TECHgium™
Engineering Innovators for Tomorrow

Full Paper Presentation on

PID-229

Design and Development of High Pressure Trunnion Mounted Ball Valves

L&T Technology Services

Gajendiran R

Index

PID No.

Use this slide whenever a section break is required

Challenge Statement

To Design and develop a High pressure Trunnuion-Mounted Ball Valve within Target cost (€9000).

Concept / Scope of solution

The Concept and Scope of the project :

- To develop the Ball Valve within Target cost (€9000).
- To design as per API, PED, NACE & Fugitive Emission requirements.
- To Introduce unique design features like Automatic Cavity Pressure Relief, Anti-Blow out Stem, Fire Safe design, Sealant Injection Arrangement etc.
- To design major parts of the valve (Body /connector) through Forging process.
- To develop the Supply chain & Prototypes of valve.

Pros and Cons of the solution

- Developing the design meeting to Target cost .
- Developing Unique Design Features like Automatic Cavity Pressure Relief, Sealant injection & Fire Safe design.
- Developing Forged design is a challenge compared to casting design.
- Developing Soft seat design for sealing at Normal & Fire condition.
- Achieving “Zero leakage” at less torque.(350 N)
- Challenges to fix the Tight tolerance band for critical assemblies.
- Developing Supply chain within India (High Capacity Forgings)

Detailed Description

The project is to Design & Development of 8” Class 900 Trunnion Mounted High pressure Ball valve (TMBV)

for the oil and gas industry application complying with API and NACE standards.

A valve is a Mechanical device that controls the flow of fluid & pressure

in the Pipe lines, Vessels etc by opening or closing.

- Stopping and starting flow – On/Off applications.
- Regulating the fluid volume – Throttling applications
- Preventing reverse flow – Non-Return applications
- Relieving over pressure – Safety relief.

Super Critical & Ultra- Supercritical Technology

- Higher Pressure & Temperatures => Better Efficiency
- Better Efficiency = Less Emissions and Less Carbon Dioxide

Plant type with power rating	Steam Pressure PSI (Kg/cm^2)	Steam Temp. (˚C)	Efficiency (%)
Sub Critical (500 MW)	2418 (170)	540	35 - 38%
Super Critical (800 MW)	3556 (250)	560 – 590	40 – 42 %
Advanced Ultra Super Critical (800 MW)	4267 (300)	> 700	45 – 47 %

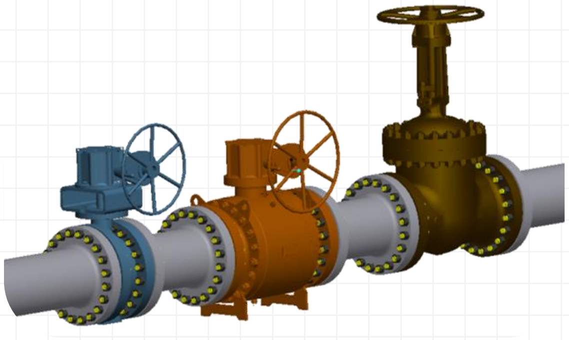
In recent years, the valve manufacturers across the world focused their attention towards developing the High Pressure & Performance Ball valve.

Development Procedure/Methodology

Design of 8” class 900 Trunnion Mounted Soft Seated Ball Valve (Forged two-piece design) compliance to API standards, NACE & Customer specifications.

The detailed execution process:

- Freezing the design specifications
- Concept Design & Development
- Design optimization using VAVE approach
- Design Calculations program
- 3D Modelling & Assembly
- Validation of the design using FEA & CFD analysis
- Tolerance Stack Up Analysis
- Bill of materials with Material details
- 2D Manufacturing drawings
- Design Reports
- Supplier Chain development for the Forging, Machining, Bought out parts, Assembly.
- Prototype Development & Testing.



Implementation and prototype / POC

TECHgium™ Engineering Innovators for Tomorrow

Trunnion Mounted Ball Valve

DESIGN FEATURES	
1	Double Block & Bleed Mechanism
2	Automatic Cavity Pressure Relief system (Single Piston Effect)
3	Anti-Blow out proof- Stem design
4	Sealant Injection Arrangement
5	Fire Safe design

PARAMETERS	VALUE
Valve	Trunnion Mounted Ball Valve (TMBV)
Size	8 inches (DN 200)
Class	900
Construction	2 Piece – Forged Design
Ball Bore Type	Full Bore
Seat Sealing	Soft Seated
Material	Carbon Steel (ASTM A105)
Ball – Stem Drive	Spline Connection
Service temperature range	- 40 deg. C to +200 deg. C
Rated Pressure	15.52 Bar (2250 Psi)

Design Standards

- Design : ISO 17292 / API 6D
- Face-to-Face : ASME B16.10
- Testing : ISO 17292 / API 6D

Pressure-Temperature rating

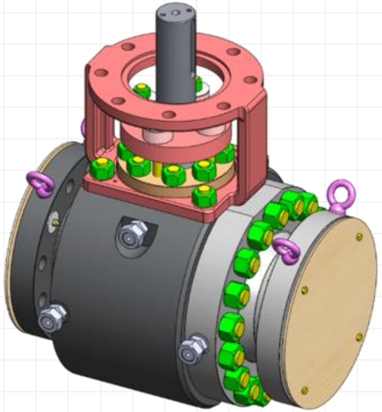
- ASME B16.34

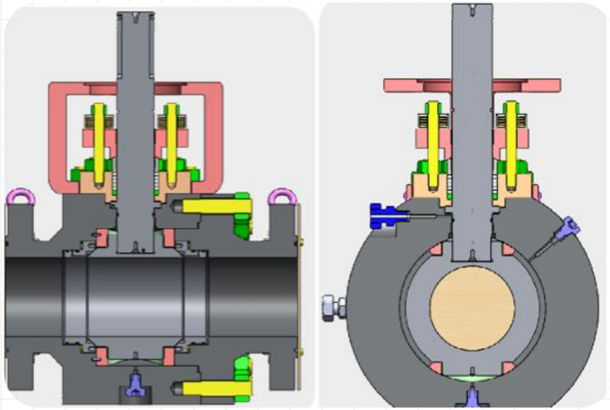
End Connection

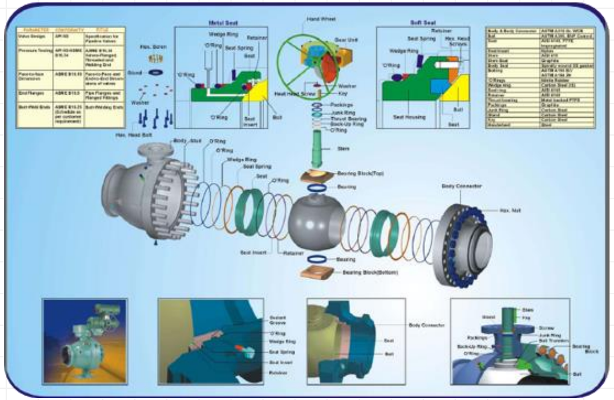
- Flanged End : ASME B16.5
- Socket Weld End : ASME B16.11
- Butt Weld End : ASME B16.25

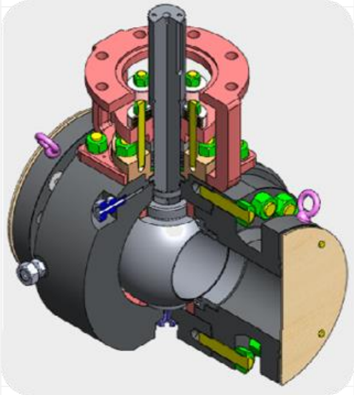
PID No.

Implementation and prototype / POC









PID No.

Implementation and prototype / POC

TECHgium™ Engineering Innovators for Tomorrow

BODY WALL THICKNESS					
Sl.No	Parameters	Formulae	Value	Unit	SOURCE
Minimum Shell Thickness - ASME B16.34					
Case 1	Body material		ASTM A105		
	Pressure rating	Pc	900		
	Stress based constant	Sf	7000		Non-Mandatory App-B
	Inside diameter	d	201	mm	
			7.9	in	
	Shell thickness	1.5* [(Pc * d) / (2*Sf-1.2*Pc)]	0.83	in	
			21.0	mm	
Case 2	Shell thickness from table		23.4	mm	Table-3A
Minimum Shell Thickness - ASME VIII UG - 27					
Case 3	Pressure rating	P	2250	Psi	
			15.52	N/Sq.mm	
	Allowable stress	S	137.93	N/Sq.mm	
	Inside radius	R	100.50	mm	
	Joint efficiency	E	1.00		
	Shell thickness (Under Circumferential stress)	(P*R) / [(S*E) - (0.6*P)]	12.1	mm	
Minimum Shell Thickness - EN12516 - Part 1					
Case 4	Calculation pressure	Pc	15.17	N/Sq.mm	Table-1
	Allowable stress	S	118	N/Sq.mm	Table-1
	Inside diameter	Di	201	mm	
	Constant (Erosion & Linear corrosion)	E	1		Table-1
	Shell thickness	(1.5*Pc*Di)/((2*S) - (1.2*Pc)) + Constant(E)	22.0	mm	
Case 5	Shell thickness from table		23.7	mm	Table-10
	Maximum wall thickness		23.70	mm	
	Thickness provided in the design		24.0	mm	

No. of spring		Nos.	18	18
Force on each spring		N	248.2	248.2
Deflection		mm	4	4
Stiffness of spring	k=F/deflection	N/mm	62.05	62.05
Total spring force	F*no of spring	N	4467	4467
Total Force at upsteam		N	8201	8201
Seating area	pi()/4(Dso^2-Dsi^2)	mm^2	1741.70	1741.70
Actual Seating Area	from 3D model	mm^2	2542	2542
Seating Stress	Net Force/Seat area	N/mm^2	4.71	4.71
Actual Seating stress	Based on 3d Model	N/mm^2	3.23	3.23
Safe Design	if Seating stress > 2 N/mm2		YES	YES

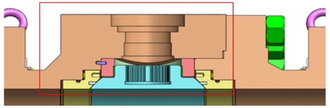
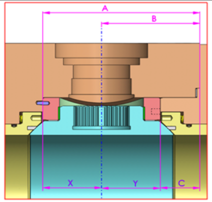
LEGEND ID:

- INPUTS (yellow)
- EXTERNAL LINKS (pink)
- RESULTS (green)
- FORMULAS (white)

PID No.

Validation / Testing / Analysis Method

Bearing Block and Connector Assembly Clearance

A			B			X = A-B
263.50	+	0.05	165.00	+	0.00	
	-	0.00		-	0.05	

Max	Min	Max	Min	
263.55	263.5	165	164.95	98.55
263.55	263.5	165	164.95	98.60
263.55	263.5	165	164.95	98.50
263.55	263.5	165	164.95	98.55

X	MIN	98.50
	MAX	98.60

(B)			C			Y = B-C
165.00	+	0.05	66.50	+	0.00	
	-	0.00		-	0.05	

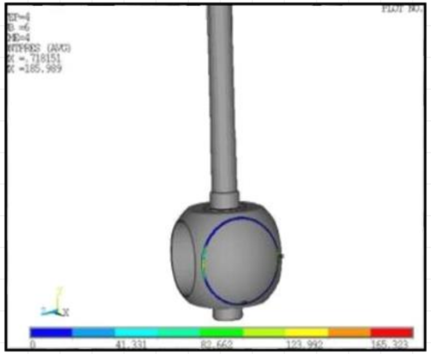
Max	Min	Max	Min	
165.05	165.00	66.50	66.45	98.55
165.05	165.00	66.50	66.45	98.50
165.05	165.00	66.50	66.45	98.60
165.05	165.00	66.50	66.45	98.55

Y	MIN	98.50
	MAX	98.60
DERIVED (X+Y)	MIN	197.00
	MAX	197.20
Bearing Block Dimension	MIN	196.95
	MAX	197.00
CLEARANCE	MIN	0.00
	MAX	0.25

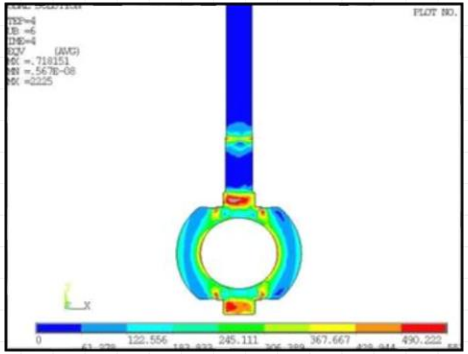
= Input value can be given in these colour cells only.

Conclusion:
The maximum clearance calculated from this analysis is 0.25mm. Thus the design is safe.

Tolerance Stack – Up analysis

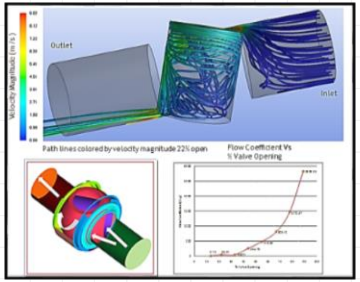


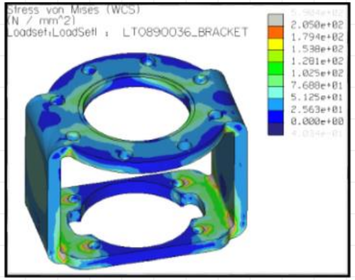
Contact Pressure



Stresses

FE model Ball-valve assembly





Cost /benefits

Weight Details

Forging Cost

Casting Cost

Machining Cost

Project:METSO-Phase1C-Standard Valve															Prodcution Quote
8" CL 900 TMBV Two piece HPBV - Carbon Steel- S.S Trim -Cost Estimation Report															
S.no	Components	Material	Weight - After Machining	Qty	Forged Weight	Drop Forging / Open Die Forging		Casting / Sand Casting				Machining			
			Each		Pouring weight	Indian Supplier		Indian supplier				Indian supplier			
						Production-40 No's				Production-40 No's		Production-40 No's			
			in Kg	in no's	in Kg	Unit Price-In INR	Unit Price-In Euro	Tooling Investment Cost in INR	Tooling Investment Cost in Euro	Unit Price-In INR	Unit Price-In Euro	Tooling Investment Cost in INR	Tooling Investment Cost in Euro	Unit Price-In INR	Unit Price-In Euro
1	Body -(Forging+machining)	ASTM A105	575.60	1.00	982.40	103543.00	1532					74900.00	1109	23120.00	342
2	Connector -(Forging+Machining)	ASTM A105	200.20	1.00	421.40	54443.00	806					21000.00	311	10350.00	153
3	Seat Ring -(Casting+Machining)	ASTM A 351 Gr CF8M	10.10	2.00	13.40			27000.00	400	14793.60	219	17338.00	257	4320.00	64
4	Ball -(Forging+Machining)	ASTM A182 F316	55.80	1.00	144.50	64125.00	949					0.00	0	11300.00	167
5	Gland Flange -(casting+Machining)	ASTM A216 Gr WCB	9.20	1.00	13.10			17900.00	265	1713.48	25	13400.00	198	950.00	14
6	Bearing Block -(Casting+Machining)	ASTM A216 Gr WCB	4.20	2.00	5.70			25000.00	370	3556.80	53	17500.00	259	1390.00	21
8	Bonnet -(Forging+Machining)	ASTM A105	24.20	1.00	38.60	4100.00	61					11245.00	166	2670.00	40
9	Bracket-(Casting + Machining)	ASTM A216 Gr WCB	41.00	1.00	49.00			39500	585	6409.20	95	10940.00	162	1542.00	23
10	Stem-(Bar+Machining)	ASTM A479 TY 316	34.10	1.00	86.40							0.00	0	30800.00	456
Total						Rs. 2,26,211	€ 3,348	Rs. 1,09,400	€ 1,619	Rs. 26,473	€ 392	Rs. 1,66,323	€ 2,462	Rs. 86,442	€ 1,279

Results and potential Business Impact for L&T TS

Key Achievements:

- Achieved the target cost of ball valve (€9000)
- Implemented unique product features to boost up the product sales.
- Optimized the Torque by 10% through introduction of bearings & material selection.
- The sealing integrity is enhanced by the fire safe & emergency sealant design.

Conclusion

- Achieved the within target cost €8100 as set by client, helps to be competitive on the market.

- Top down assembly helps to reduce the design lead time for size extension.
- Automated the Design calculations and tolerance stack up analysis & parametric relations programs which helped to reduce the lead time.
- Design is successfully validated through FEA (both linear & non-linear) & CFD flow analysis (with different openings).

References

- http://ec.europa.eu/enterprise/sectors/pressure-and-gas/documents/ped/
- Beychok, Milton R. (2005). *Fundamentals Of Stack Gas Dispersion* (4th ed.). *author-published*. ISBN 0-9644588-0-2. See Chapter 11, *Flare Stack Plume Rise*.
- *ONE TUEV BV Technische Inspektions GmbH. "List of countries accepting the ASME Boiler & Pressure Vessel Code". Onetb.com. Retrieved 2012-01-19.*
- *"API 5210-1, Sizing and Selection of Pressure-Relieving Devices". Techstreet.com. Retrieved 2012-01-19.*
- *"DIERS". Iomosaic.com. Retrieved 2012-01-19.*
- *H.G. Fisher, H.S. Forrest, Stanley S. Grossel, J. E. Huff, A. R. Muller, J. A. Noronha, D. A. Shaw, B. J. Tilley (1992). Emergency Relief System Design Using DIERS Technology: The Design Institute for Emergency Relief Systems (DIERS) Project Manual. ISBN 978-0-8169-0568-3.*
- *"EDUG: European DIERS Users' Group". Edug.eu. Retrieved 2012-01-19.*
- *"CRR 1998/136 Workbook for chemical reactor relief system sizing". Hse.gov.uk. Retrieved 2012-01-19.*

TECHgium™
Engineering Innovators for Tomorrow

THANK YOU

L&T Technology Services