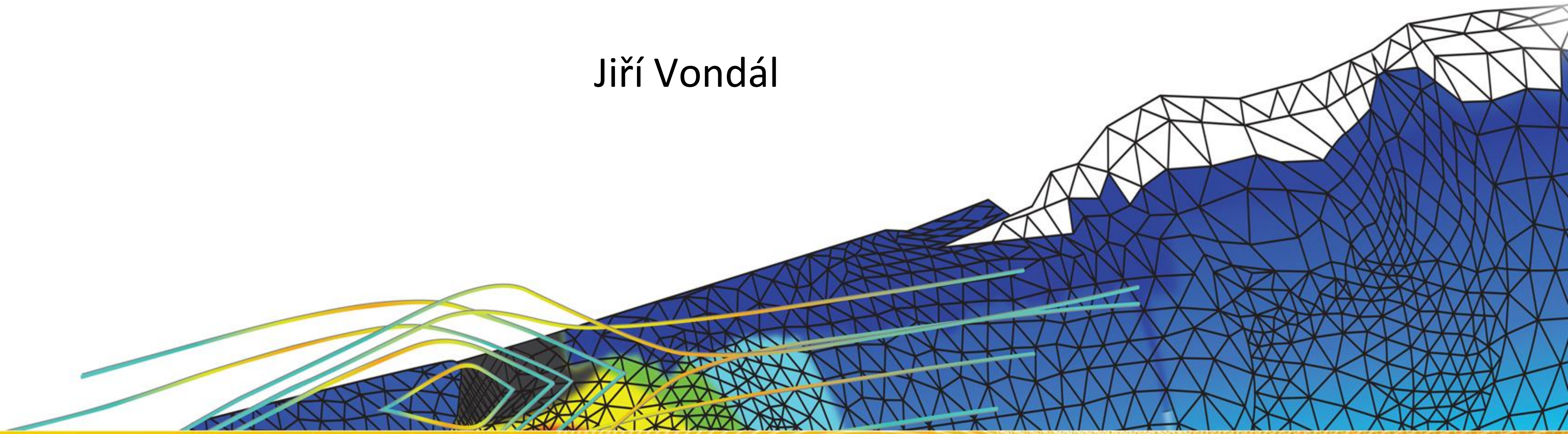
PorZo

Efficiently model the pressure drop

Jiří Vondál



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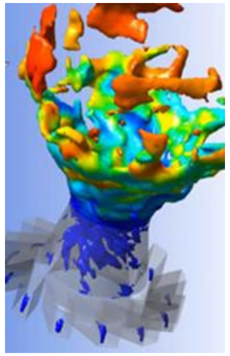

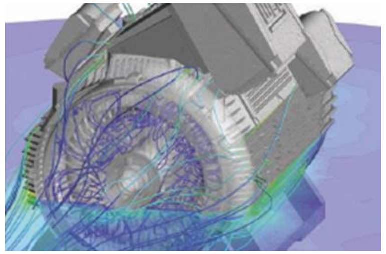

- ANSYS Channel Partner for Czech Republic and Slovak Republic from 1991
- 25 years of experience and know-how from projects and customer's support
- High expertise in Mechanical Engineering, CFD, Low and High frequency
- Stable and experienced team of engineers covers ANSYS portfolio
- Technical software developement – ACT, Standalone Apps, …
- Hardware configurations for high-intensive computations
- Proud holder of: ISO 9001:2008 and ISO 27001
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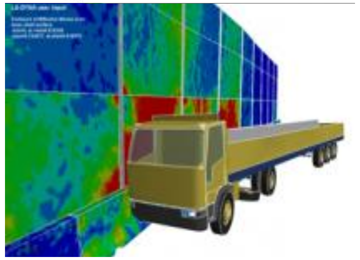

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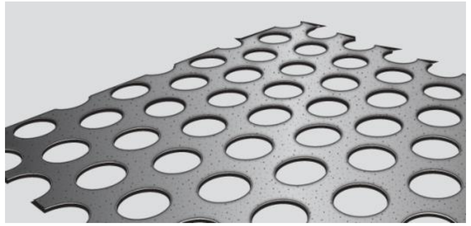
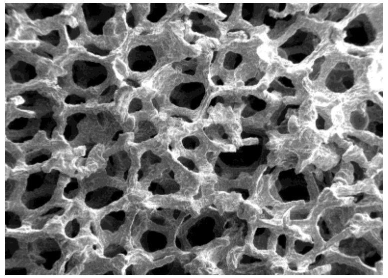
ANSYS

Specific Pressure Drop

- Simulations often need to account for pressure drop without modelling local details
- Examples:
  - Filters
  - Perforated plates
  - Porous materials
  - Flow restrictors
  - Heat Exchangers

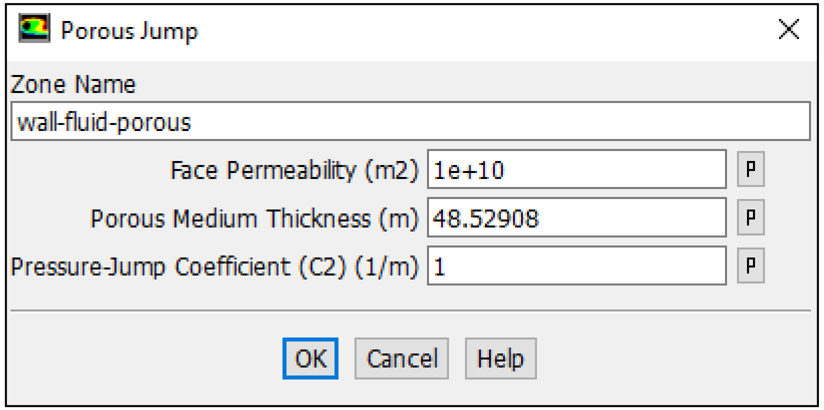




- ANSYS Fluent allows to model such a pressure restricting devices (flow restrictors), BUT with complicated and unfamiliar inputs

ANSYS Fluent procedure

- **Two choices:**
  - **Porous Jump**
  - **Porous Zone**
- **Both need to specify Viscous Resistance coefficient (1/alpha) or Face Permeability (alpha) and Inertial Resistance Coefficient (C2)**
- **Calculations are based on equations:**



$$S_i = -\left(\sum_{j=1}^{3} D_{ij} \mu v_j + \sum_{j=1}^{3} C_{ij} \frac{1}{2} \rho |v| v_j \right)$$

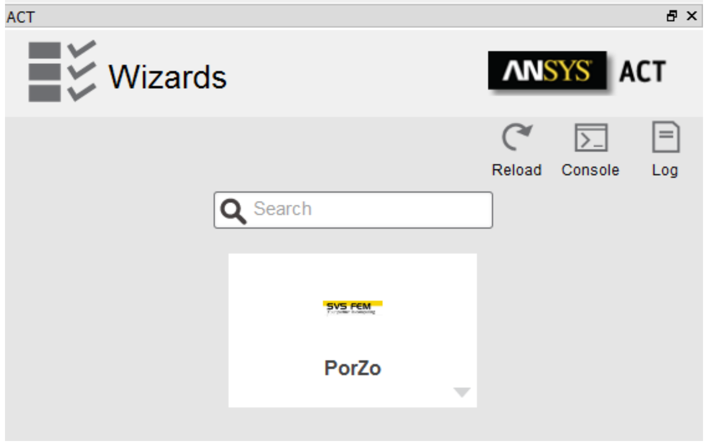
$$\Delta p = -S_i \Delta n$$

$$\Delta p = -\left(\frac{\mu}{\alpha} v + C_2 \frac{1}{2} \rho v^2 \right) \Delta m$$

ANSYS Fluent procedure

- How to obtain alpha and C2 coefficients?
  - Based on measured data – fit the coefficients
  - Based on analytical solution - calculate coefficients
- Often you would need third party program to fit data
- Time consuming procedure with potentially erroneous result
- Want to speed up?
  - Use:

PorZo



PorZo

- ACT Extension for ANSYS Fluent
- Written in IronPython
- Custom solution for linear regression
- Table or Text file based inputs of measured data
- Easy usage with detailed help including technical background
- Simple setup of Porous Jump and Porous Zone
- User-focused graphical interface

PorZo

- Two options:
  - Flow restrictor
  - Perforated plate
- General, measurement-based Flow restrictors
  - Input in a form: *velocity* × *pressure*
  - Applied either to the 2D surface or 3D fluid zone
  - Isotropic and anisotropic pressure drop
  - Suitable for: filters, tube banks, porous materials, etc.
- Perforated plates
  - Staggered, Square, 60° Offset Staggered and General arrangement
  - Thin plates with sharp edges, based on Idelchik equations
  - Applied to 2D surface only

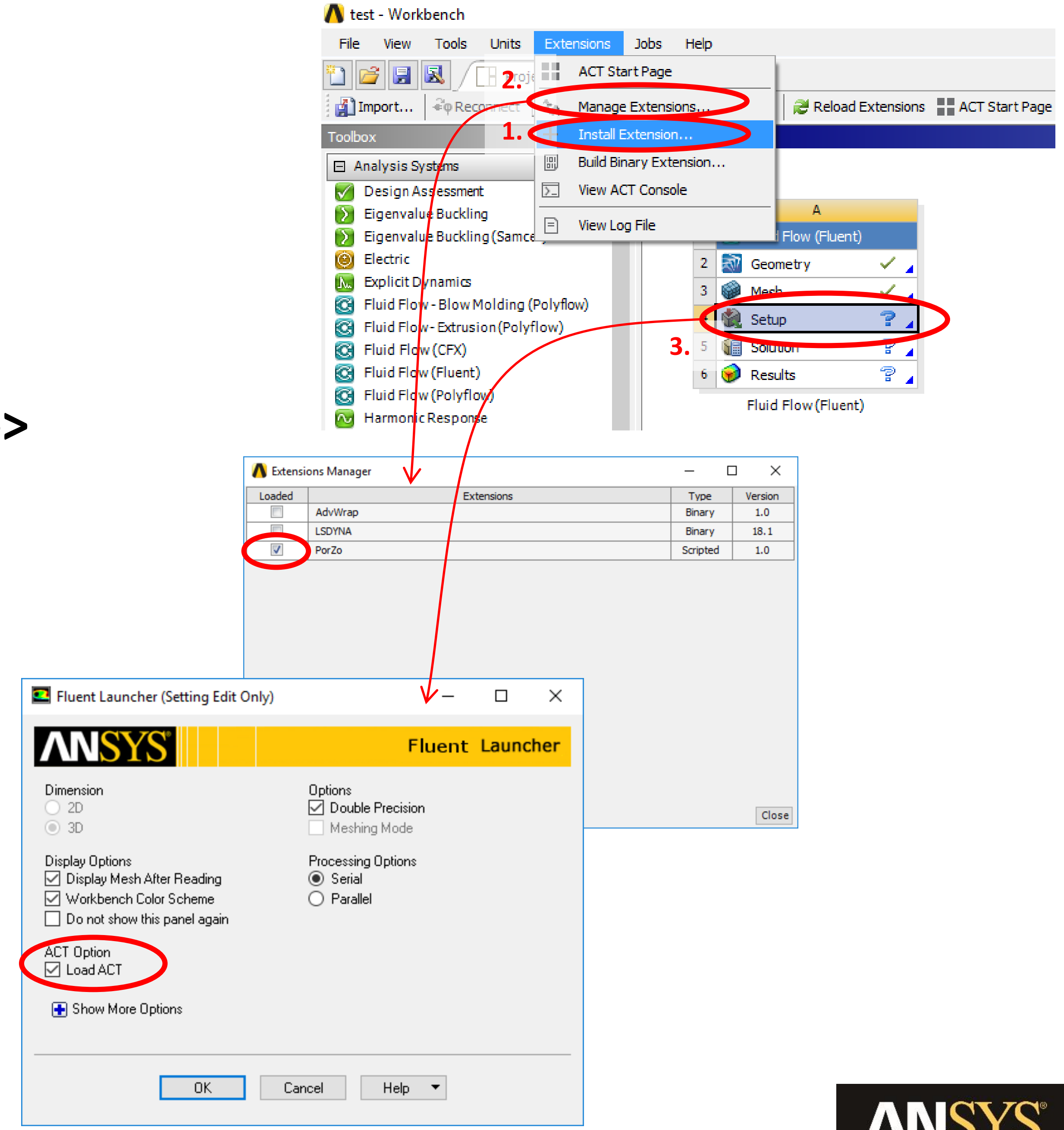
PorZo - Installation

- Use procedure for ACT installation

1) In Workbench choose menu Extension -> Install Extension select PorZo.wbex file

2) Choose menau Extension -> Manage Extensions and load PorZo

3) Run Fluent Setup and in the launcher select ACT Option -> Load ACT



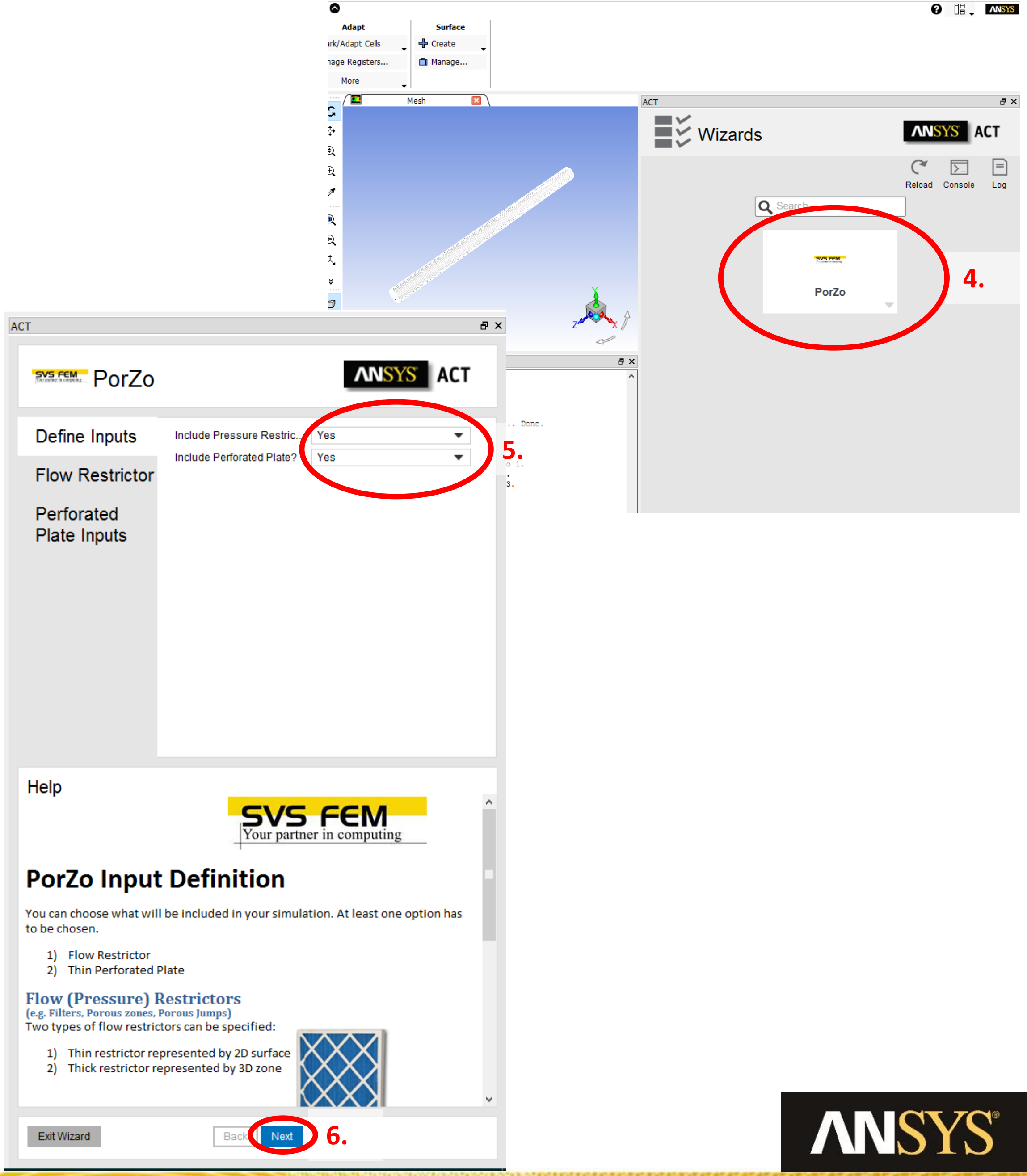
PorZo – Run and Control

- New side panel in Fluent is displayed, here you can see log window with outputs from PorZo or Console for further programming

4) Click white area with PorZo name

5) First step in PorZo is displayed – you can choose either Pressure Restrictor, Perforated Plate or both specification methods

6) Click Next button at the bottom



PorZo – Flow Restrictor – 2D

- Inputs are self-explanatory, if in doubt use help window at the bottom.

7) Choose restrictor type (2D/3D)

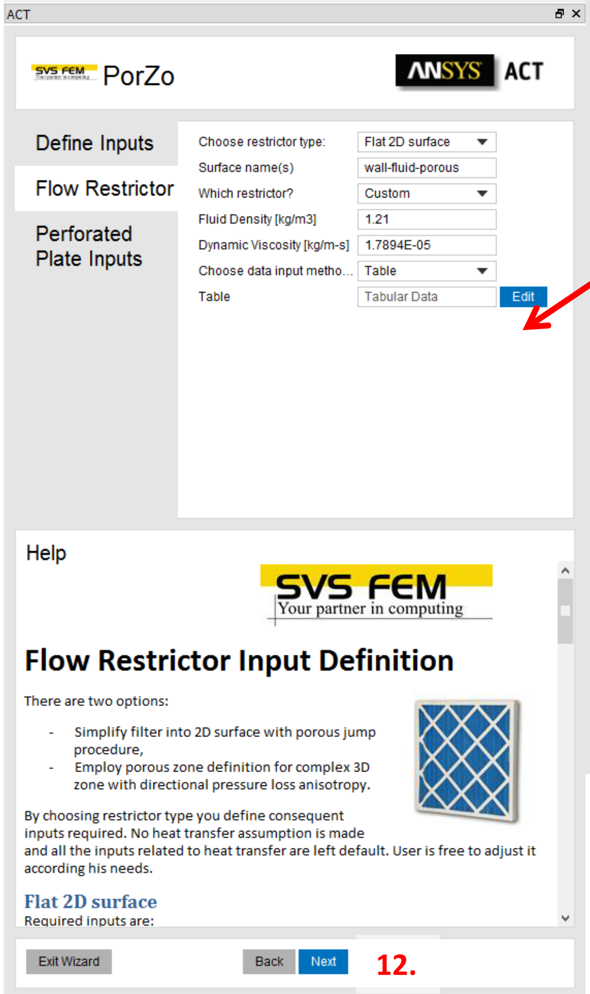
8) Type-in surface name to the text field (Ctrl-c -> Ctrl-v can be used from BC list)

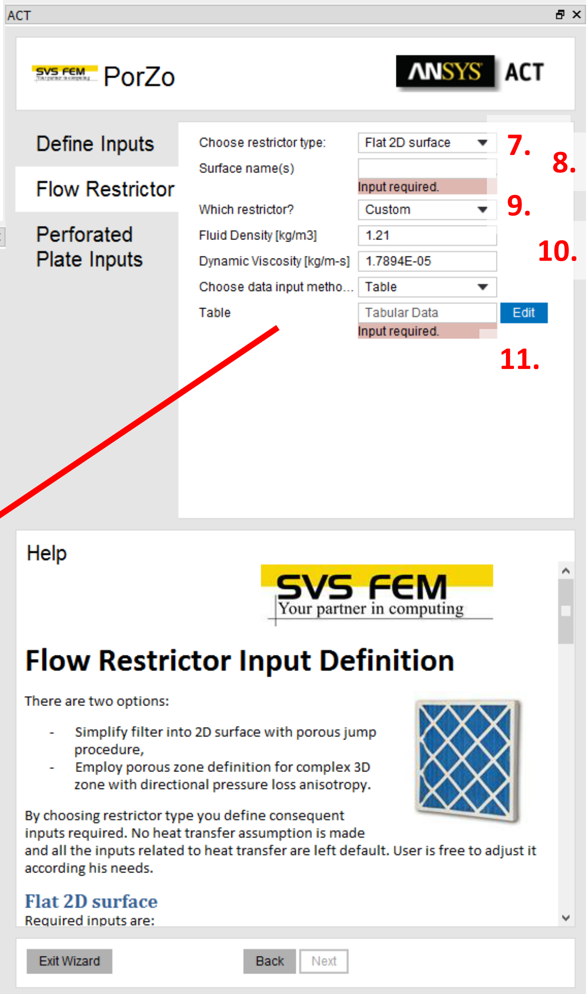
9) Specify either predefined or Custom restrictor

10) Fill in material properties bounded to measurement (density and viscosity)

11) Choose either Table-based or Text file input of measured data

12) Use Next button





Fluent output window - TUI

```
Preparing mesh for display...
Done.

Setting Post Processing and Surfaces information ...     Done.
/define/boundary-condition/zone-type wall-fluid-porous porous-jump
wall 1 and wall 5 sewn together, wall 5 deleted.
/define/boundary-condition/porous-jump (wall-fluid-porous)
wall-fluid-porous 10000000000.000000 146.923783 1.000000
```

PorZo – Flow Restrictor – 3D

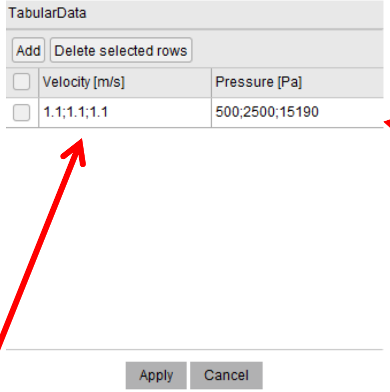
- **When you choose Direction dependent (anisotropic pressure loss) use semicolon delimiter**

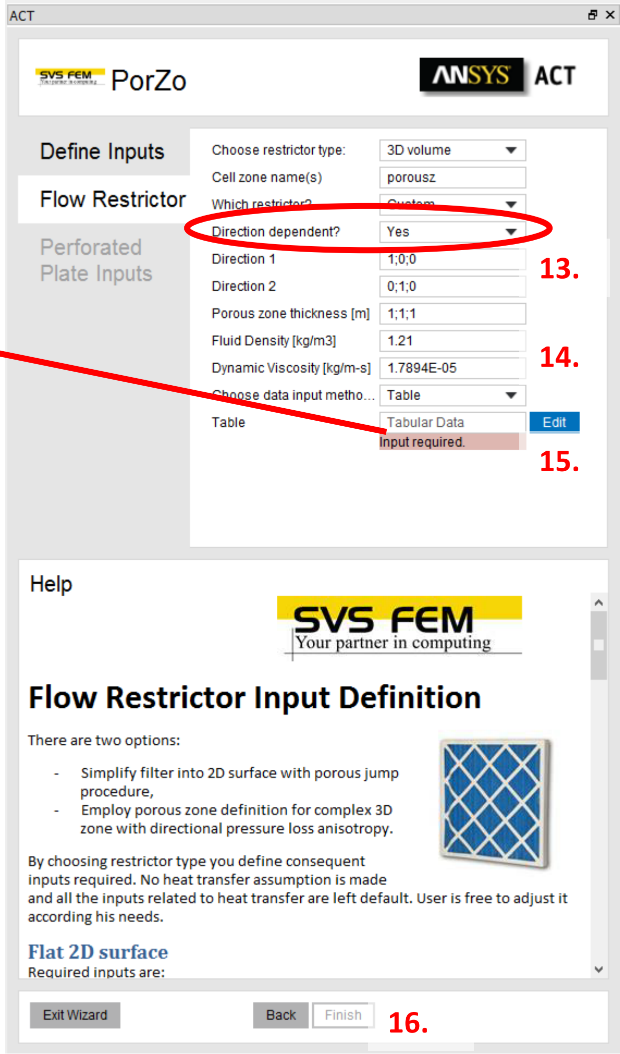
13) For Direction 1 and 2 and Porous zone thickness specify: x;y;z

14) Set material properties for the measurement conditions

15) For Table-based inputs follow the example: direction1;direction2;direction3

16) Use Next button





Fluent output window - TUI

```
> /define/boundary-conditions/set/fluid porousz () porous yes
Setting to change (use "info" for descriptions)>          direction-1-x , 1 direction-1-y , 0 direction-1-z , 0
Setting to change (use "info" for descriptions)>          direction-2-x , 0 direction-2-y , 1 direction-2-z , 0
Setting to change (use "info" for descriptions)>          porous-c-1 , 683.0135 porous-c-2 , 3415.0673 porous-c-3 , 20749.9488
Setting to change (use "info" for descriptions)>          porous-r-1 , 1e-10 porous-r-2 , 1e-10 porous-r-3 , 1e-10
Setting to change (use "info" for descriptions)>          q
```

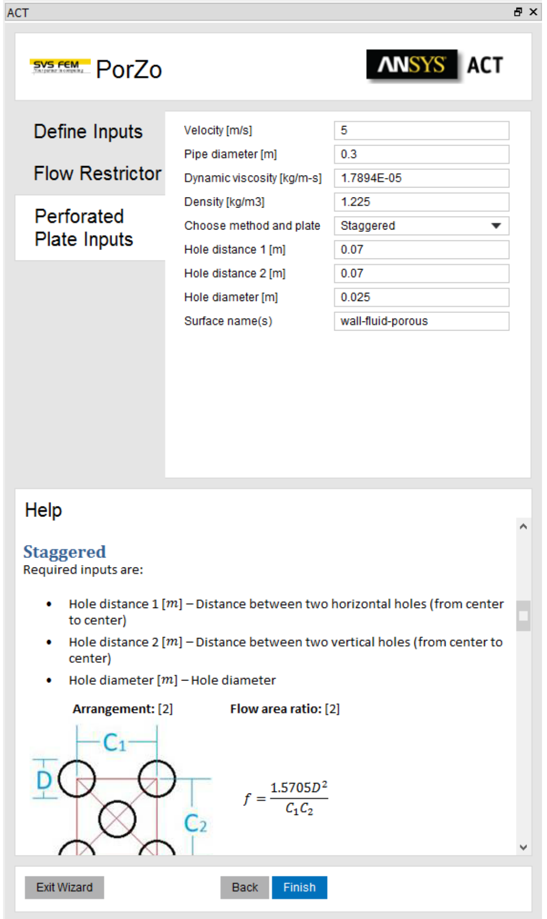
PorZo – Perforated Plate

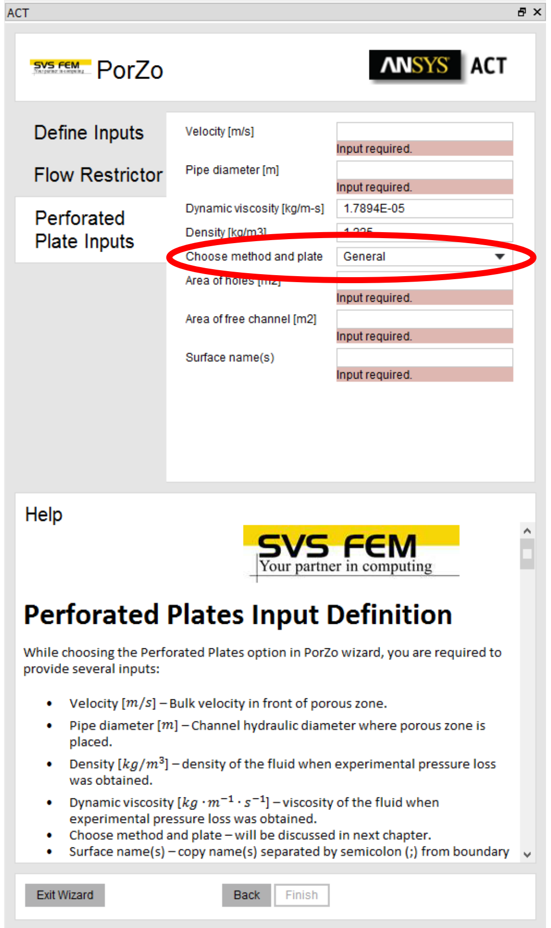
- There are four basic options to define holes in plate:
  - General
  - Staggered arrangement
  - Square arrangement
  - 60° offset staggered arrangement

17) When you choose General, specify Area of holes (F0) and Area of free channel (F1)

18) When you choose other option than General specify: Hole distance 1 (C1), Hole distance 2 (C2) and Hole diameter (D)

19) Fluid properties are meant for simulation, to determine Re range





PorZo – Flow Restrictor Theory Guide

- Non-negative Least Square Error method is utilized to fit measured data and provide positive coefficients of equation:

$$y = ax + bx^2$$

- Basic equation is used to derive other parameters:

$$\Delta p = -\left(\frac{\mu}{\alpha} v + C_2 \frac{1}{2} \rho v^2\right) \Delta m$$

- Face permeability (α) is then calculated:

$$\alpha = \frac{\mu}{a} \Delta m$$

- Inertiela resistance (C2) holds:

$$C2 = \frac{2b}{\rho \cdot \Delta m}$$

PorZo – Perforated Plate Theory Guide

- **Based on Idelchik [1] – thin, sharp edge, perforated plates:**

$$\xi = \left(1 + 0.707\sqrt{1-f} - f\right)^2 (f)^2$$

- **Where:**

$$f = \frac{F0}{F1}$$

- **Or *f* is function of arrangement (staggered, square, …)**
- **Specific corrections are applied for low-Re flows:**

Re < 10:

$$\xi = \frac{33}{Re}\frac{1}{f^2}$$

10<Re<25:

$$\xi = \frac{33}{Re}\frac{1}{f^2} + \epsilon_{0Re}\xi_{qu}$$

25<Re < 10^5:

$$\xi = \xi_{\phi}\frac{1}{f^2} + \epsilon_{0Re}\xi_{qu}$$

- **Viscous resistance is neglected and Inertial resistance holds:**

$$C_2^* = \frac{\Delta p}{\Delta m \rho \frac{v^2}{2}} = \frac{\xi}{\Delta m}$$

Questions?

- Do you have any question?
- Do you want to suggest enhancement, or new feature?
- Have you encountered any troubles running PorZo?

- Let us know:

https://www.svsfem.cz

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Thank you