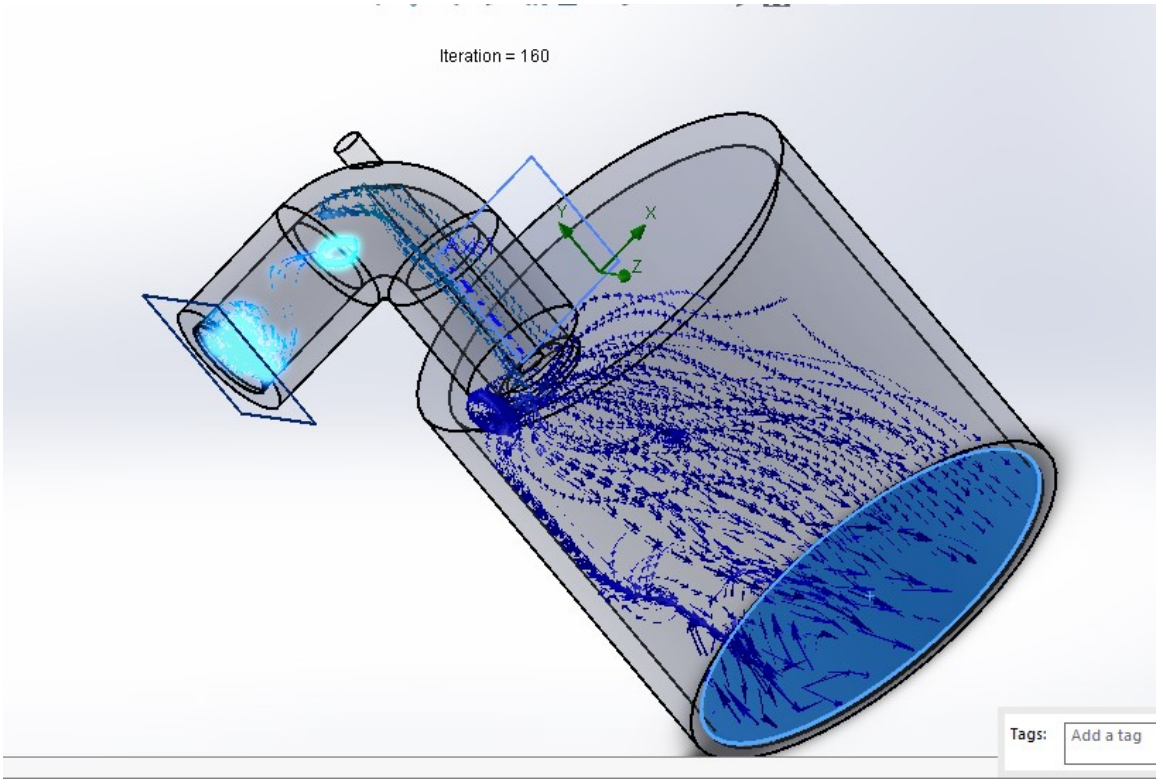
This shows that approximately 97.63% of the pressure is retained, confirming the valve's effectiveness.

3. Mass Flow Rate through Leakage

The simulation recorded a mass flow rate through the leakage path as -0.1525 kg/s at the outlet. A negative sign indicates flow direction opposite to the reference direction. This value represents the amount of air escaping through the valve's gap.

4. Interpretation of Results

- The valve retains most of the pressure, showing effective sealing.
- The small but measurable mass leakage rate confirms a realistic leakage scenario.



Conclusion

The CFD simulation successfully demonstrates that the valve is highly effective in maintaining internal chamber pressure under the given operating conditions. The valve retains approximately **97.63%** of the inlet pressure, with a calculated pressure loss of **523,069.29 Pa**, indicating strong sealing capability. The observed mass flow leakage rate of **0.1525 kg/s** confirms that although there is some leakage through the small gap, it remains within a controlled and measurable range.

The simulation goals associated with the **inlet boundary condition** showed excellent convergence, providing confidence in the accuracy of inlet-side data. However, outlet-related goals displayed partial convergence.

Project Summary

As part of my mechanical engineering project, I modeled a sealed cylindrical chamber with a valve in SolidWorks and performed CFD analysis using Flow Simulation. The objective was to evaluate pressure loss and mass flow leakage through a small gap in the valve. I defined proper boundary conditions (inlet total pressure of 600,000 Pa and outlet static pressure of 0.001 Pa), refined the mesh near the leakage zone, and monitored goals to evaluate pressure and mass flow rate. The simulation showed that the valve retained approximately **97.63%** of the pressure, confirming effective sealing. I also interpreted convergence data and identified improvement areas, such as outlet mesh refinement. This project enhanced my understanding of internal flow behavior, pressure dynamics, and boundary condition handling in CFD.