CHAPTER 1

INTRODUCTION

Three Piece Ball Valve consist of three pieces: two end caps and a body. All the three pieces are generally clamped together by bolt connections. The three-piece design allows for the center part of the valve containing the ball, stem & seats to be easily removed from the pipeline.

1.1 Background of the Mini Project

- The Problem statement for the mini project (DESIGN OF THREE PIECE BALL VALVE AND ANALYZE FOR ANY LEAKAGE (3/4 INCH, FLANGED, CLASS 300)) was provided by Caliper Engineering and Lab Pvt. Ltd.
- Three Piece Ball Valve is preferred because it is a component which can be easily disassembled for maintenance, repair etc.
- The required documents and information for the mini project was gathered from different sources.

1.2 Application of the Product

- Three Piece Ball valves uses a metal ball with a hole bored through the centre, sandwiched between two seats to control flow. Used in many hydrocarbon process applications, ball valves are capable of throttling gases and vapours and are especially useful for low-flow situations.
- They are used for various purposes throughout the oil and gas industry. For upstream applications, they control the flow of oil. For the midstream, they protect equipment by controlling the flow of gas and oil. For the downstream, they are used for refining crude oil.
- Ball valve is the most used fluid shutoff valve in upstream oil and gas production facilities, both onshore and offshore. They are also used in fuel gas systems feeding furnaces.

CHAPTER 2

METHODOLOGY

A 3-way ball valve works by turning the handle, which rotates a ball in the valve body, to align the cut-out channels in the ball with the inlets and outlets of the valve. The cut-out on the ball lets the fluid to flow through the pipes.

2.1 Process

- The problem statement given: - "DESIGN OF THREE PIECE BALL VALVE AND ANALYZE FOR ANY LEAKAGE (3/4 INCH, FLANGED, CLASS 300)".
- The above problem statement was discussed and analyzed to gather the requirements.
- Using the ASME (The American Society of Mechanical Engineers) standard dimensions for the dimensional sketch of the Parts of the 3 piece ball valve.
- Using the SOLIDWORKS software the modeling of the parts and assembly of the parts was achieved.
- The leakage analysis was done through SOLIDWORKS FLOW SIMULATION.
- After several improvements of the model according to the suggestions provided by the project guide the final approved model was successfully built.
- The result of the leakage analysis was in favour to our requirements that is no leakage was detected.
- The model of 3 piece ball valve was successfully built.

2.2 Flowchart

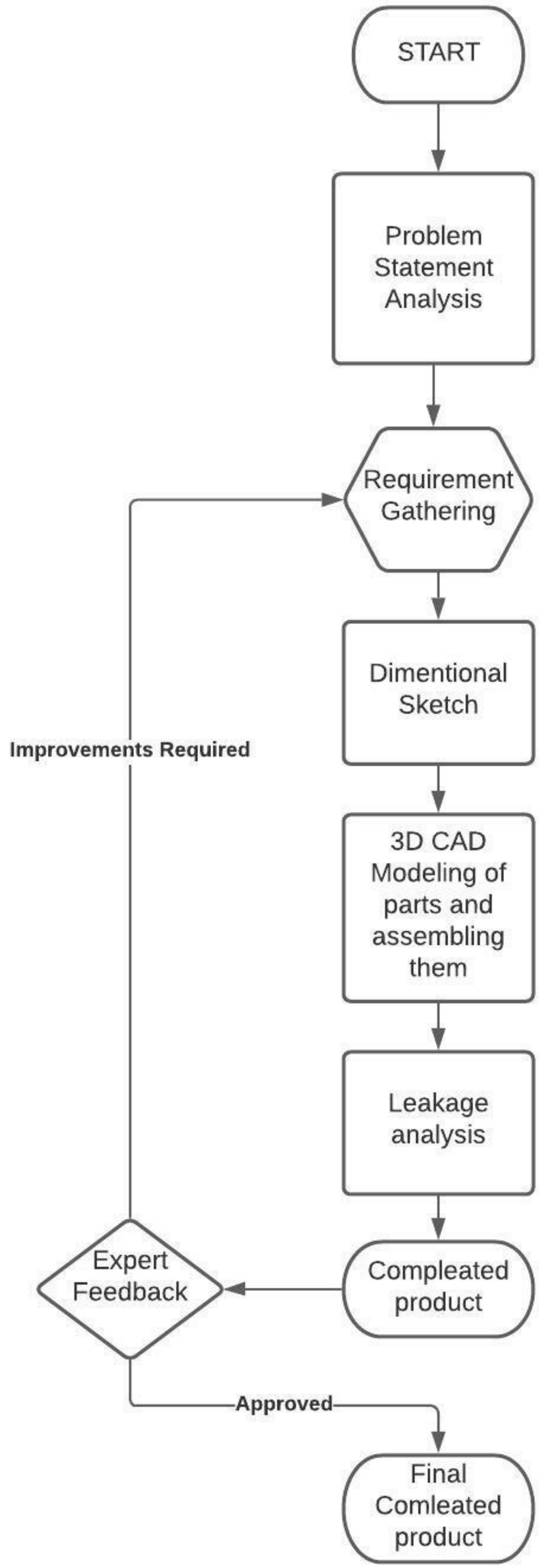

Fig. 2.1: Flowchart of the Process

2.3 Material Specifications

Table 1: Material Specifications

ITEM NO.	PART NUMBER	MATERIAL	QTY.
1	Body	Carbon Steel (ASTM A105) or (PTFE)	1
2	Flange ends	Carbon Steel (ASTM A105) or (PTFE)	2
3	Bolt 1	Carbon Steel	4
4	Nut 1	Carbon Steel	4
5	Ball	Carbon Steel (AISI 304)	1
6	Valve ring	Carbon Steel (ASTM A105) or (PTFE)	2
7	Valve seat	Carbon Steel (ASTM A105) or (PTFE)	1
8	Washer	Carbon Steel (AISI 304)	1
9	Valve pin	Carbon Steel	1
10	Handle	Stainless Steel	1
11	nut 2	Carbon Steel	1
12	Bolt 2	Carbon Steel	1
13	LID1	Carbon Steel (ASTM A105) or (PTFE)	1
14	LID2	Carbon Steel (ASTM A105) or (PTFE)	1

- Carbon Steel ASTM A105 (also known as ASME SA 105) covers seamless steel piping components for use in pressure systems at ambient and high-temperature service.
- Carbon steel is an iron-carbon alloy, which contains up to 2.1 wt. % carbon. For carbon steels, there is no minimum specified content of other alloying elements; however, they often contain manganese. The maximum manganese, silicon and copper content should be less than 1.65 wt.
- Carbon Steel AISI 304 typically contains 17.5-19.5% chromium, 8-10.5% nickel, 2% manganese, 1% silicon, 0.11% nitrogen, 0.07% carbon, 0.05% phosphorus, and 0.03% sulphur.
- Stainless steels are steels containing at least 10.5% chromium, less than 1.2% carbon and other alloying elements. Stainless steel's corrosion resistance and mechanical properties can be further enhanced by adding other elements, such as nickel, molybdenum, titanium, niobium, manganese, etc.

2.4 2-Dimensional sketches of parts

2.4.1 Valve Body

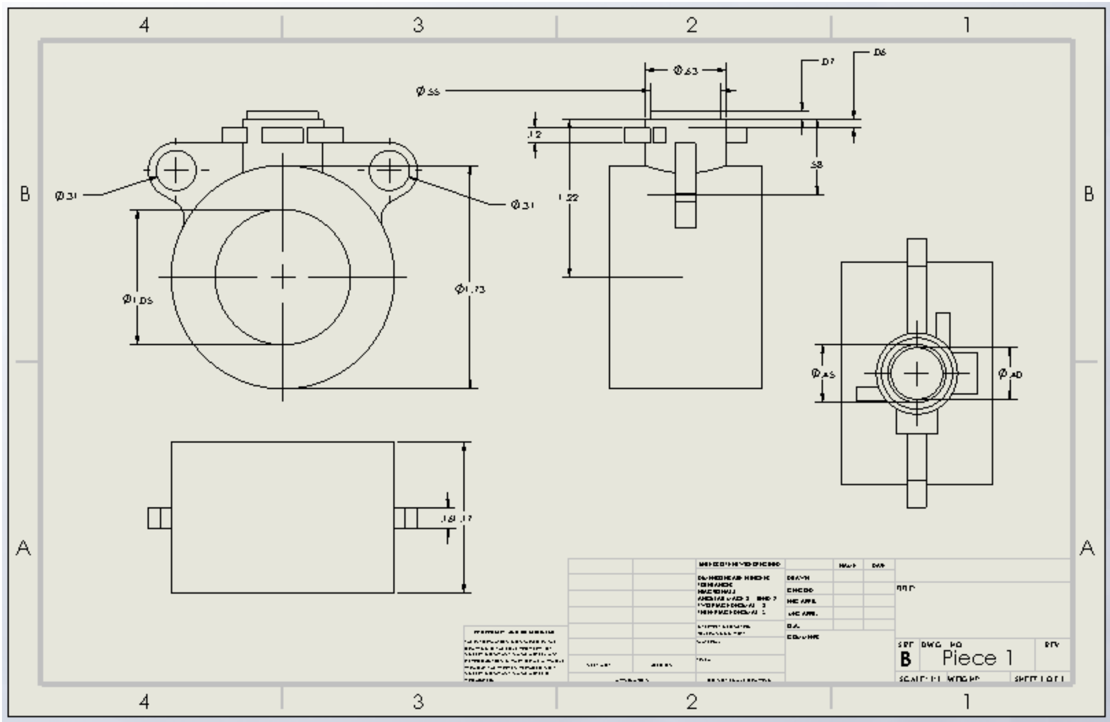

Fig. 2.2: 2-Dimensional Sketch of Valve Body

2.4.2 Flange Ends

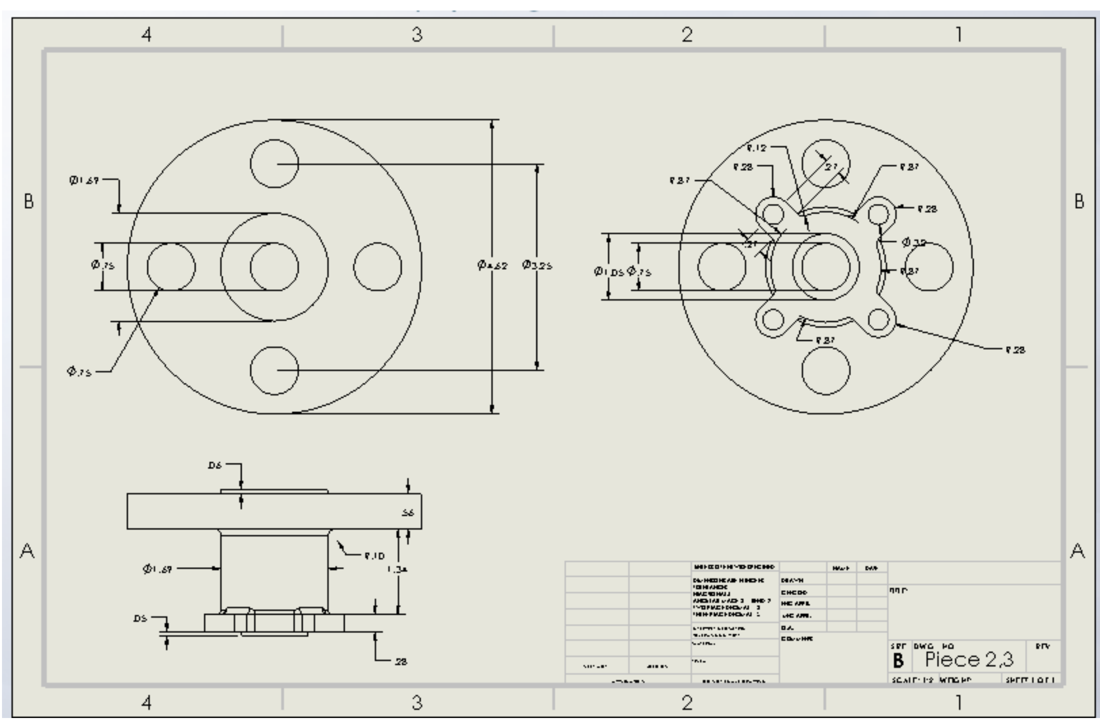

Fig. 2.3: 2-Dimensional Sketch of Flange Ends

2.4.3 Ball

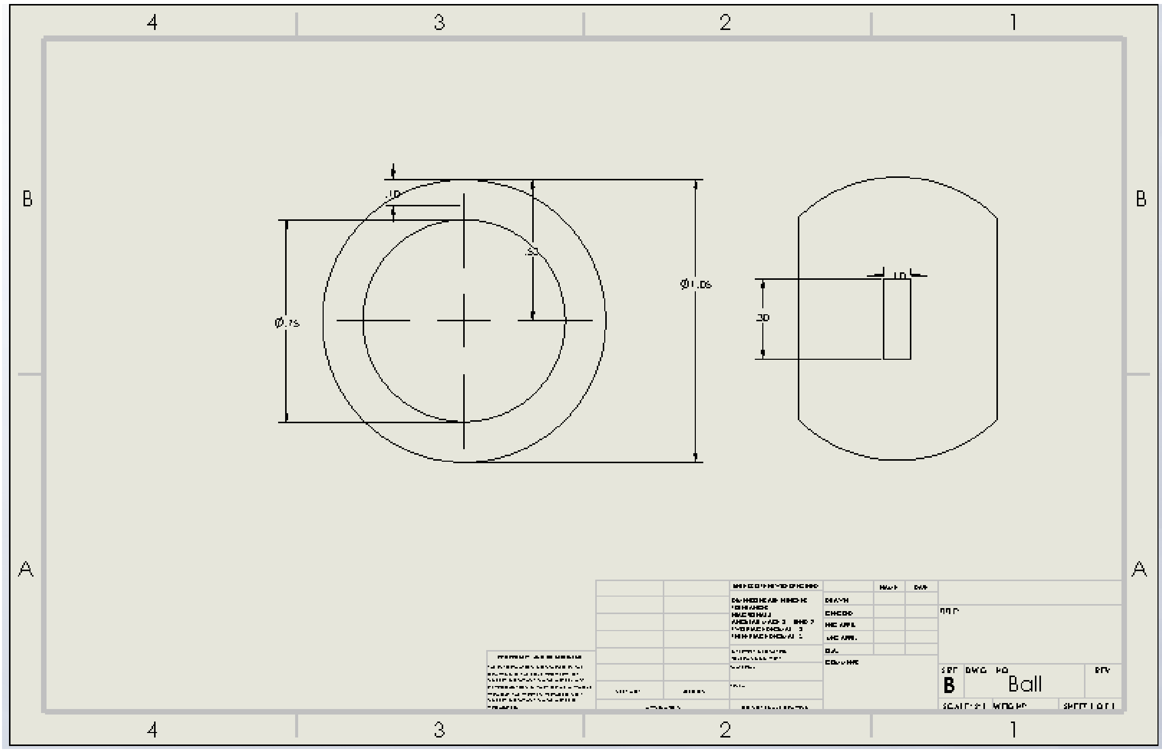

Fig. 2.4: 2-Dimensional Sketch of Ball

2.4.4 Handle

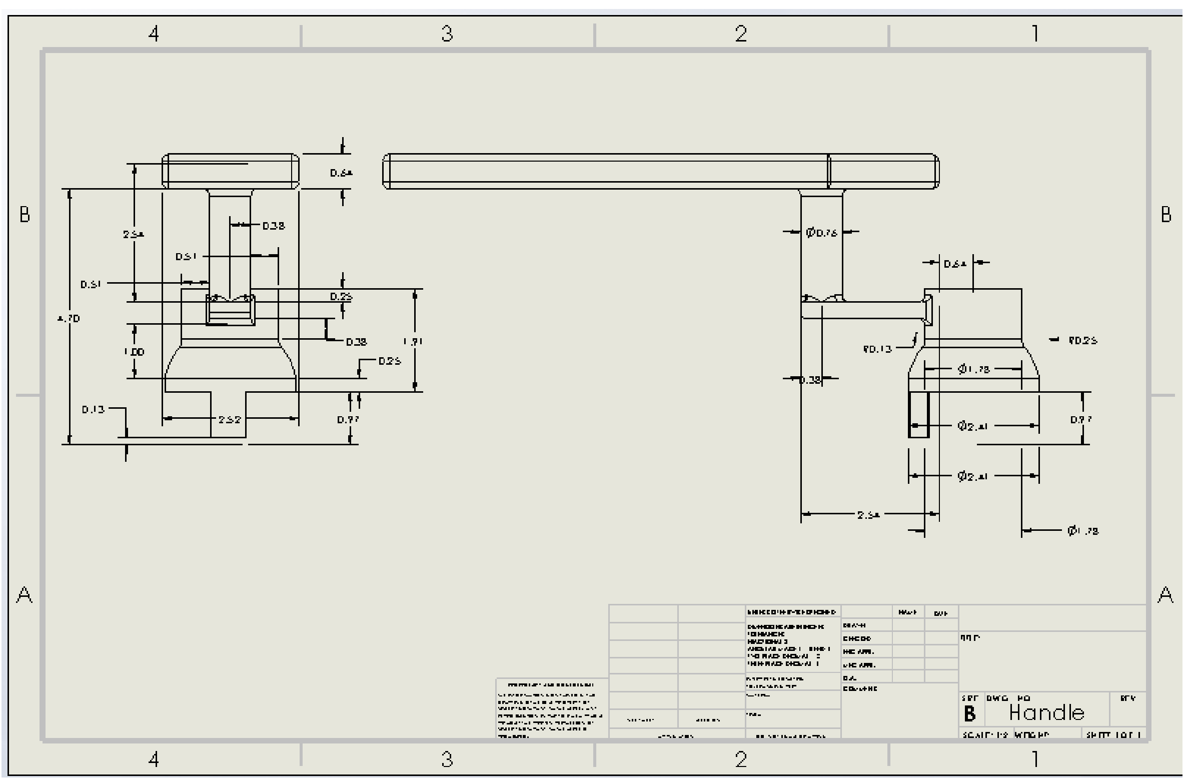

Fig. 2.5: 2-Dimensional Sketch of Handle

2.4.5 Washer, Seat, Ring and Ball pin

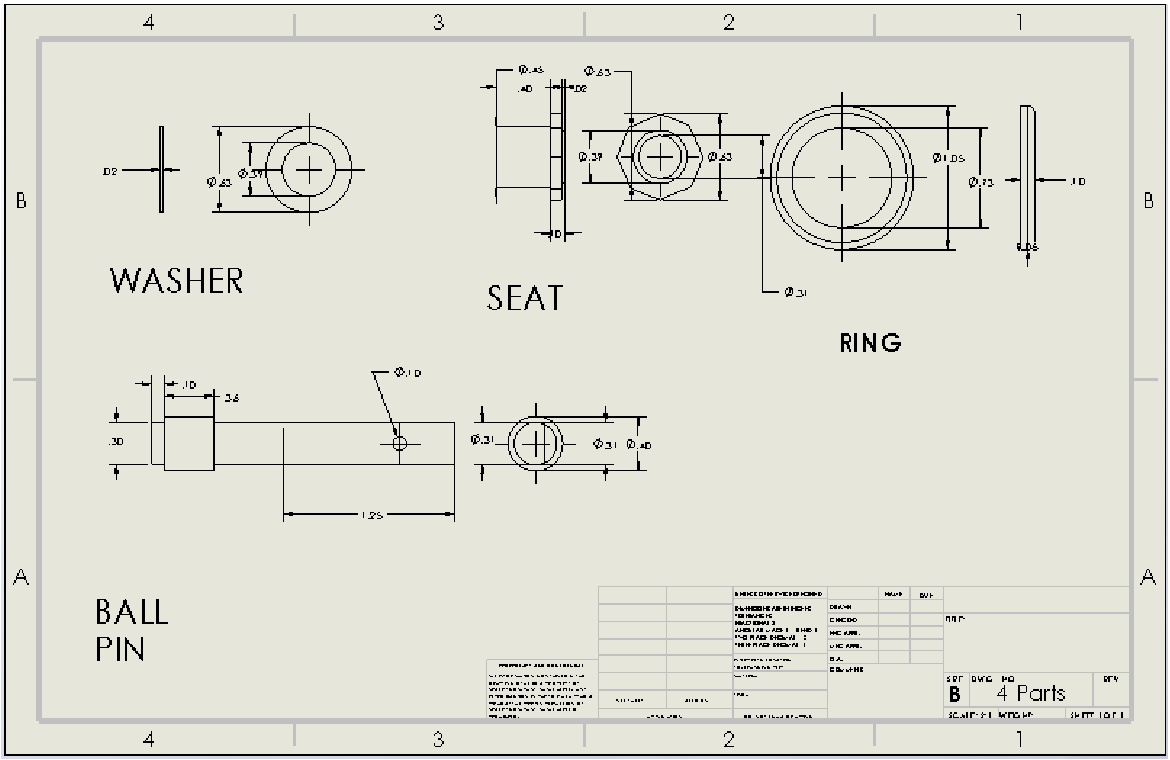

Fig. 2.6: 2-Dimensional Sketch of Washer, Seat, Ring and Ball Pin

2.4.6 Nuts and Bolts

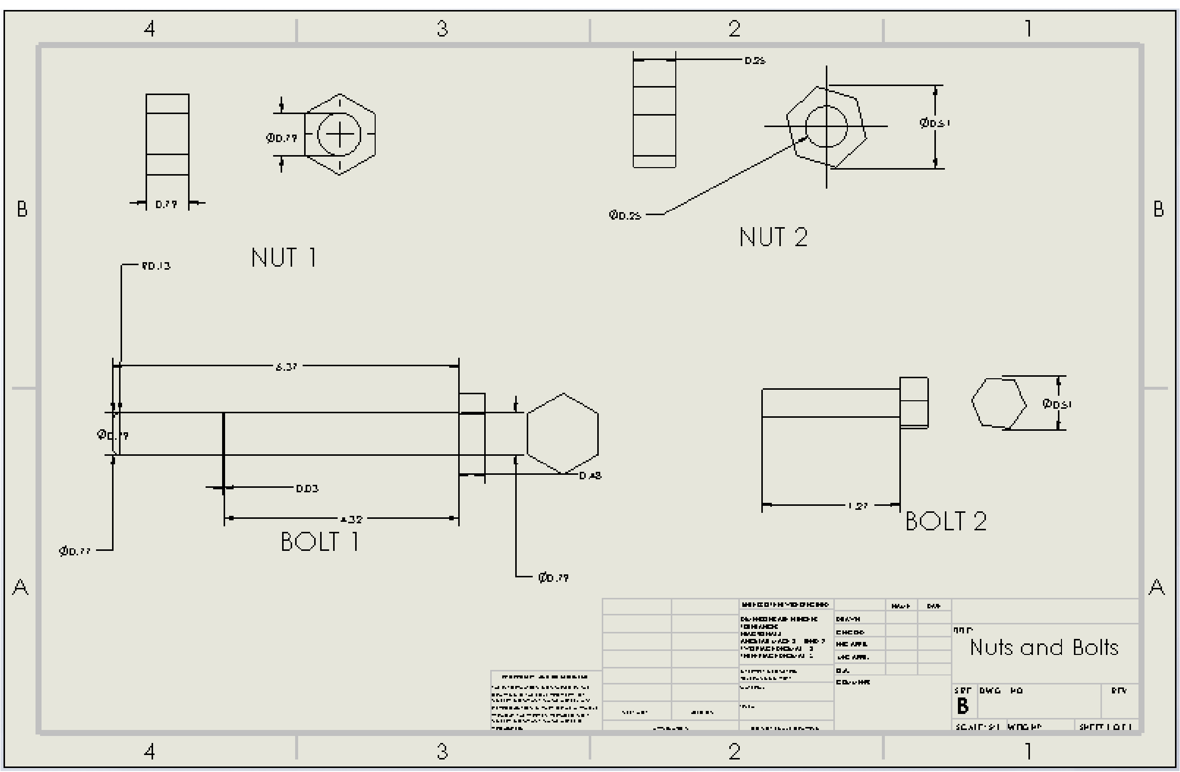

Fig. 2.7: 2-Dimensional Sketch of Nuts and Bolts

2.5 2-Dimensional Sketch of Assembly

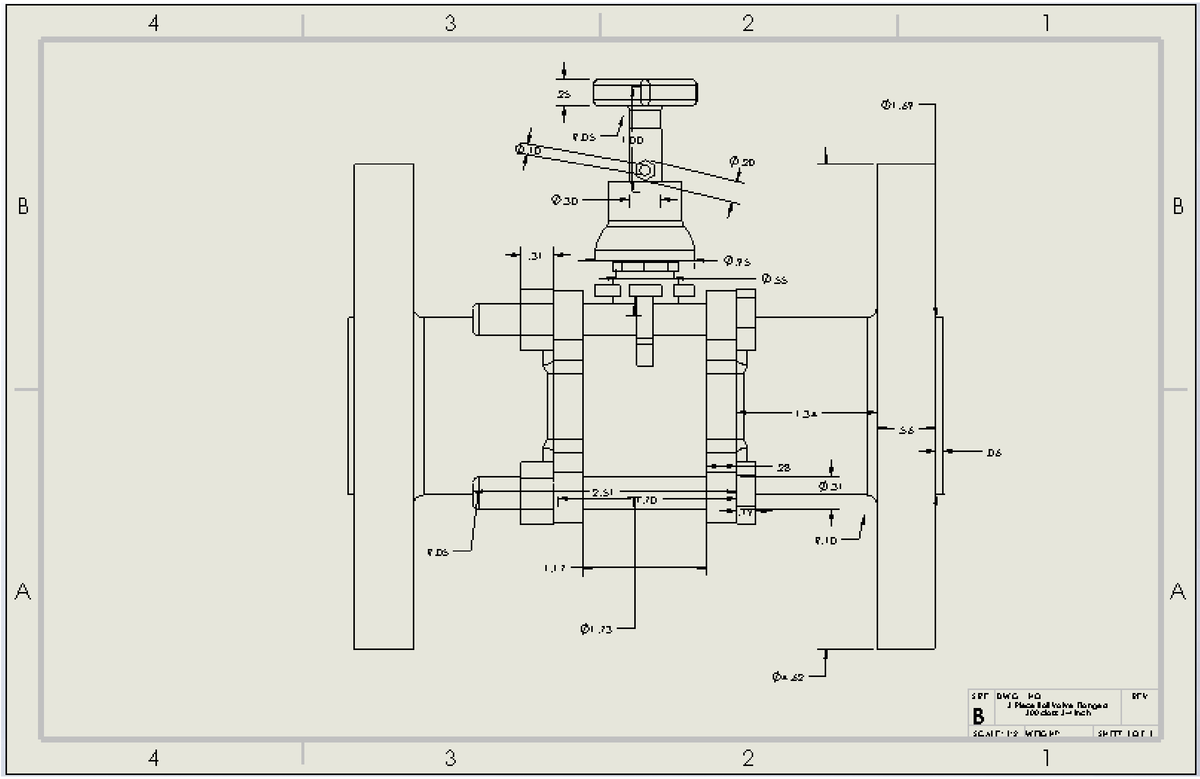

Fig. 2.8: 2-Dimensional Sketch of Assembly (Front View)

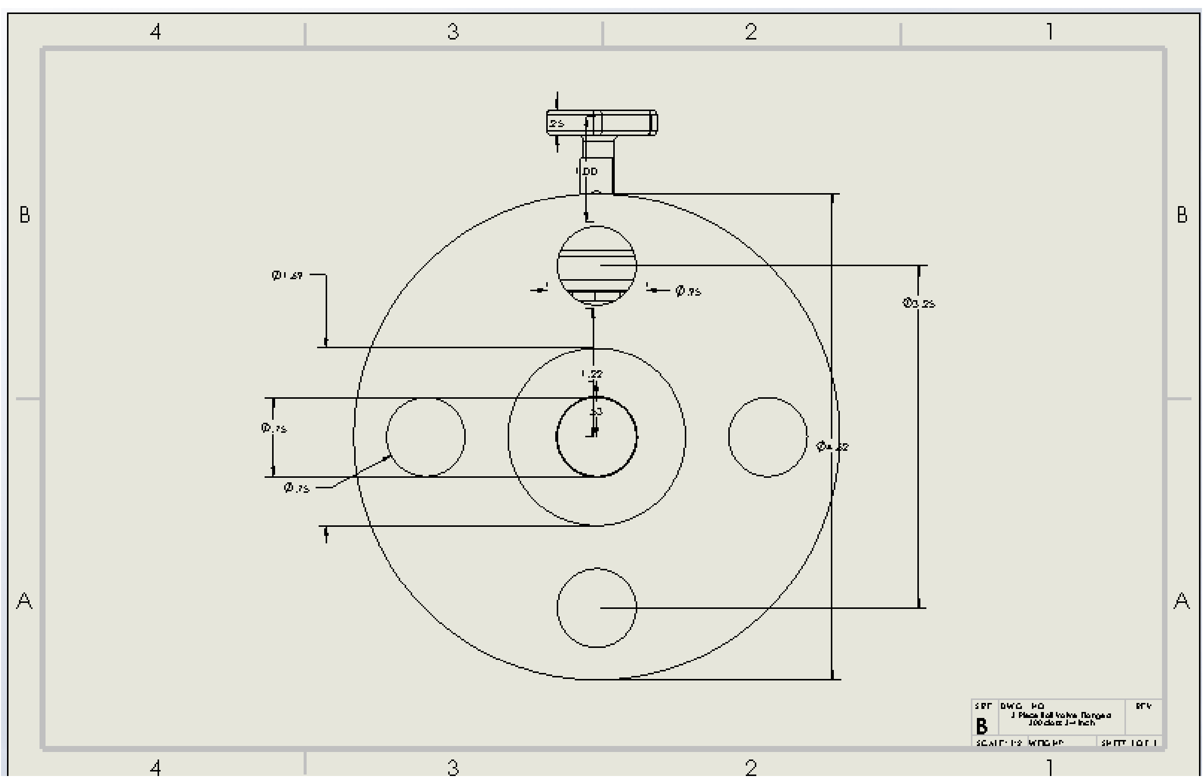

Fig. 2.9: 2-Dimensional Sketch of assembly (Side view)

2.6 3-Dimensional sketches of parts

2.6.1 Valve Body

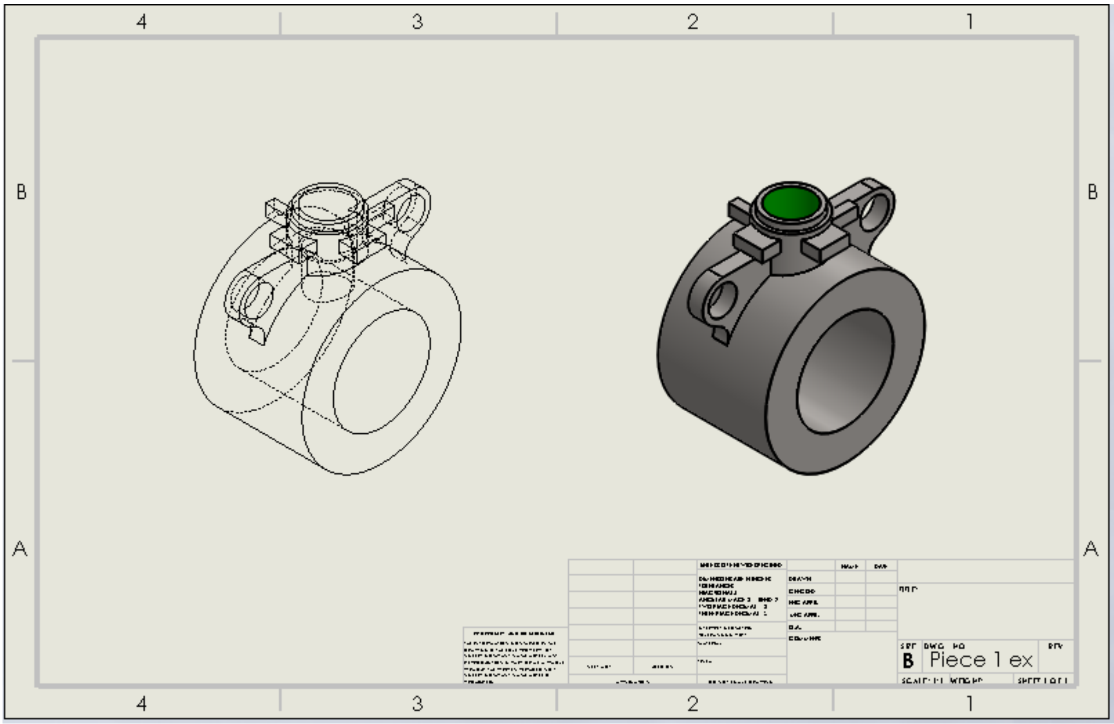

Fig. 2.10: 3-Dimensional Sketch of Valve Body

2.6.2 Flange Ends

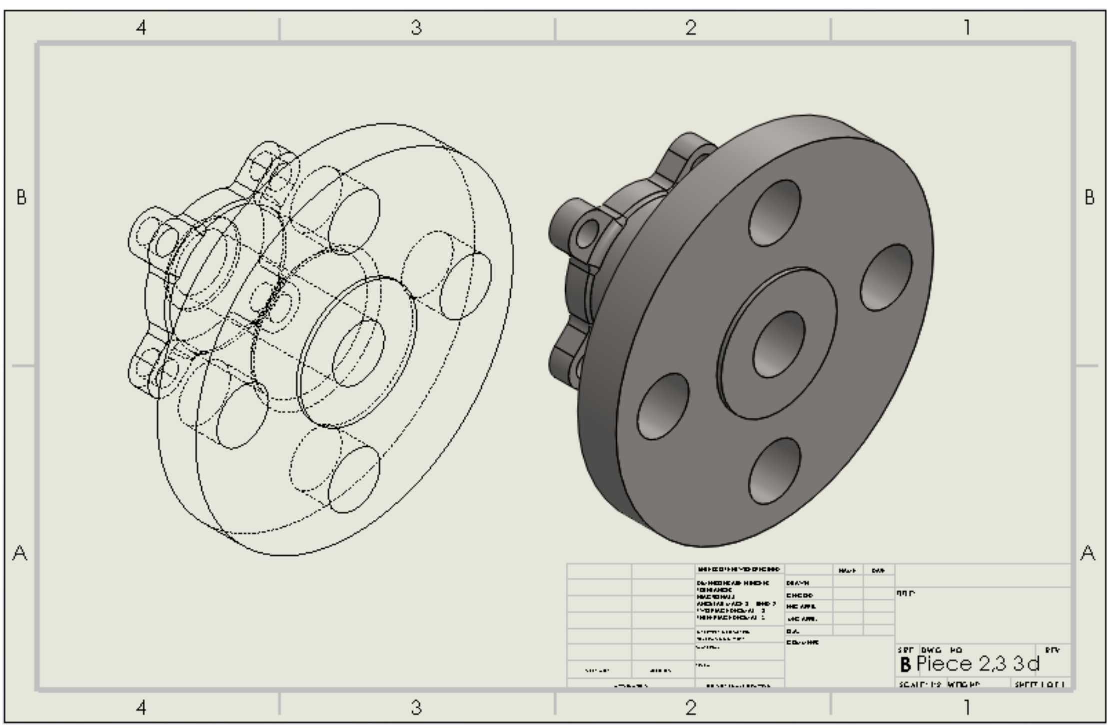

Fig. 2.11: 3-Dimensional Sketch of Flange Ends

2.6.3 Ball

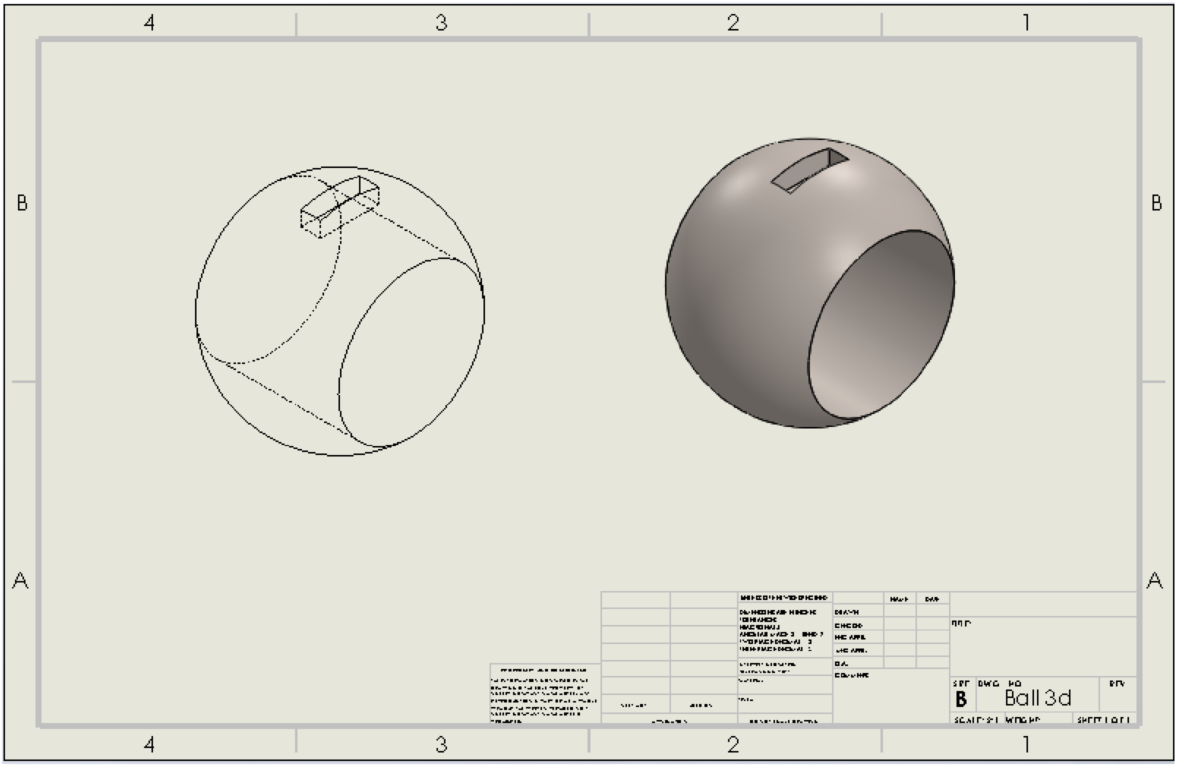

Fig. 2.12: 3-Dimensional Sketch of Ball

2.6.4 Handle

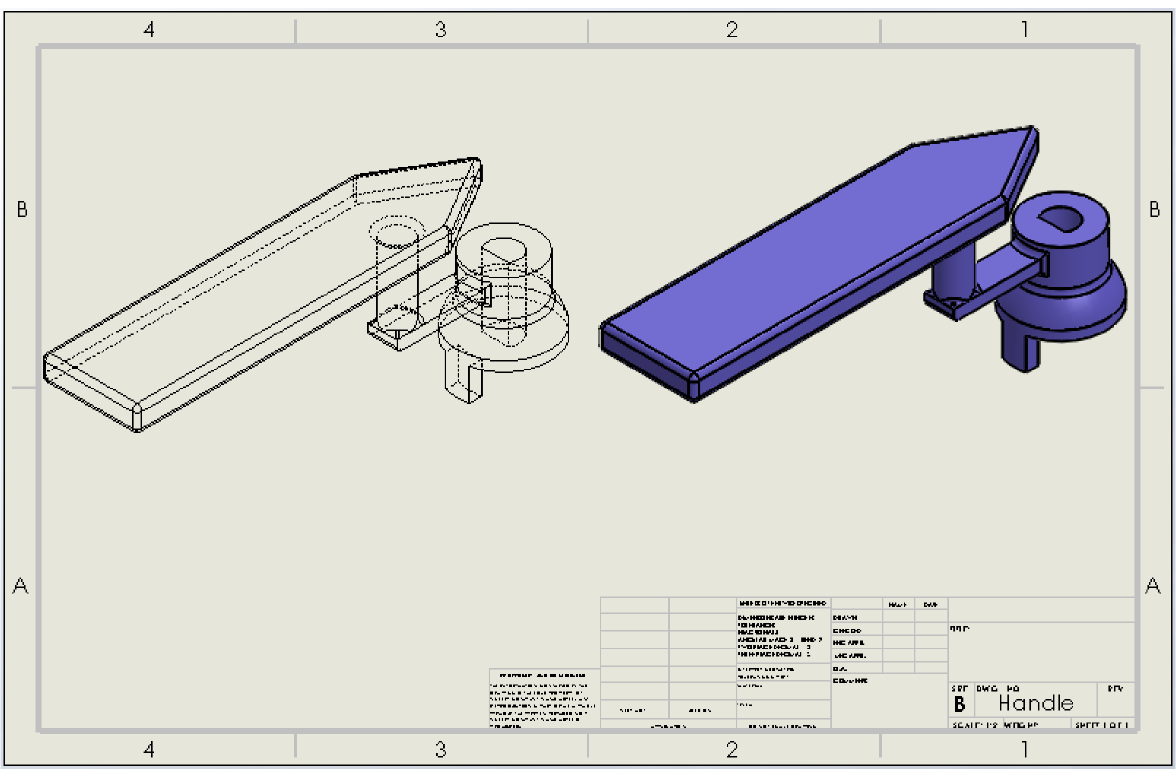

Fig. 2.13: 3-Dimensional Sketch of Handle

2.6.5 Washer, Seat, Ring and Ball pin

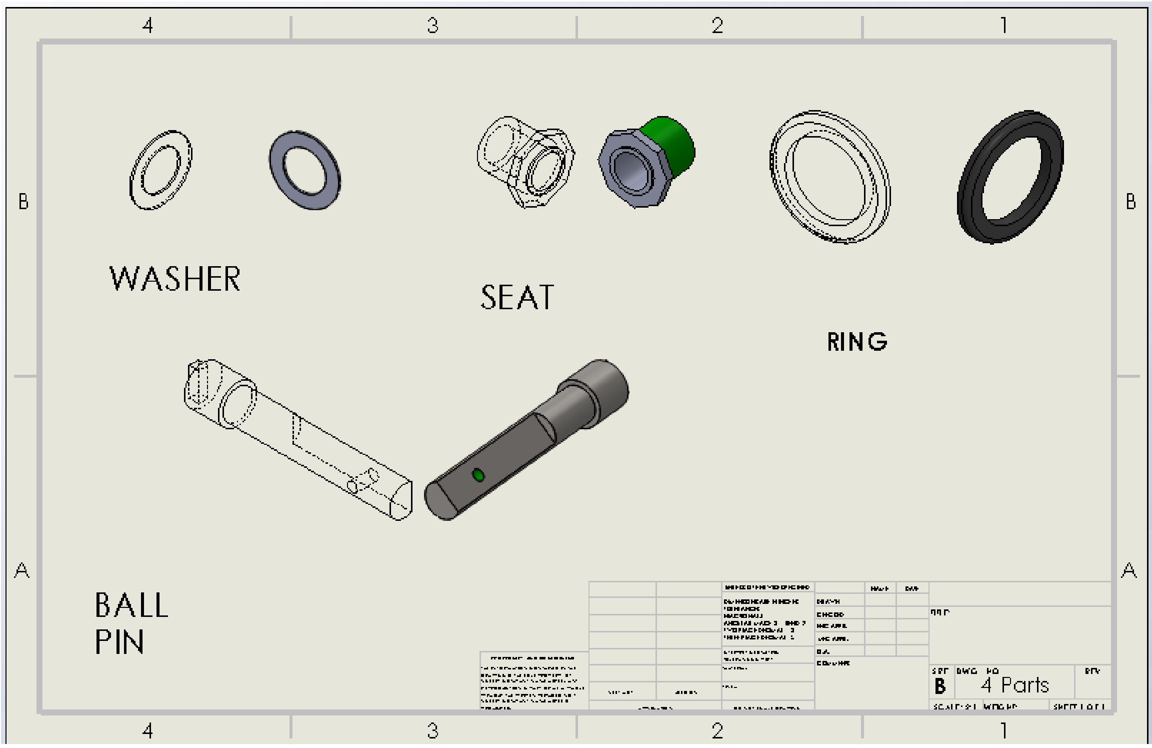

Fig. 2.14: 3-Dimensional Sketch of Washer, Seat, Ring and Ball Pin

2.6.6 Nuts and Bolts

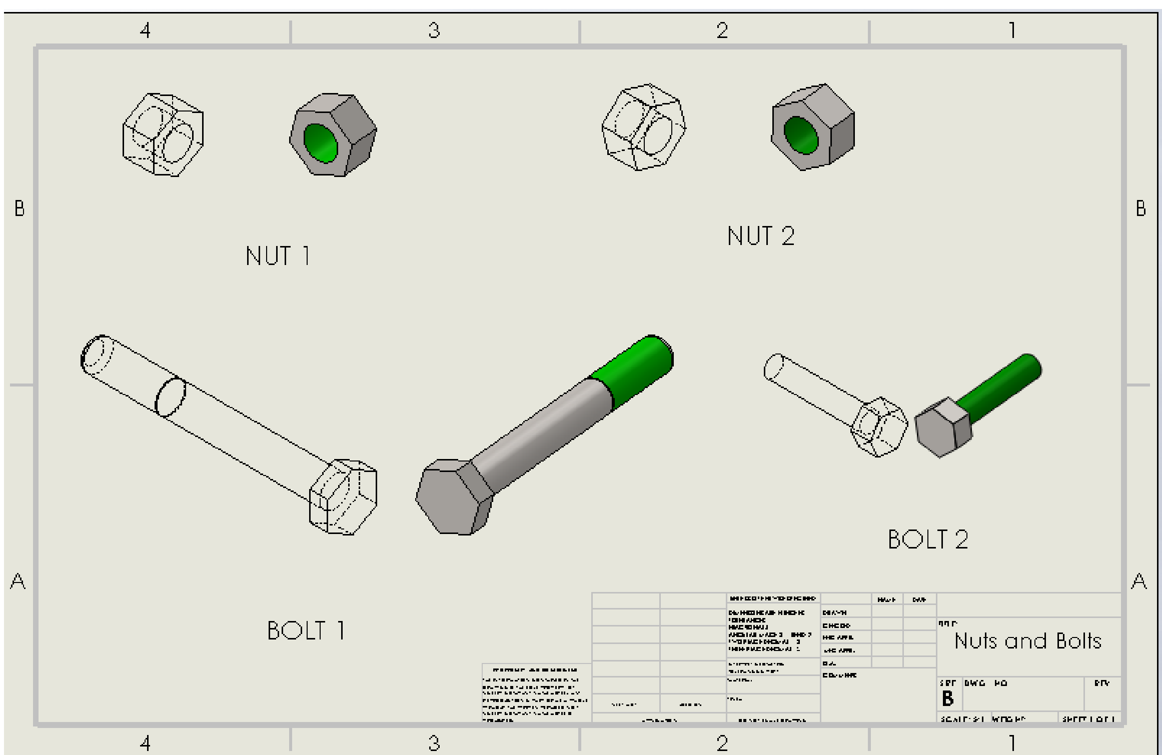

Fig. 2.15: 3-Dimensional Sketch of Nuts and Bolts

2.7 3-Dimensional Sketch of Assembly

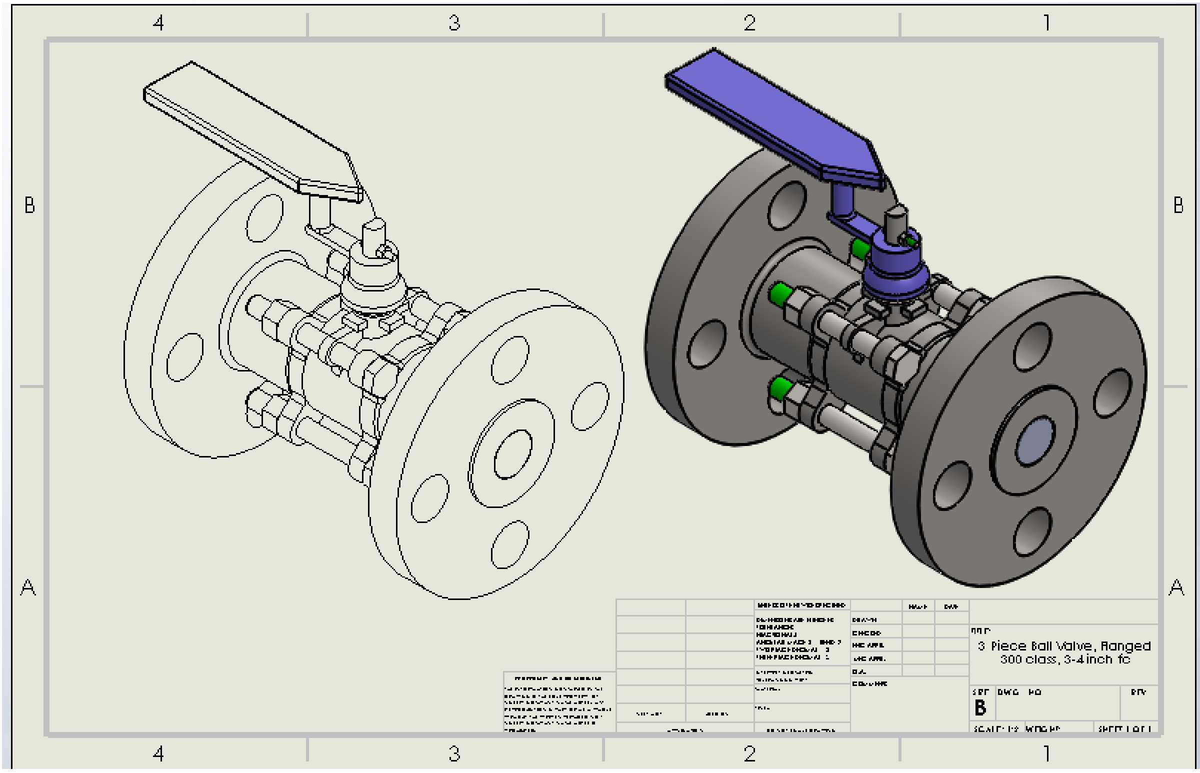

Fig. 2.16: 3-Dimensional Sketch of Assembly

2.8 Analysis

2.8.3 Summary of the leakage analysis

INPUT DATA

Global Mesh Settings

Automatic initial mesh: On
Result resolution level: 5
Advanced narrow channel refinement: Off
Refinement in solid region: Off

Geometry Resolution

Evaluation of minimum gap size: Automatic
Evaluation of minimum wall thickness: Automatic

Computational Domain

Size

Table 2: Size of the domain

X min	-0.071 m
X max	0.071 m
Y min	-0.013 m
Y max	0.023 m
Z min	-0.013 m
Z max	0.013 m
X size	0.142 m
Y size	0.036 m
Z size	0.027 m

Boundary Conditions

Table 3: Boundary Conditions

2D plane flow	None
At X min	Default
At X max	Default
At Y min	Default
At Y max	Default
At Z min	Default
At Z max	Default

Physical Features

Heat conduction in solids: Off
Time dependent: Off
Gravitational effects: On
Rotation: Off
Flow type: Laminar and turbulent
Cavitation: On
High Mach number flow: Off
Free surface: Off
Default roughness: 0 micrometer

Gravitational Settings

Table 4: Gravitational parameters

X component	0 m/s^2
Y component	-9.81 m/s^2
Z component	0 m/s^2

Default wall conditions: Adiabatic wall

Initial Conditions

Table 5: Initial Conditions

Thermodynamic parameters	Static Pressure: 101325.00 Pa Temperature: 293.20 K
Velocity parameters	Velocity vector Velocity in X direction: 0 m/s Velocity in Y direction: 0 m/s Velocity in Z direction: 0 m/s
Turbulence parameters	

Material Settings

Fluids

Water

Boundary Condition

Table 6: Inlet Velocity 1

Type	Inlet Velocity
Faces	LID2-1/Imported1//Face
Coordinate system	Face Coordinate System
Reference axis	X
Flow parameters	Flow vectors direction: Normal to face Velocity normal to face: 2.000 m/s Fully developed flow: No
Thermodynamic parameters	Temperature type: Temperature of initial components Temperature: 293.20 K
Turbulence parameters	Boundary layer parameters
Boundary layer type: Turbulent	

Table 7: Environment Pressure 1

Type	Environment Pressure
Faces	LID1-1/Imported1//Face
Coordinate system	Face Coordinate System
Reference axis	X
Thermodynamic parameters	Environment pressure: 101325.00 Pa Temperature type: Temperature of initial components Temperature: 293.20 K
Turbulence parameters	Boundary layer parameters
Boundary layer type: Turbulent	

Goals

Surface Goals

Table 8: SG Inlet Velocity 1 and Mass Flow Rate

Type	Surface Goal
Goal type	Mass Flow Rate
Faces	Face<1>@LID2-1
Coordinate system	Global coordinate system
Use in convergence	On

Table 9: SG Inlet Velocity 1 and Volume Flow Rate

Type	Surface Goal
Goal type	Volume Flow Rate
Faces	Face<1>@LID2-1
Coordinate system	Global coordinate system
Use in convergence	On

Table 10: SG Inlet Velocity 1 and Static Pressure Av

Type	Surface Goal
Goal type	Static Pressure
Calculate	Average value
Faces	Face<1>@LID2-1
Coordinate system	Global coordinate system
Use in convergence	On

Table 11: SG Inlet Velocity 1 and Total Pressure Av

Type	Surface Goal
Goal type	Total Pressure
Calculate	Average value
Faces	Face<1>@LID2-1
Coordinate system	Global coordinate system
Use in convergence	On

Calculation Control Options

Finish Conditions

Table 12: Finishing Conditions

Finish Conditions	If one is satisfied
Maximum travels	4.000
Goals convergence	Analysis interval: 0.500

Solver Refinement

Refinement: Disabled

Advanced Control Options

Flow Freezing - Disabled

Engineering Database

Liquids

Water

Path: Liquids Pre-Defined

Density

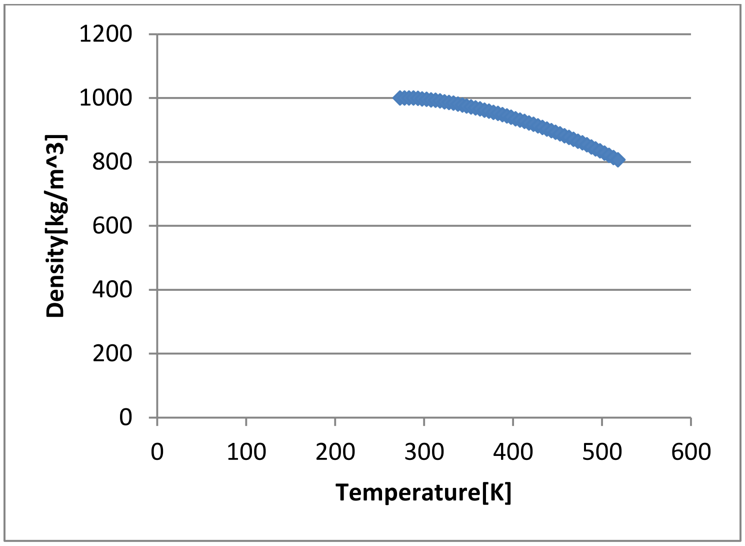

Fig. 2.17: Density vs. Temperature graph

Dynamic viscosity

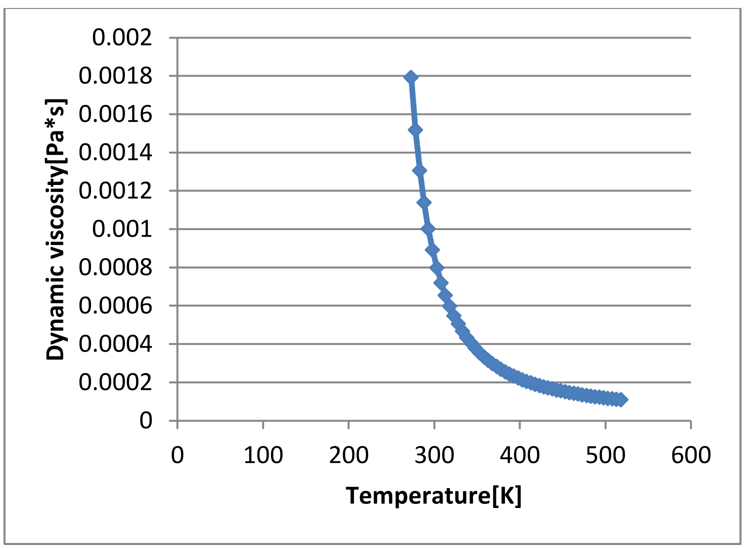

Fig. 2.18: Dynamic viscosity vs. Temperature graph

Specific heat (Cp)

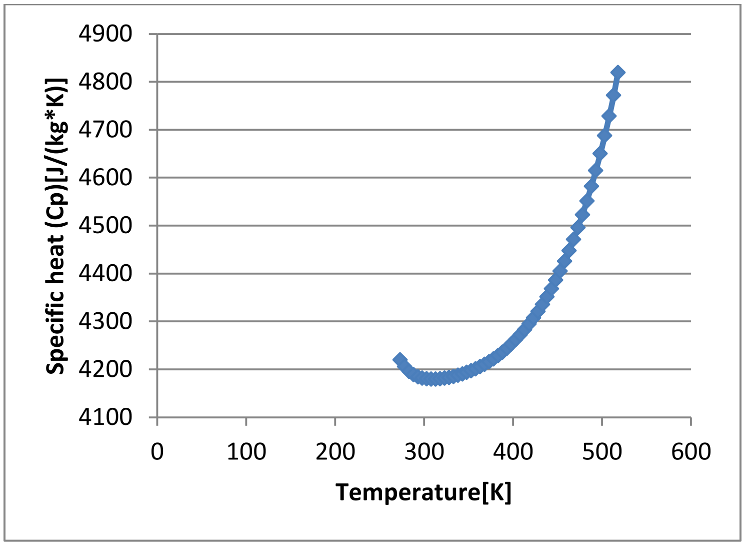

Fig. 2.19: Specific heat vs. Temperature graph

Thermal conductivity

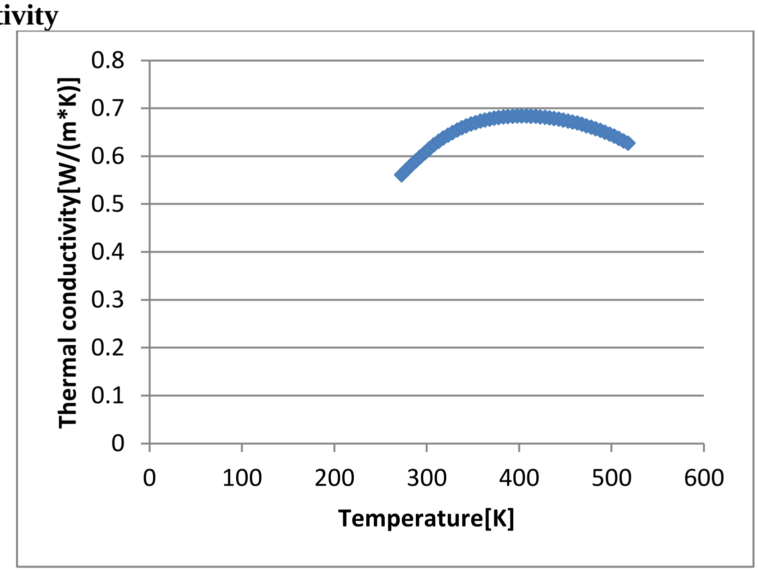

Fig. 2.20: Thermal conductivity vs. Temperature graph

Cavitation effect: Yes
Temperature: 0 K
Saturation pressure: 0 Pa
Radiation properties: No

CHAPTER 3

RESULTS AND DISCUSSIONS

- The design of 3 piece ball valve and the analysis for leakage was successfully completed.
- The leakage analysis of the model was successful as there was no leakage detected.
- From the results of the analysis we found that the model was undergoing cavitation which can be solved by changing the material of the model. This topic needs to be researched and discussed for further development of the product.
- The model consists of an outdated handle mechanism which needs to be researched and improved in the future.

Sectional View

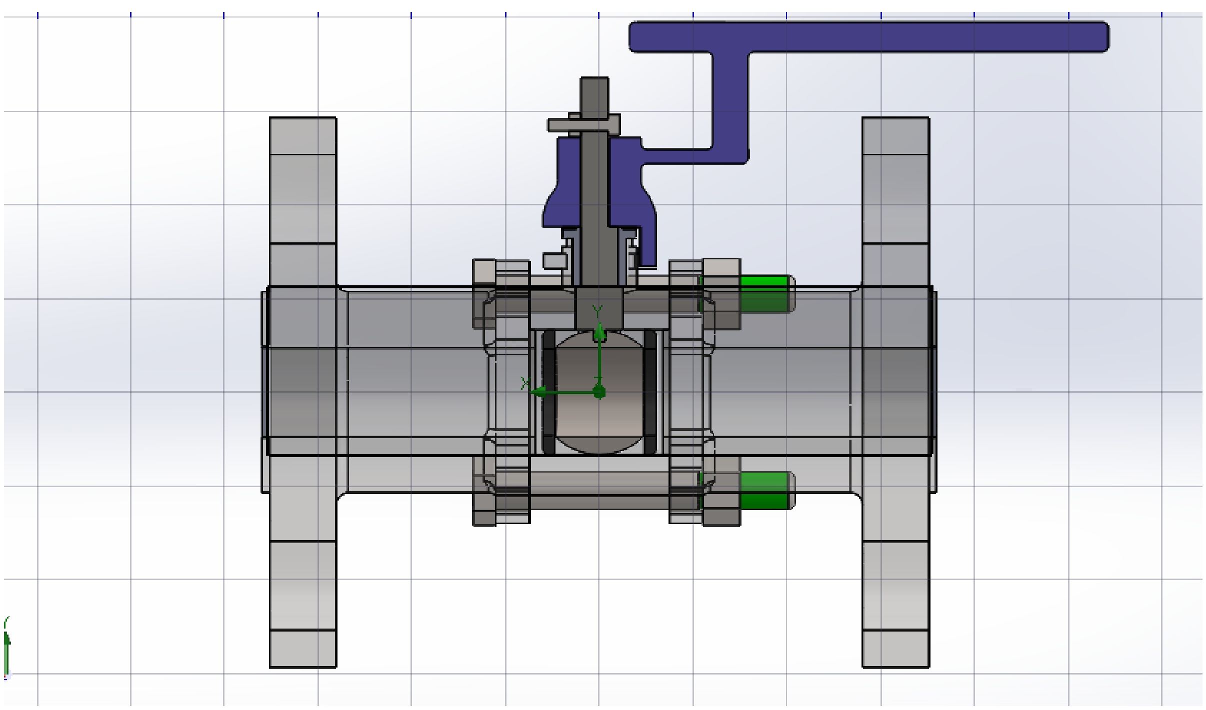

Fig. 3.1: Sectional View

Flow Simulation

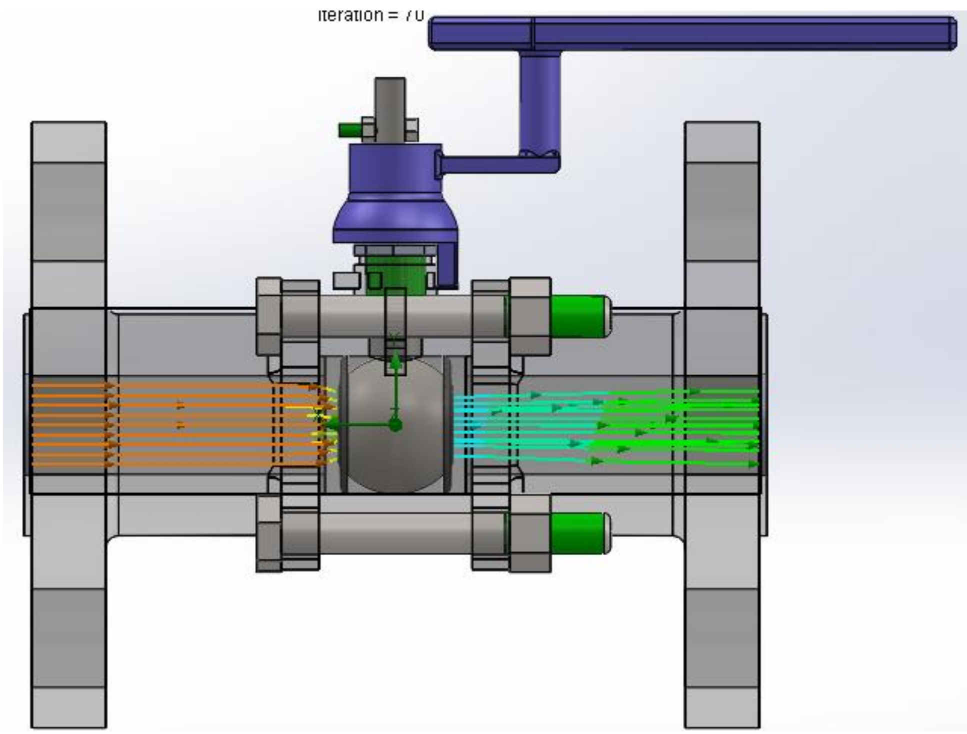

Fig. 3.2: Flow Simulation

Leakage Analysis

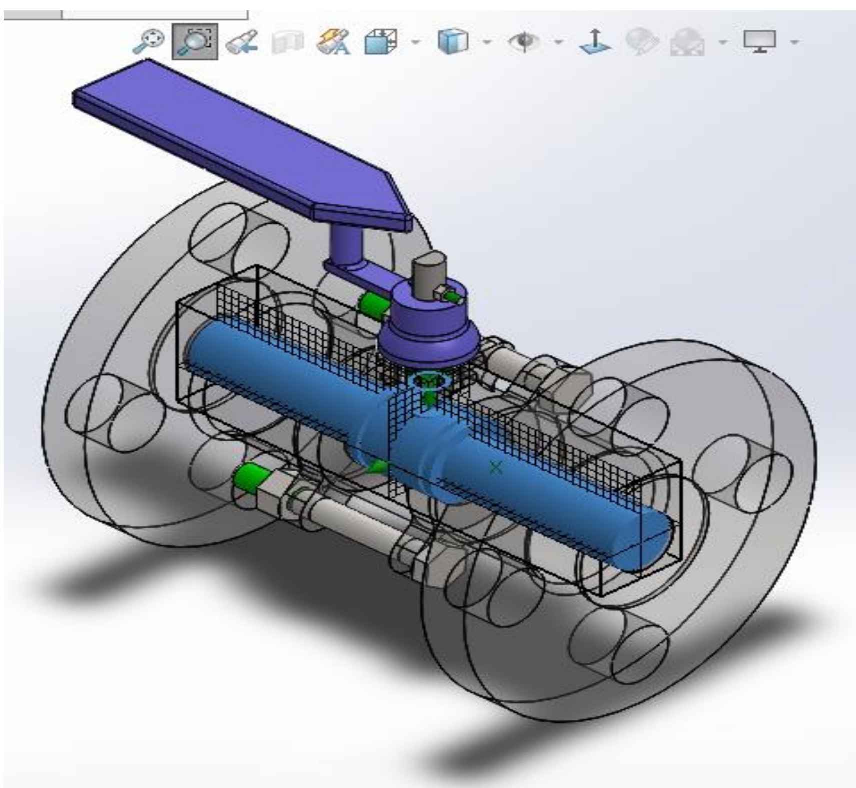

Fig. 3.3: Leakage Analysis

REFERENCES

[1] ASMI standards from Smith – cooper international (www.smithcooper.com)

[2] ASMI standards from Sharp valves (www.sharpevalves.com).

[3] ASMI standard Dimensions for the flange was obtained from the below table

Table 13: ASMI standard dimensions table for flange

Nominal Size	Outside Diameter (OD)	Min. Thickness (T)	RF Dia. (R)	No. of Bolt Holes	Diameter of Holes	Bolt Circle (BC)	SO Bore ID (SB)	WN Bore ID (WB)	Dia. Hub Base (HB)	Dia. Hub Top (HT)	SO LTH (SL)	WN LTH (WL)
1/2	3.75	0.50	1.38	4	0.63	2.62	0.88	0.62	1.50	0.84	0.81	2.00
3/4	4.62	0.56	1.69	4	0.75	3.25	1.09	0.82	1.88	1.05	0.94	2.19
1	4.88	0.62	2.00	4	0.75	3.50	1.36	1.05	2.12	1.32	1.00	2.38
1 1/4	5.25	0.69	2.50	4	0.75	3.88	1.70	1.38	2.50	1.66	1.00	2.50
1 1/2	6.12	0.75	2.88	4	0.88	4.50	1.95	1.61	2.75	1.90	1.13	2.63
2	6.50	0.81	3.62	8	0.75	5.00	2.44	2.07	3.31	2.38	1.25	2.69
2 1/2	7.50	0.94	4.12	8	0.88	5.88	2.94	2.47	3.94	2.88	1.44	2.94
3	8.25	1.06	5.00	8	0.88	6.62	3.57	3.07	4.62	3.50	1.63	3.06
3 1/2	9.00	1.12	5.50	8	0.88	7.25	4.07	3.55	5.25	4.00	1.69	3.13
4	10.00	1.19	6.19	8	0.88	7.88	4.57	4.03	5.75	4.50	1.82	3.32
5	11.00	1.31	7.31	8	0.88	9.25	5.66	5.05	7.00	5.56	1.94	3.82
6	12.50	1.38	8.50	12	0.88	10.62	6.72	6.07	8.12	6.63	2.00	3.82

ANSI/ASME B16.5 Class 300 Forged Flanges

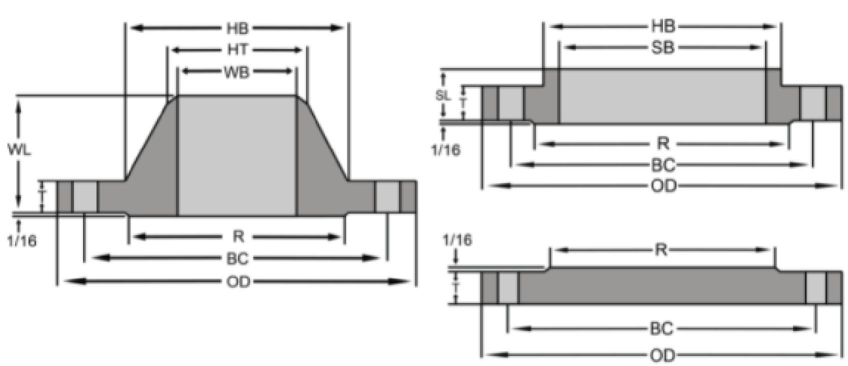

Fig. 3.4: Flange reference diagrams