Advanced metal sealing solution for Triple-Offset butterfly valves

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Agenda

• Type of butterfly valves (DOBV vs. TOBV)
• Main sealing technologies for TOBV
• Lamellar seal principle
• Concept weaknesses
• How to reduce leak paths with lamellar seals?
• Design optimization:
• Lab test examples & results
Type of butterfly valves (DOBV vs. TOBV)

- **Double-offset butterfly valve (DOBV)**
  - Still present on the market
  - Reliable and cost-efficient but limited regarding pressure range
  - Can be sealed on the seat with a circular metal seal (like spring energized)

- **Triple-offset butterfly valve (TOBV)**
  - Able to achieve higher pressure
  - More difficult to machine compared to DOBV
  - “Zero-Torque” valve (no torque before initiating contact seat/seal)
Main sealing technologies for TOBV

- **Massive metal seal**: metal part machined with high accuracy on the sealing surface
- **Lamellar seal**: sandwich of metal and soft layers (usually graphite) machined with high accuracy on the sealing surface
- **For both concepts**: “perfect” conical inclined surface on the seal matching with a “perfect” counter face → surface contact

Lamellar seal preferred as can accommodate deformations → enhanced sealing properties
Lamellar seal principle

- Right-angle conical design → sealing by contact
- Torque seating during closing position of the disc → uniform forces equally distributed around the entire circumference of the valve seat
- Closing torque constantly maintained in closed position
- Resilient seal flexes and energizes, assuming the shape of the seat → allows the valve body and disc to contract or to expand

Self-adjusting radial movement between metal layers facilitated by soft layers
Concept weaknesses

- When fitting the lamellar seal on a valve, compression of a secondary seal
- → significant deformation of the seal (bending effect)
- Thickness and density of graphite layers become irregular with an impact on the geometry of the cone
How to reduce leak paths with lamellar seals?

- Optimization of tightness with lamellar seal: result of **combined improvements and choices for**:
  - Metallic components
  - Graphite layers
  - Bonding media
  - Secondary seal
  - Machining process

- Strong technical knowledge & understanding of:
  - **Technical customer requirements** (valve kinematic, how the seal is maintained…)
  - **Materials interactions** when combined in one component
  - **Sealing mechanism** to find the best sealing solution
Design optimization | 1
Shape definition & manufacturing

- Definition of precise pre-compression on the seal while machining
  → ideally, pre-compression load = load applied by the secondary seal once fitted on the valve
- Choice of secondary seal with a well-known compression curve
- Obtain right shape of the seal once fitted on the valve

Machining  Free shape  Fitted on valve

- FEA Support to anticipate deformations of lamellar seal
• **Metal layers**: importance of choice of material for optimizing blades mechanical behavior

  → Lamellar seal is a metal-to-metal seal

• **Graphite layers**:
  
  • Optimization graphite width & density to reduce deformations while compressing the secondary seal
  
  • Tightness improvement due to efficient contact on the seat seal and achievement of leak rate criteria
  
  • Graphite still in contact with the seat on all circumference of the seal. Expected leak rate facilitated on the test bench (pressure static tests)
Robust bonding process for lamellar seals:

- **Excellent parallelism** of the seal between external faces due to thin layer of glue
  - Controlled geometry of the seal → optimize the seat contact and leak rate
  - Better compliance with the definition plan of the seal

- **No risk for lack of glue or air bubbles** around all circumference of the seal
  - No graphite blow off during machining operations and good visual control
  - Graphite remains in place at the edge of metal layers to facilitate static leak test

- **Graphite 100% glued to the metal layers**
  - No risk of graphite delamination and leak path between metal layers
Design optimization | 4

Measurement procedure

Dimension control:

- Definition of a robust measurement procedure to control lamellar seals geometry
Guarantee of global leak results:

- Leak rate achievement by combining laminated seal and secondary seal

Consider stiffness of both lamellar seal and secondary seal

→ master deformations

- Leak path on a poor quality secondary seal can be higher than at seat/seal contact
Lab tests example

- Leak results criteria on a dedicated mockup
- Strong understanding on how different components interact on mechanism and consequences regarding final tightness performance

- Tests performed either with soft O-Ring or stiffer spiral wound gasket as secondary seal
- Different leak paths through laminated seal defined by TECHNETICS to achieve expected general leak rate
  - On seat seal due to geometry and surface roughness
  - Through graphite layers (or other soft materials) and glue due to porosity
  - Through secondary seal working on semi-static position
- FEA in parallel to make correlations between axial loading and loading on a real butterfly valve
Results Example

- Test pressure: 50 bar
- Quality criteria: API 598
- Tests of secondary seals (O-Ring or SWG, 8” size) from different manufacturers loaded under 35 or 50 kN
Conclusion

Lamellar seal, best sealing solution for TOBV

Why?
• Achieve expected leak rates
• Significantly reduce leak paths

How?
• Strong knowledge on interaction of materials when combined in one component
• Strong technical understanding of sealing mechanism
Thank you!

Any Questions?

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IVS - VALVECampus 2019 Conference