CFD

Use and benefits

V&W valves

What is CFD?

"Computational Fluid Dynamics"

- **An Engineering Tool**
  - Design
  - Troubleshooting
  - "Virtual laboratory"
- **A Numerical Method**
  - Solves equations of motion for fluid
  - Steps:
    - set up problem
    - solve
    - view results

V&W valves

CFD: Numerical method

- **CFD solves the Navier-Stokes equations, i.e. Conservation Principles of**
  - mass,
  - momentum,
  - energy, chemical species, turbulence...

$$\frac{\partial \varrho}{\partial t} + \frac{\partial}{\partial x_i}(\varrho u_i) = 0$$

$$\frac{\partial}{\partial t}(\varrho u_i) + \frac{\partial}{\partial x_j}(\varrho u_i u_j) = -\frac{\partial p}{\partial x_i} + \frac{\partial \tau_{ij}}{\partial x_j} + \varrho g_i + F_i$$

V&W valves

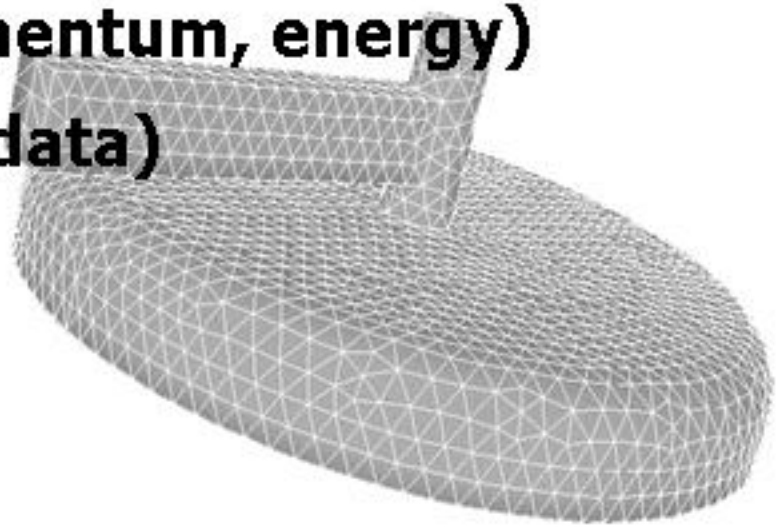
Getting at the solution

- **Problem set up, or "pre-processing"**
  - integration with design group / CAD
  - graphical interface
  - parametric studies
- **Solver computes the flow field**
  - speed, accuracy, reliability
  - features "models"
- **Viewing results, "post-processing"**
  - numbers, graphs, figures, animations

V&W valves

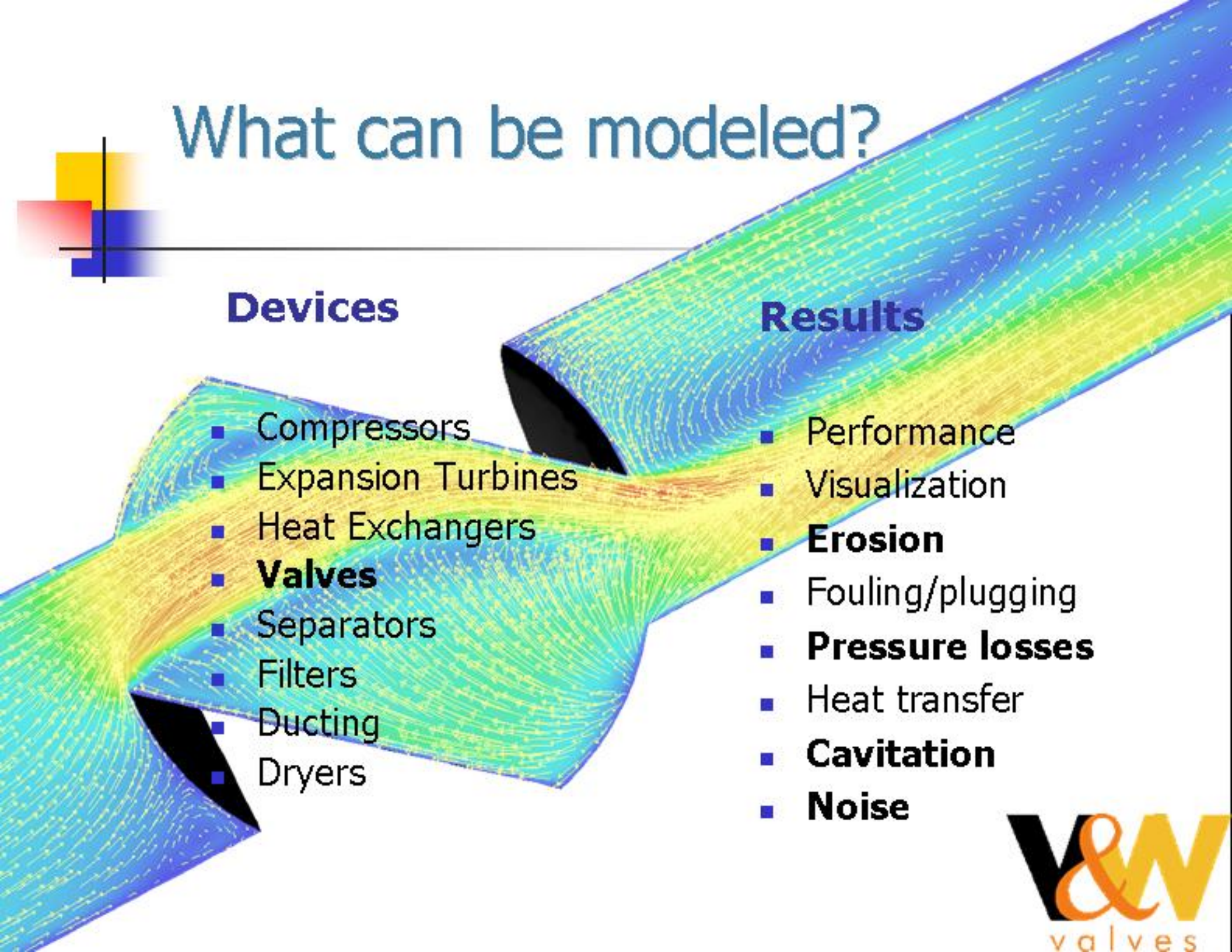
The CFD process

- Create or import your geometry using CAD-style tools
- Discretize the geometry: mesh generation, fluid and solid domains
- Define flow conditions, fluid properties, physics
- Submit the calculation (solve the conservation equations for mass, momentum, energy)
- Review results (graphs, data)



V&W valves

What can be modeled?



Devices

- Compressors
- Expansion Turbines
- Heat Exchangers
- **Valves**
- Separators
- Filters
- Ducting
- Dryers

Results

- Performance
- Visualization
- **Erosion**
- Fouling/plugging
- **Pressure losses**
- Heat transfer
- **Cavitation**
- **Noise**

V&W valves

Setting expectations

To expect	*NOT to expect*
Values for Performance Forces Pressures Erosion	**Replacement for good engineering judgement**
Parametric studies	**Complete replacement for testing**
Visualization	**Immediate and effortless results** **Accurate results require** Detailed models Knowledge of your problem Knowledge of limitations
Qualitative behaviour	
Investment that pays off	

V&W valves

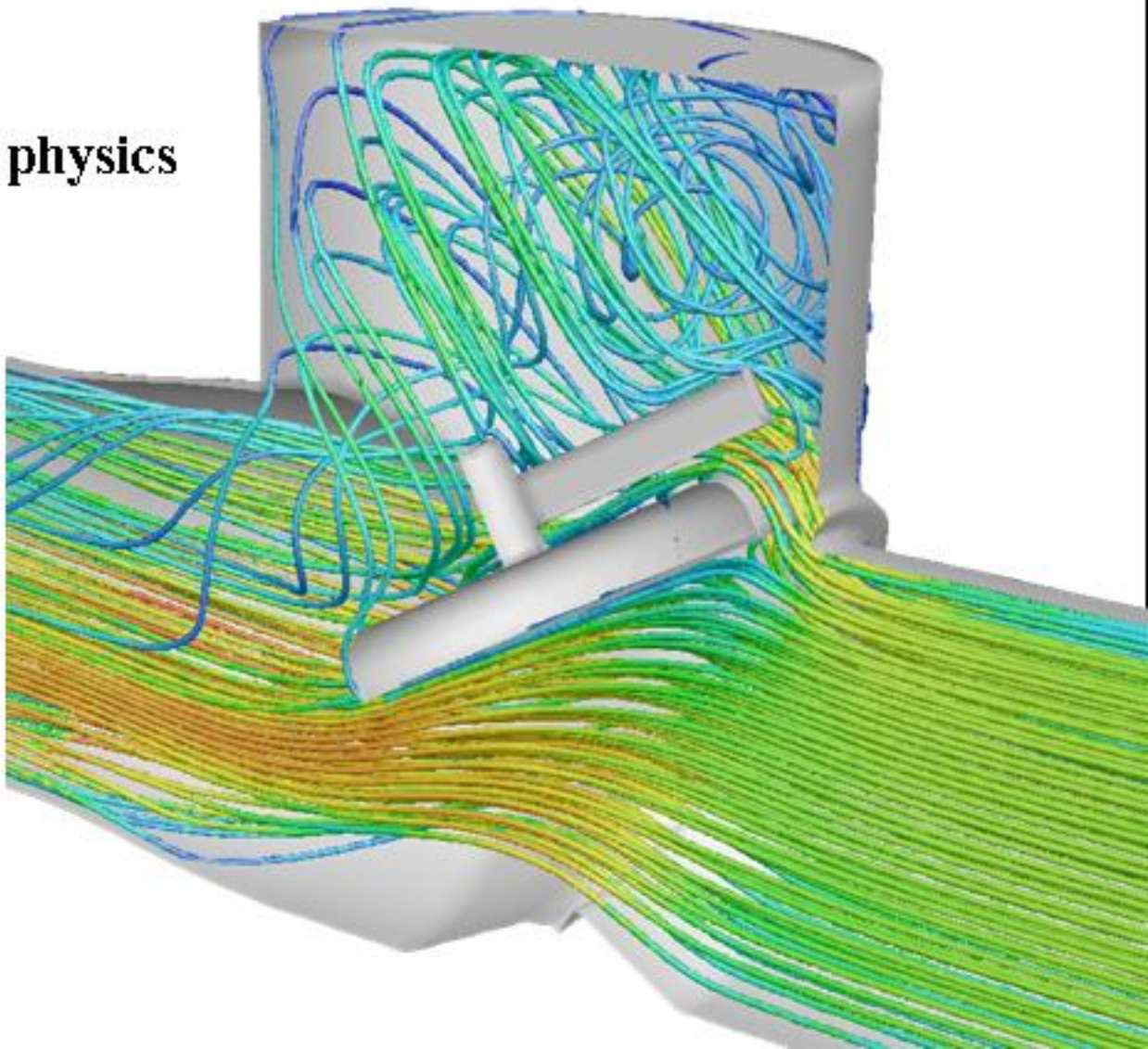
Benefits of CFD

Reduce design time

Understand problems and physics involved

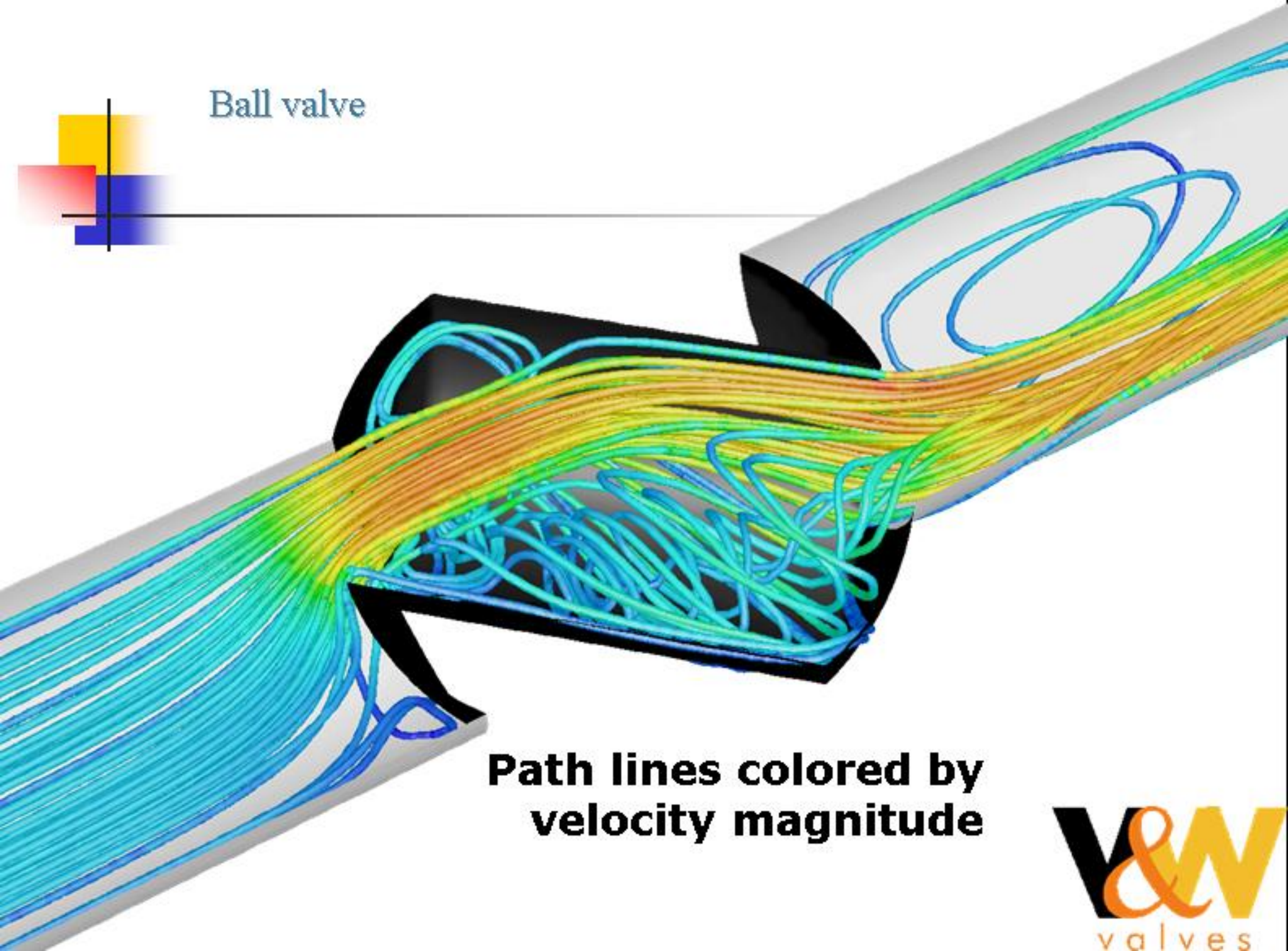
Improve performance

Enhance product quality



V&W valves

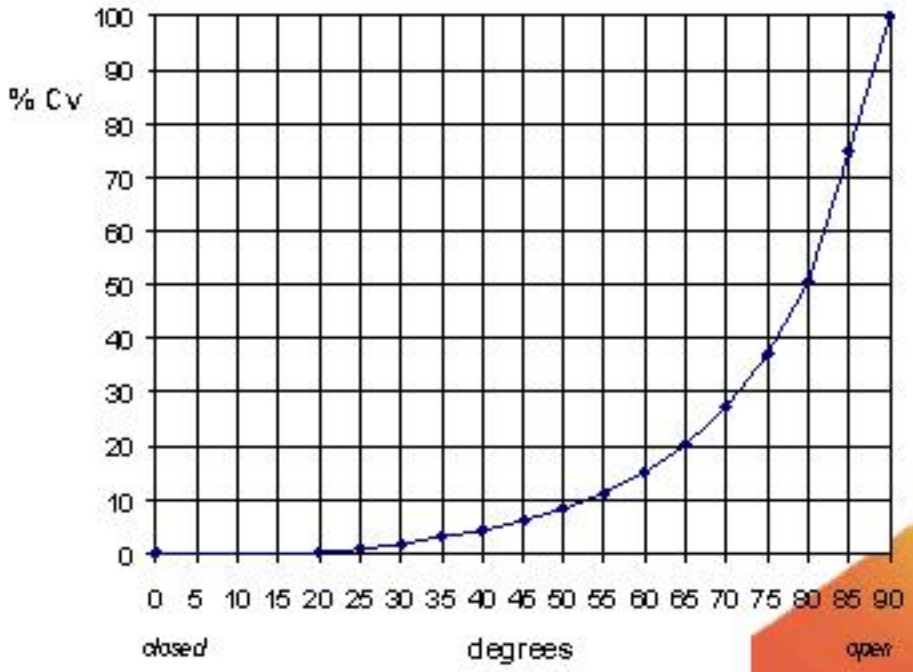
Ball valve

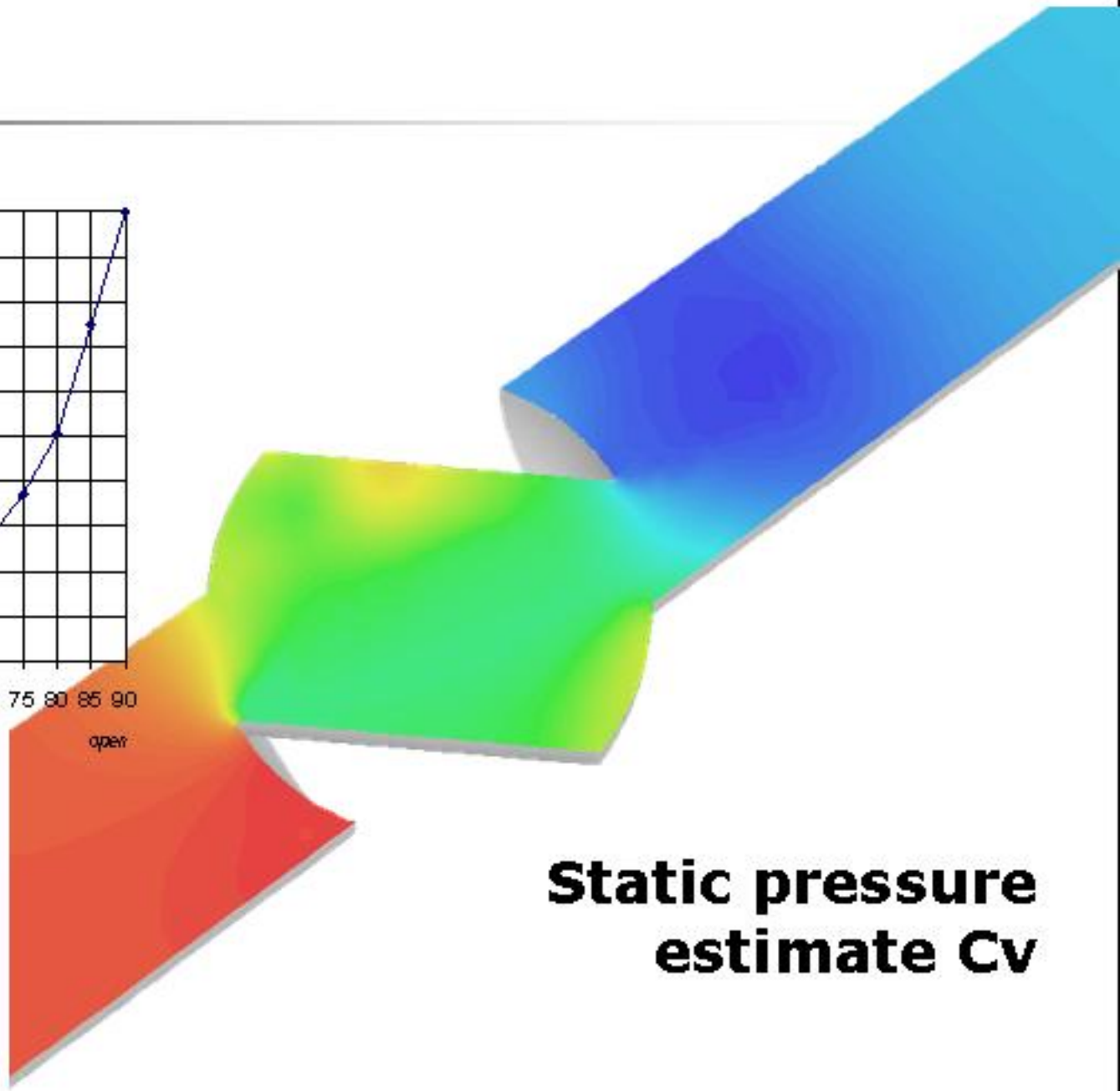


Path lines colored by velocity magnitude

V&W valves

Ball valve

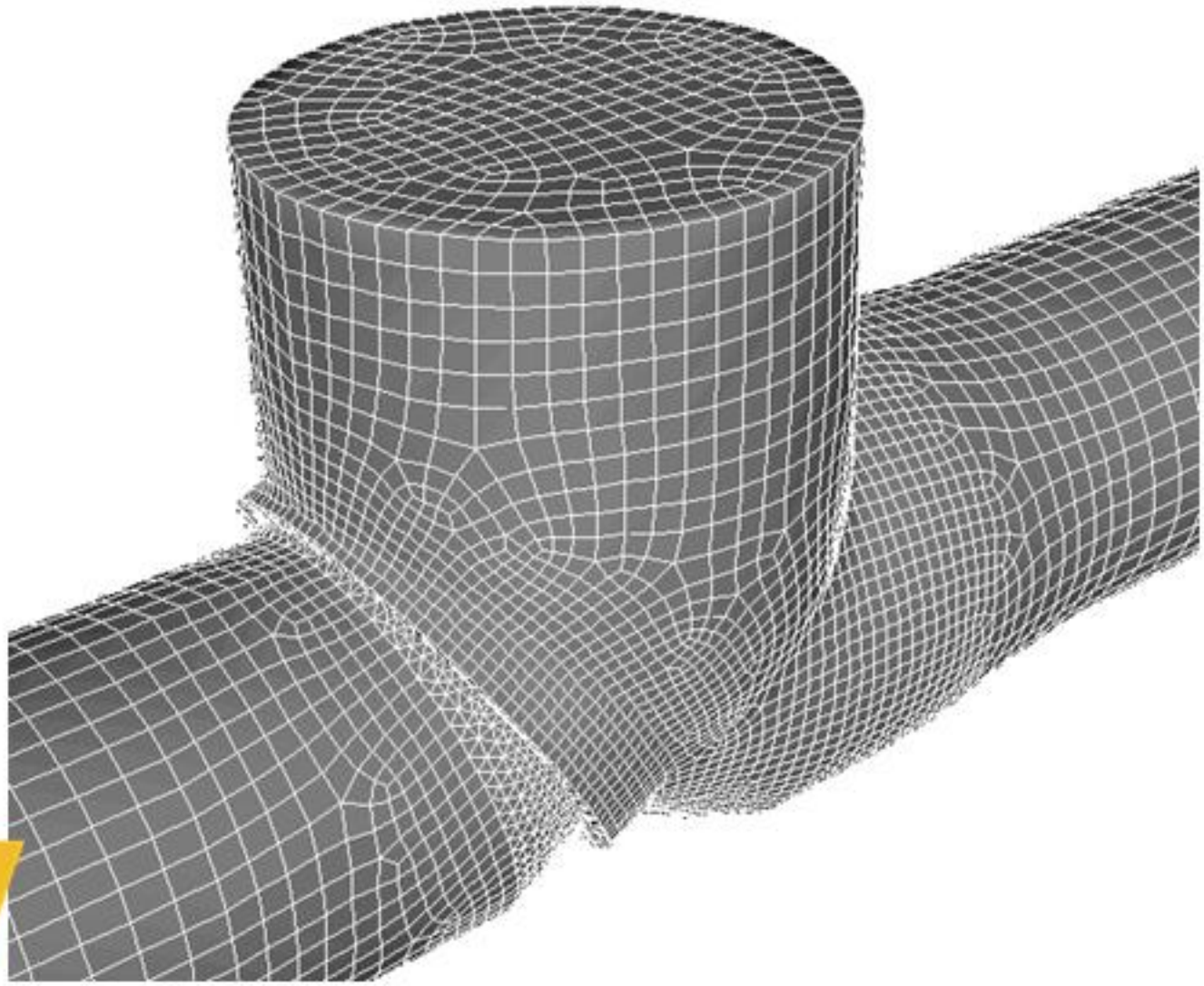




Static pressure estimate Cv

V&W valves

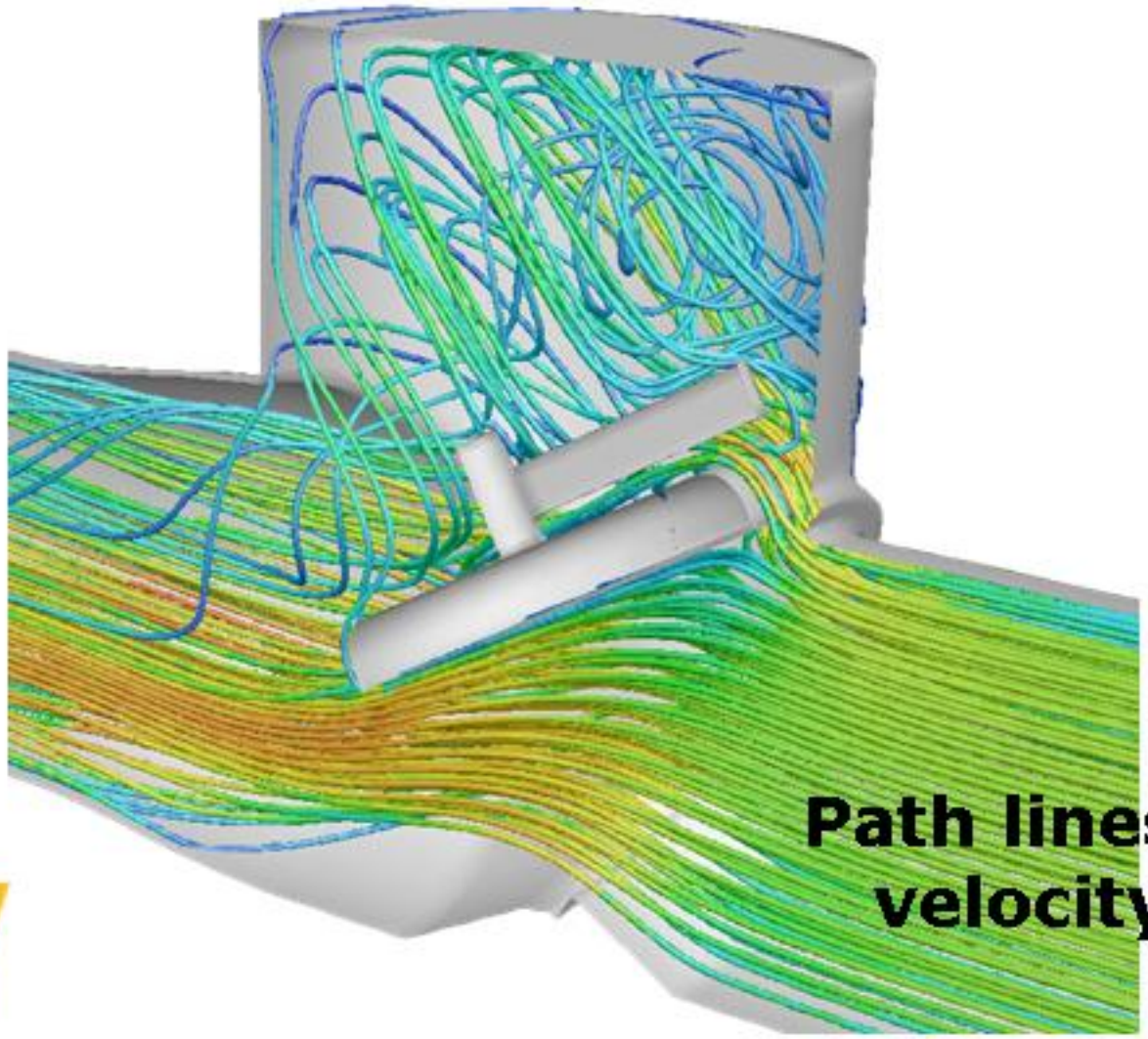
Control check valve



Grid

V&W valves

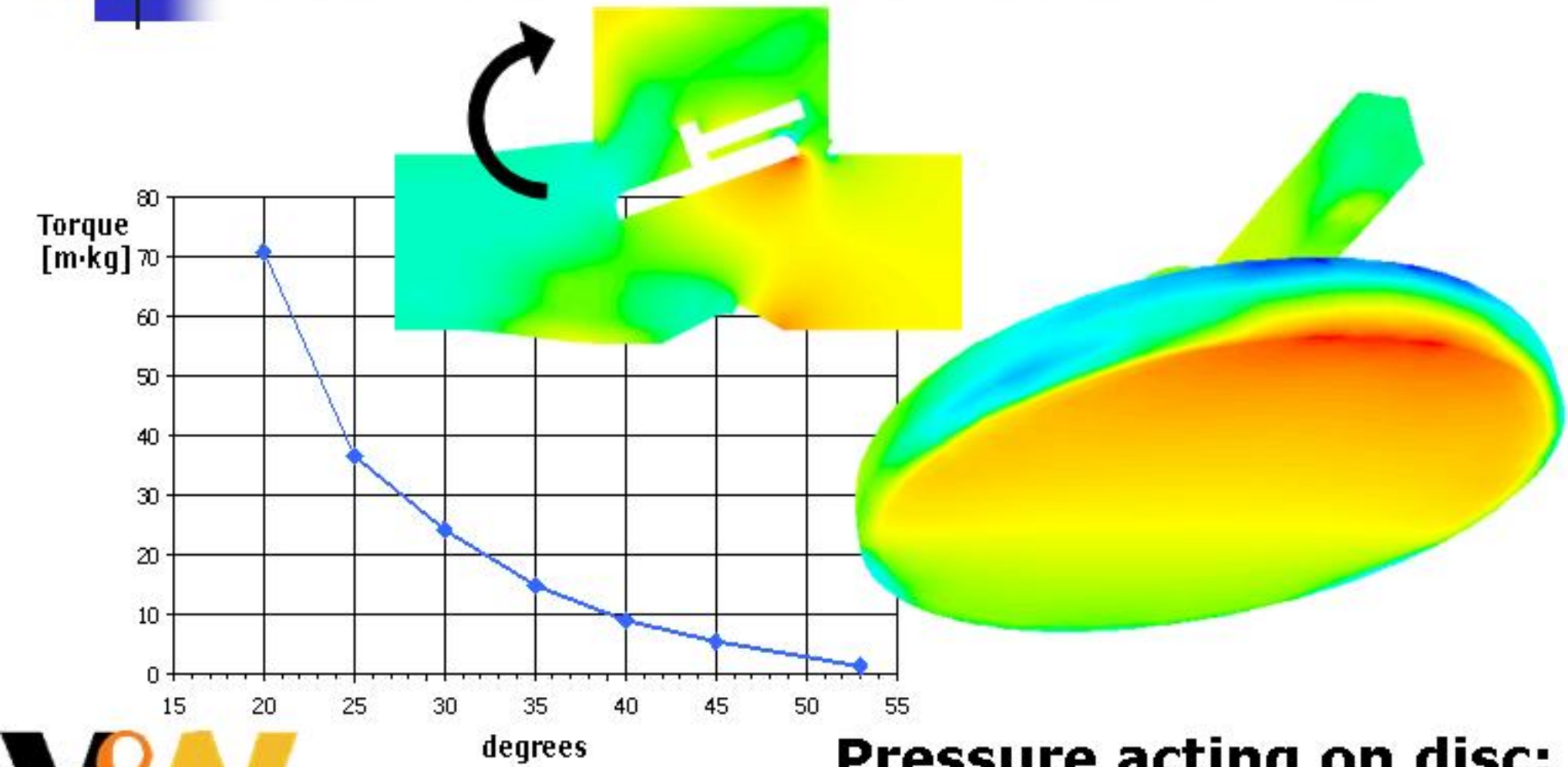
Control check valve



Path lines colored by velocity magnitude

V&W valves

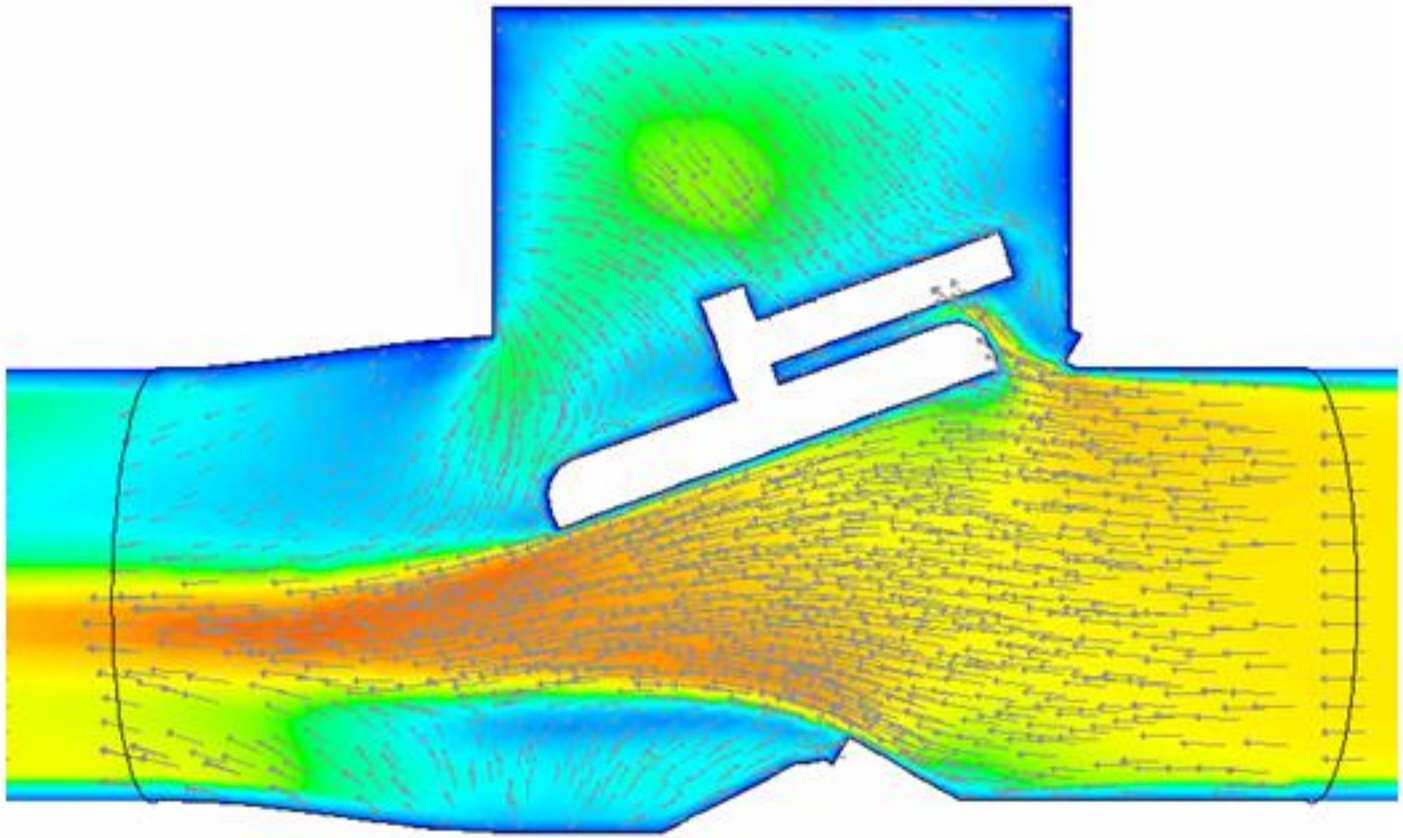
Control check valve



Pressure acting on disc: calculate forces and torque

V&W valves

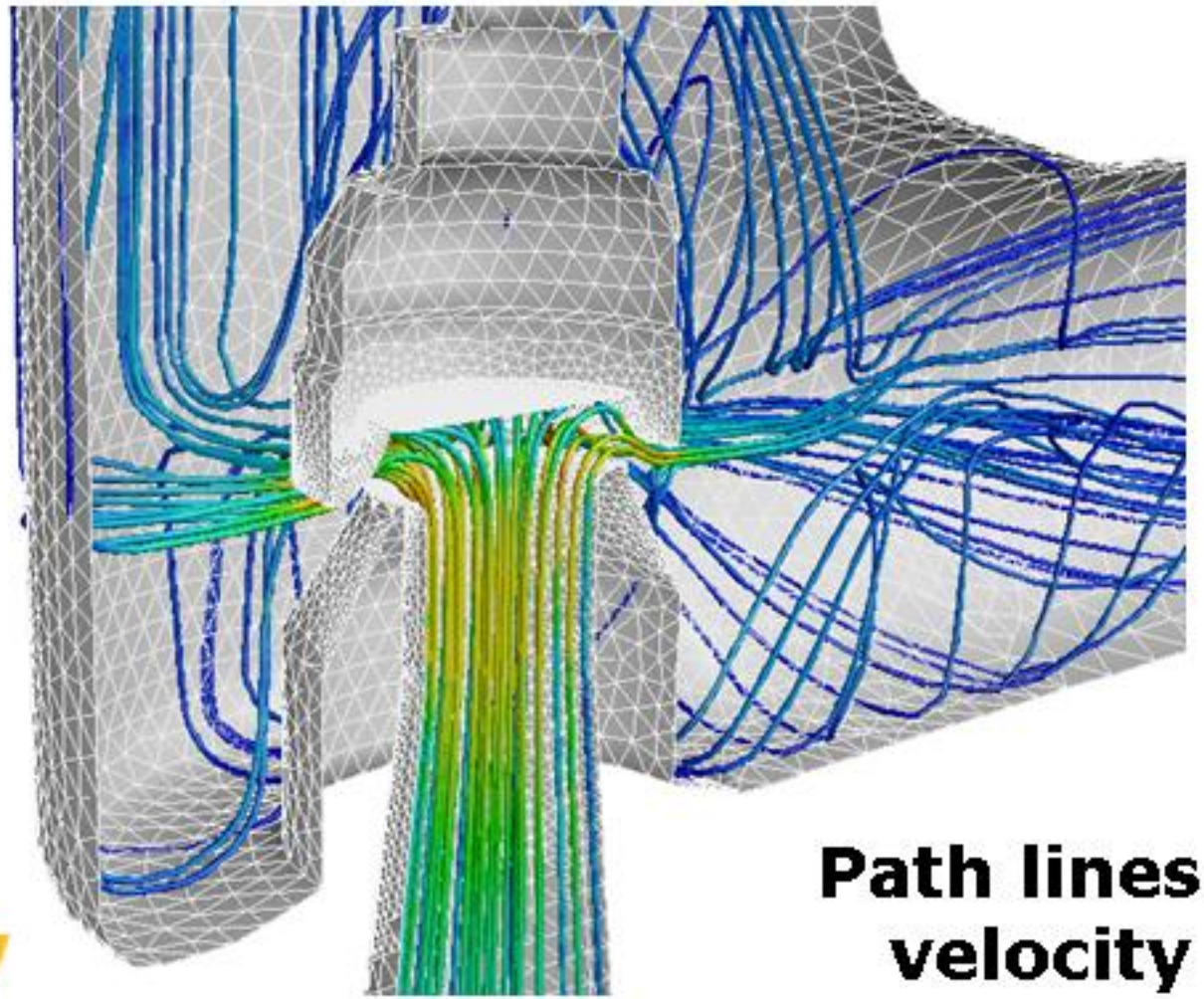
Control check valve



Velocity vectors

V&W valves

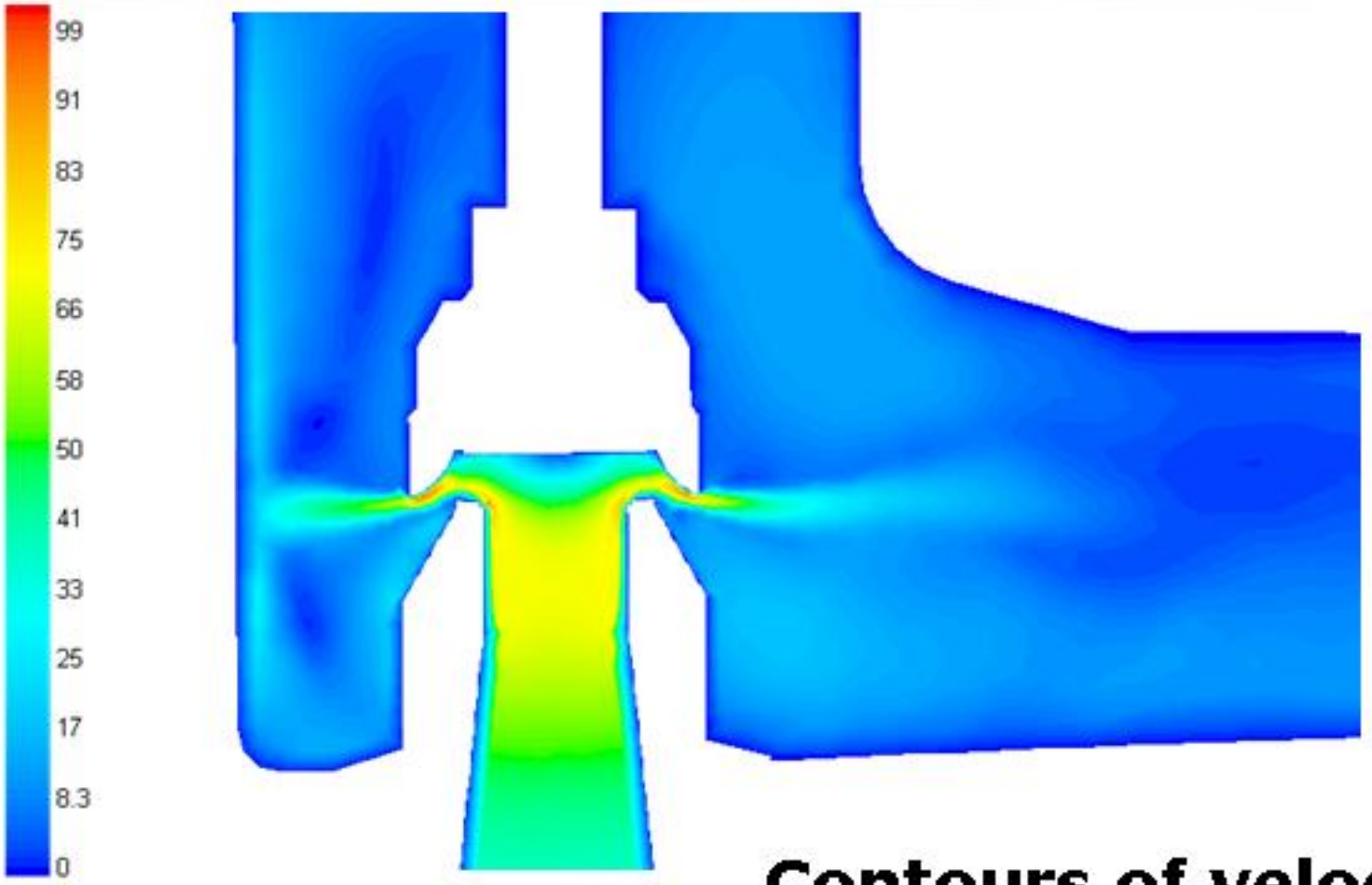
Safety relief valve



Path lines colored by velocity magnitude

V&W valves

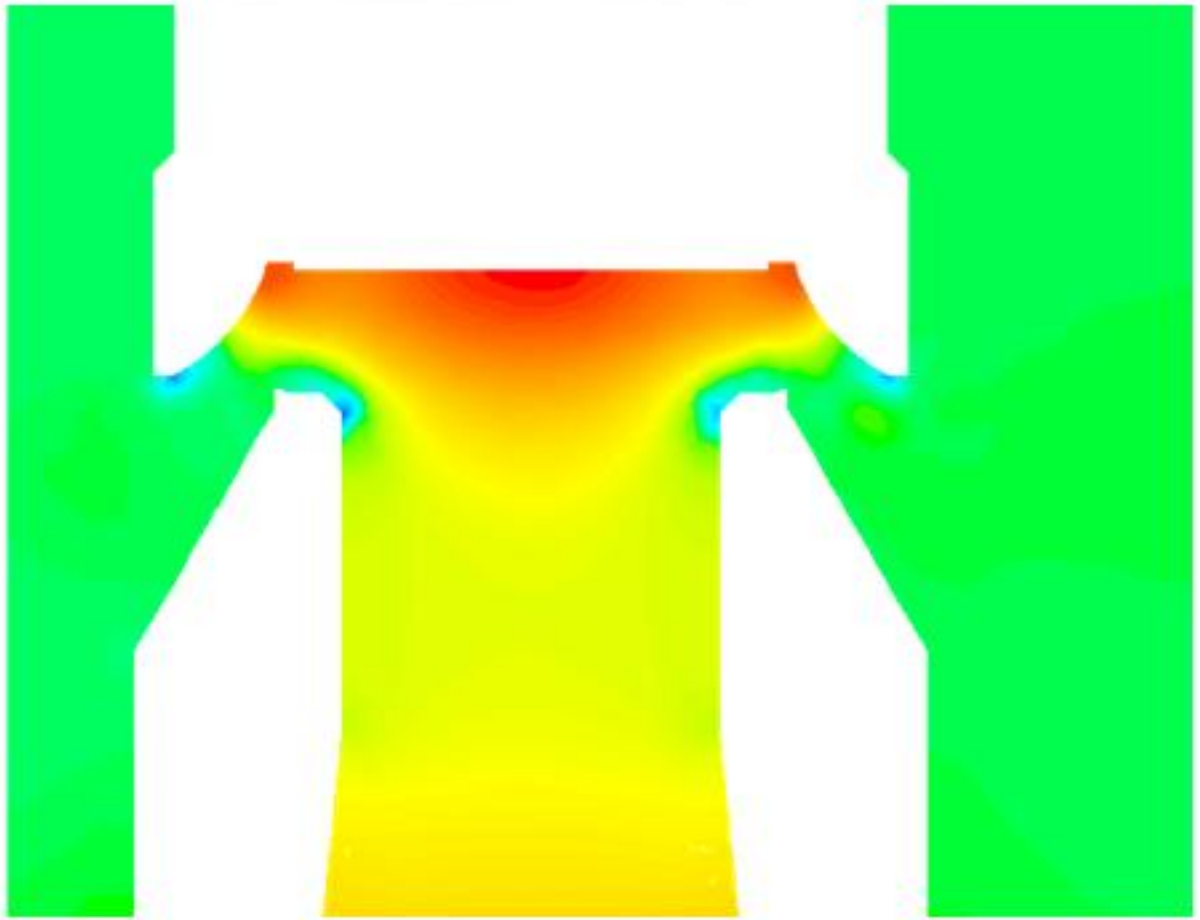
Safety relief valve



Contours of velocity in the disc zone

V&W valves

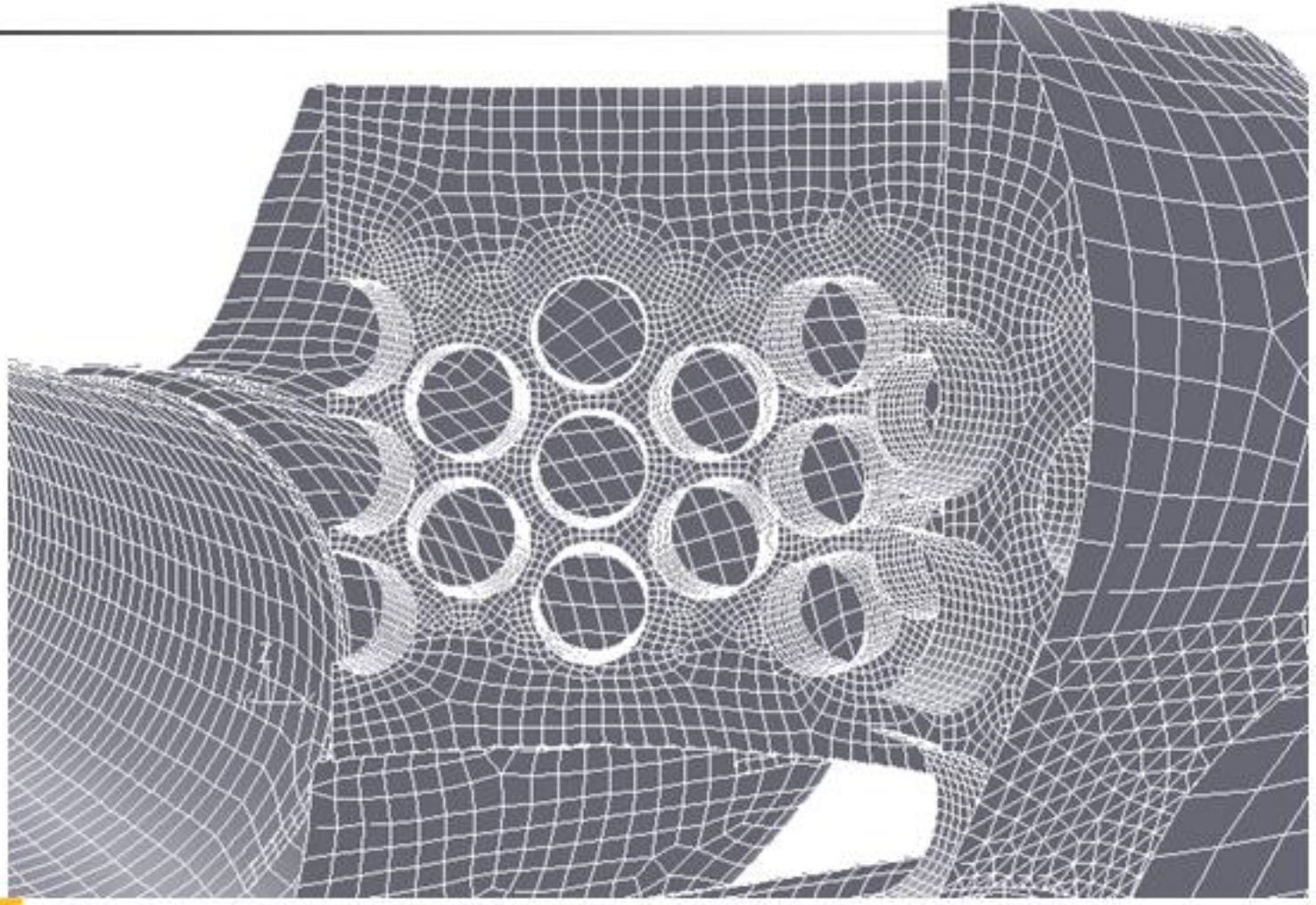
Safety relief valve



Pressure acting on disc: calculate forces & spring

V&W valves

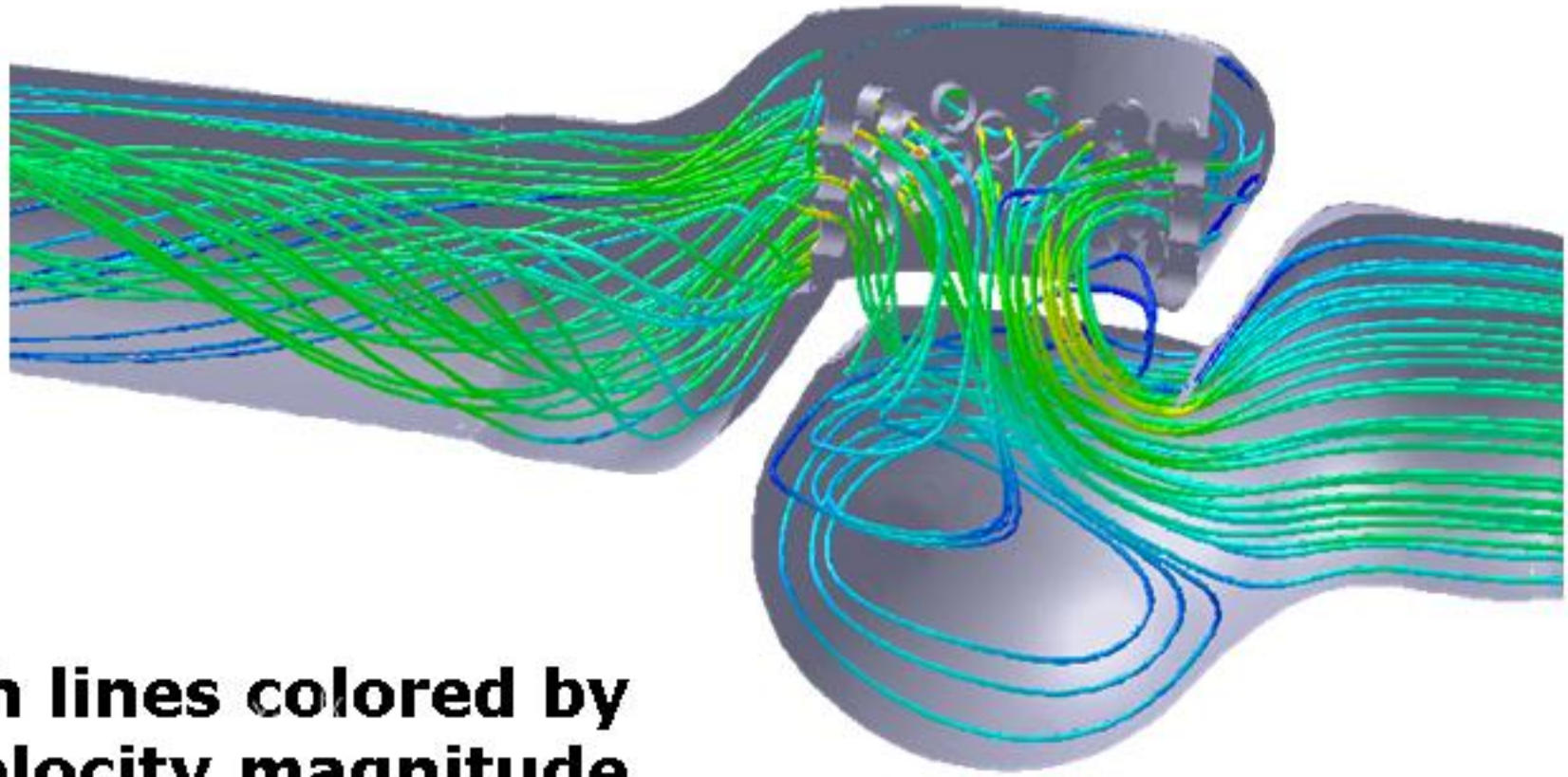
Control valve



Grid size: 400 000 cells

V&W valves

Control valve



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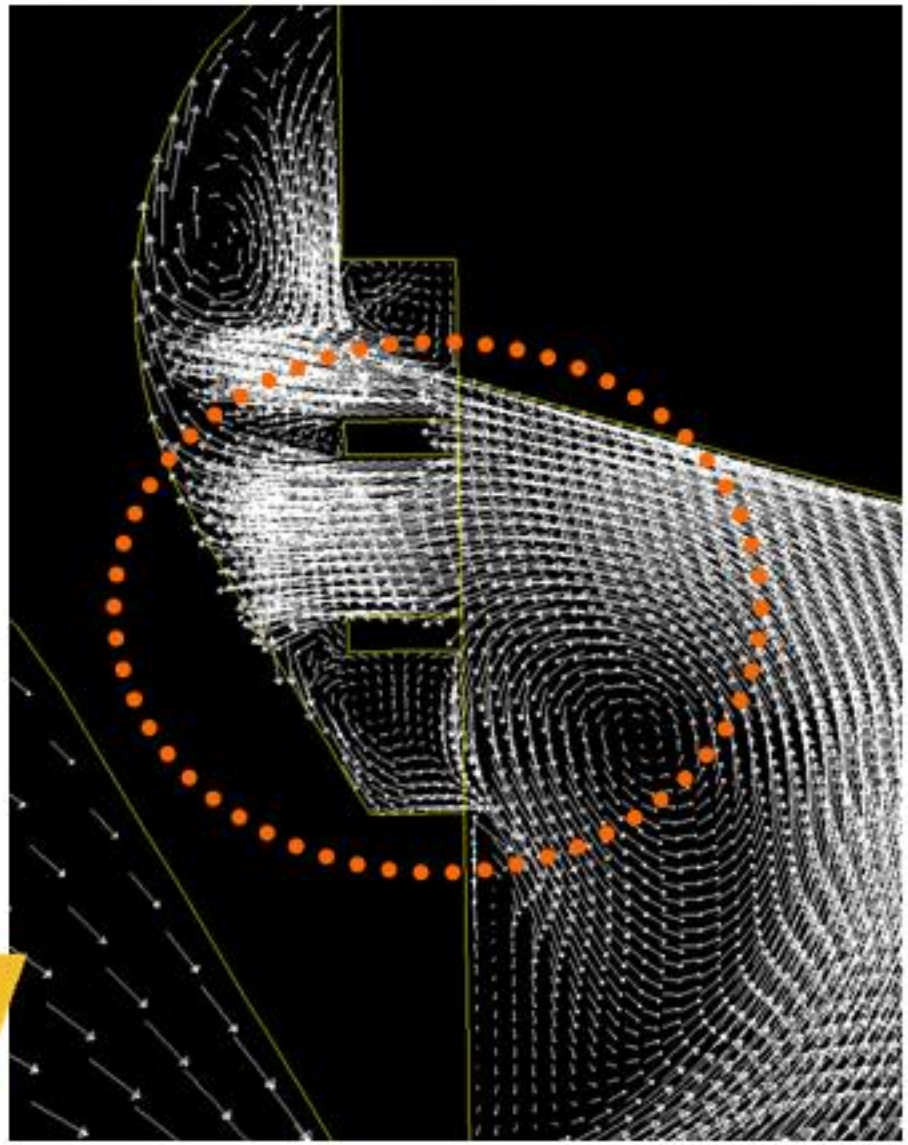
V&W valves

Control valve

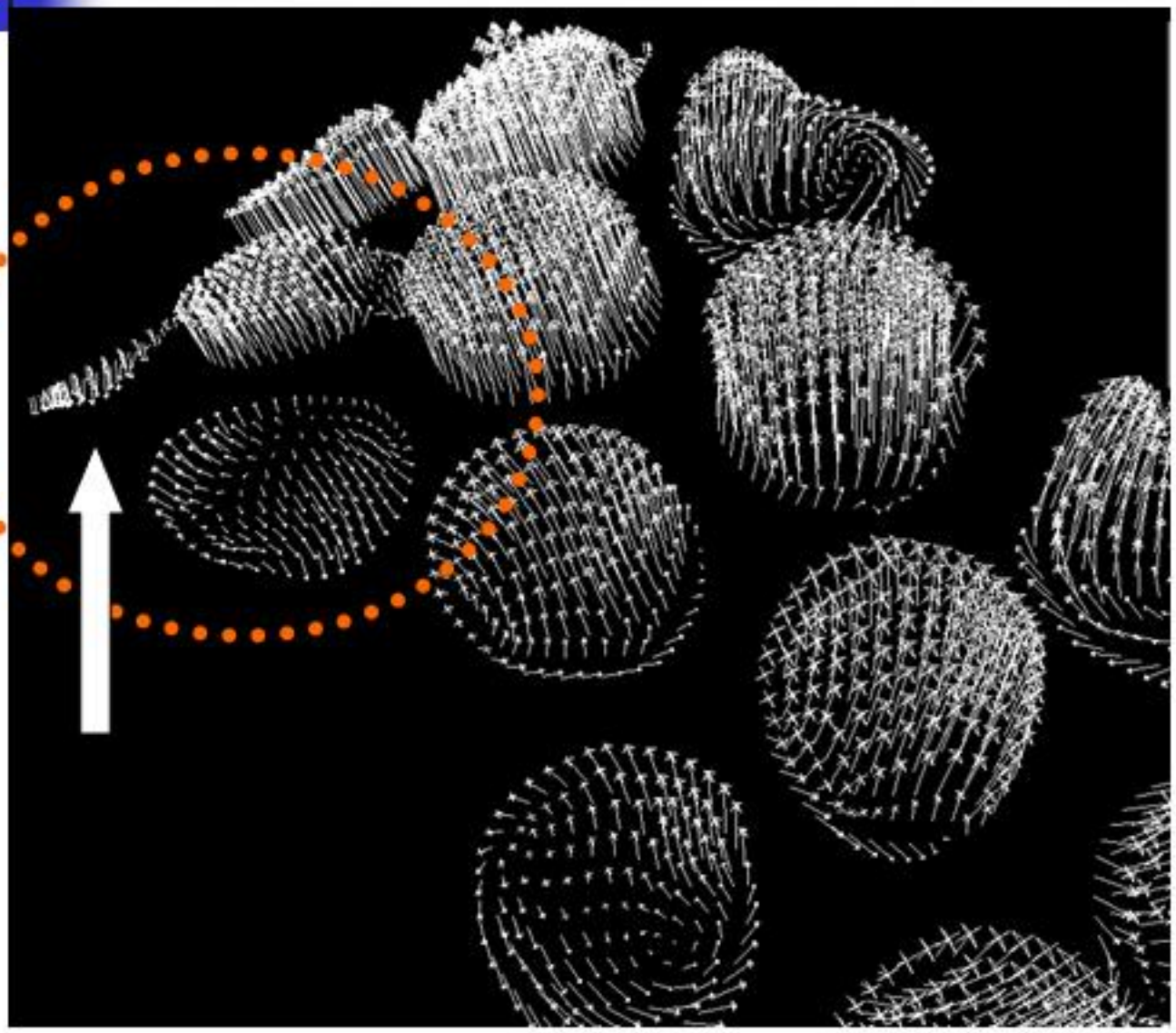


Highlight design failures:

The combined action of the **wall** (too close to the cage) and the **eddy** gets the flow out of the hole, making it ineffective.

V&W valves

Control valve



Highlight design failures:

Backflow regions in some holes

V&W valves

CFD: in summary...

- **Complements physical modelling.**
- **Provides comprehensive data not easily obtainable from experimental tests.**
- **Is more cost-effective than physical modelling.**
- **Reduces the product-to-market time scale.**
- **Answers the "what if...?" question.**
- **Highlights the cause, not just the effect.**

V&W valves