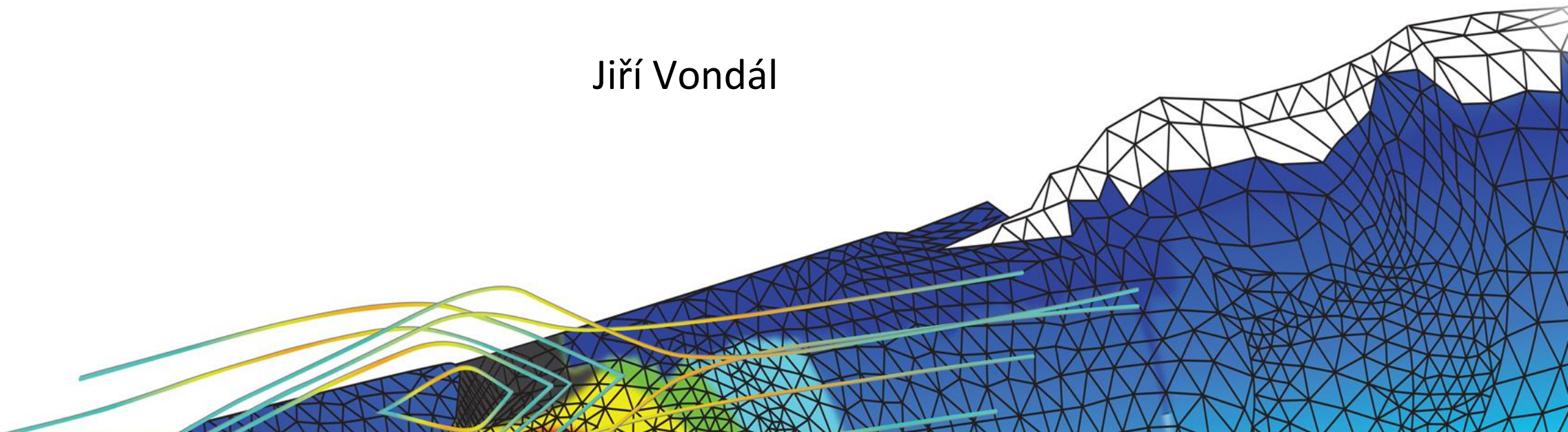


ANSYS®

PorZo

Efficiently model the pressure drop

Jiří Vondál





About SVS FEM s.r.o.

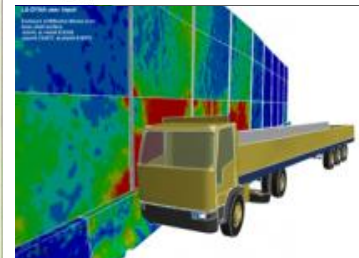
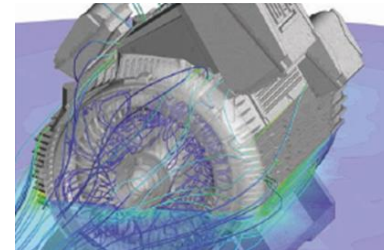
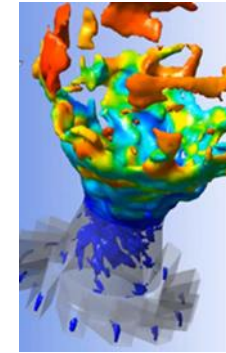
Specialized and trusted engineering company

- 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 development – ACT, Standalone Apps, ...
- Hardware configurations for high-intensive computations
- Proud holder of: ISO 9001:2008 and ISO 27001
- Member of:



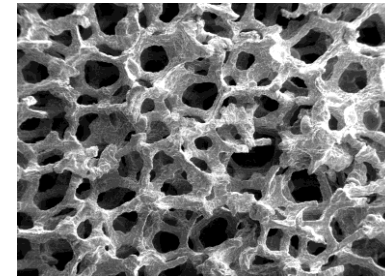
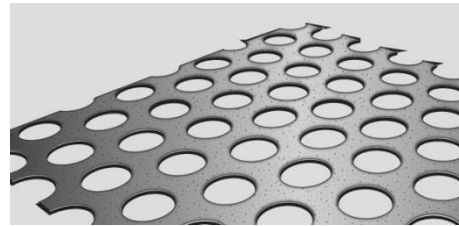
SVS FEM

Your partner in computing



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



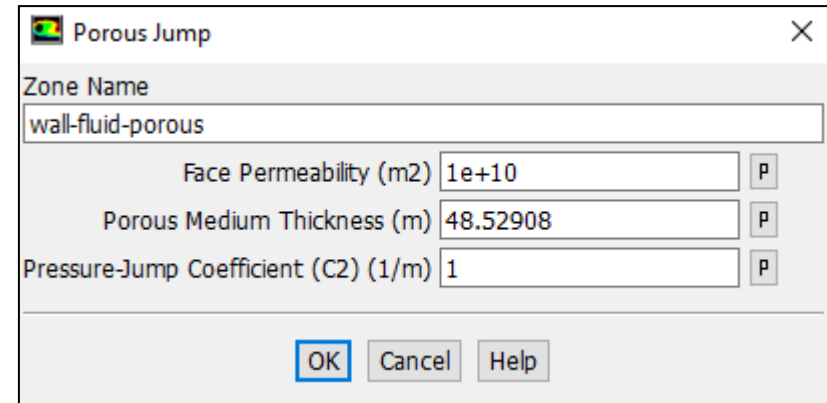
ANSYS Fluent procedure

- 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:

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

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

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



Porous Jump

Zone Name
wall-fluid-porous

Face Permeability (m2) 1e+10 P

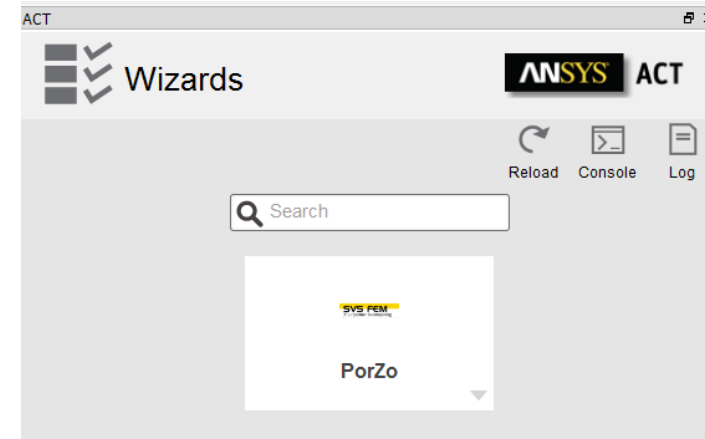
Porous Medium Thickness (m) 48.52908 P

Pressure-Jump Coefficient (C2) (1/m) 1 P

OK Cancel Help

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

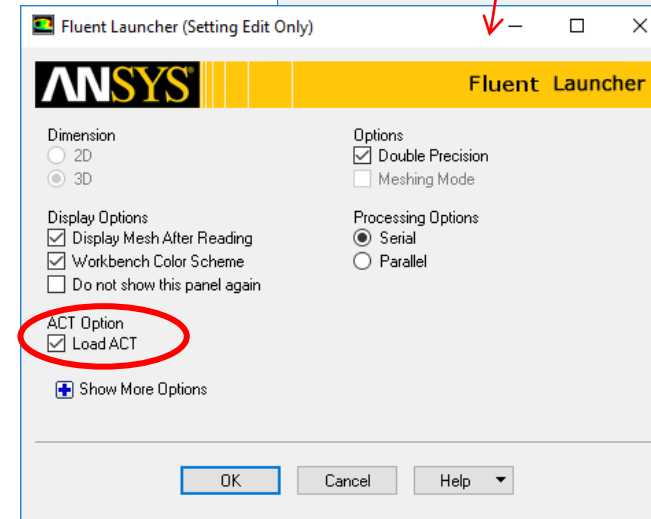
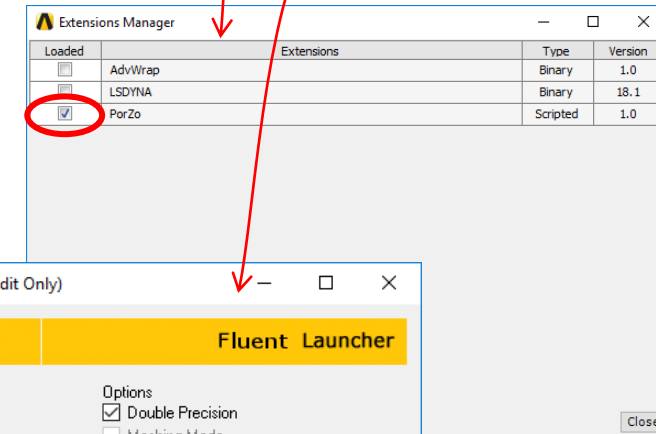
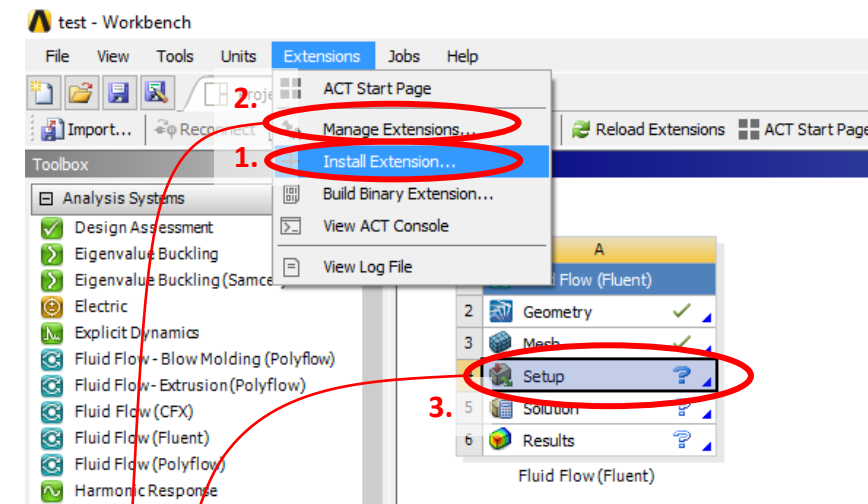
- **ACT Extension for ANSYS Fluent**
- **Written in IronPython**
- **Custom solution for linear regression**
- **Table or Text file based inputs of measured data**
- **Easy usage with detailed help including technical background**
- **Simple setup of Porous Jump and Porous Zone**
- **User-focused graphical 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 menu Extension -> Manage Extensions and load PorZo
 - 3) Run Fluent Setup and in the launcher select ACT Option -> Load ACT



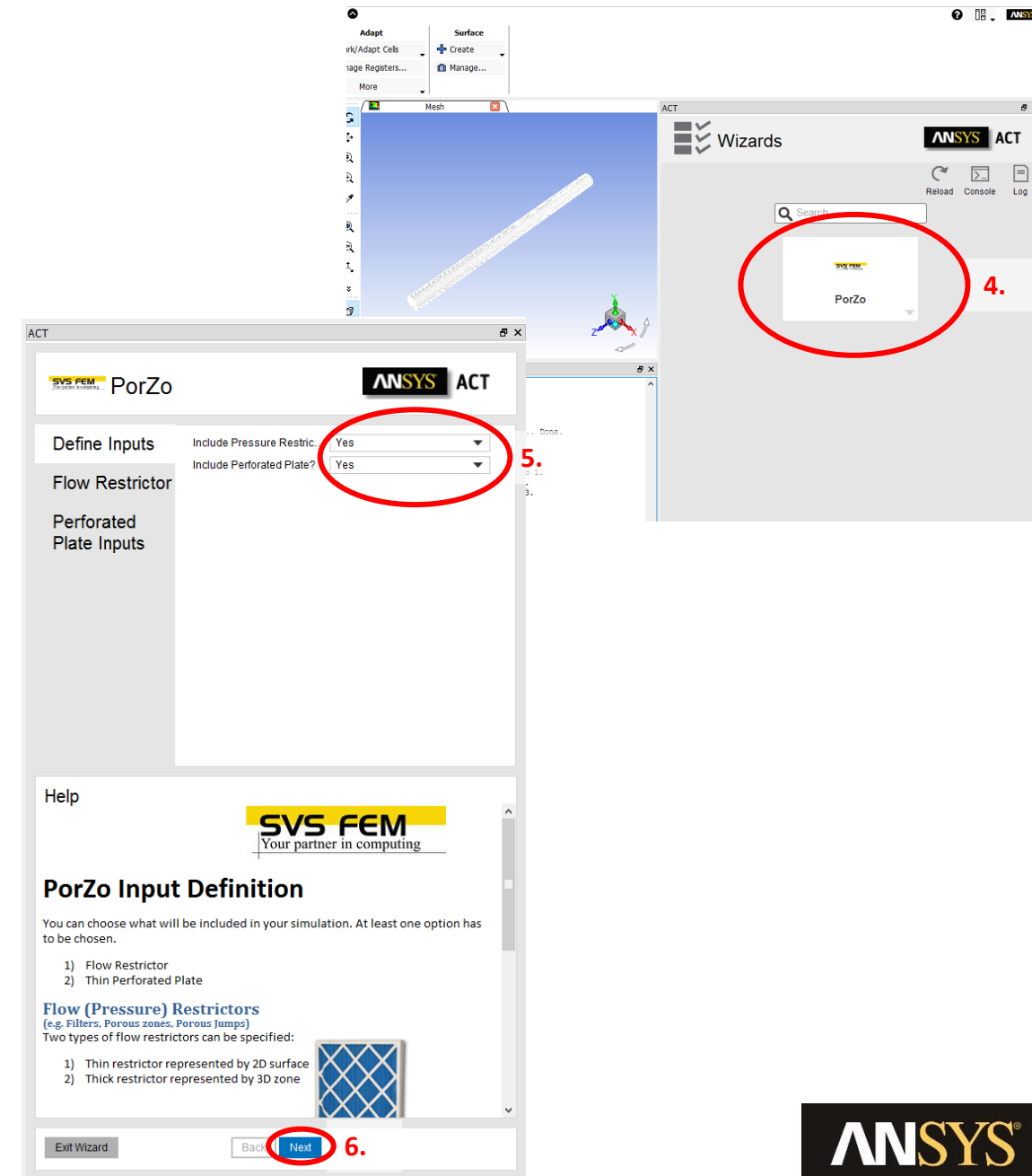
PorZo – Run and Control

- 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

ACT

SVS FEM PorZo ANSYS ACT

Define Inputs

Choose restrictor type: Flat 2D surface

Surface name(s): wall-fluid-porous

Which restrictor? Custom

Fluid Density [kg/m3]: 1.21

Dynamic Viscosity [kg/m-s]: 1.7894E-05

Choose data input method: Table

Table

Tabular Data

Edit

Help

SVS FEM Your partner in computing

Flow Restrictor Input Definition

There are two options:

- Simplify filter into 2D surface with porous jump procedure,
- Employ porous zone definition for complex 3D zone with directional pressure loss anisotropy.

By choosing restrictor type you define consequent inputs required. No heat transfer assumption is made and all the inputs related to heat transfer are left default. User is free to adjust it according his needs.

Flat 2D surface

Required inputs are:

Exit Wizard Back Next 12.

ACT

SVS FEM PorZo ANSYS ACT

Define Inputs

Choose restrictor type: Flat 2D surface

Surface name(s): input required.

Which restrictor? Custom

Fluid Density [kg/m3]: 1.21

Dynamic Viscosity [kg/m-s]: 1.7894E-05

Choose data input method: Table

Table

Tabular Data

Edit

Help

SVS FEM Your partner in computing

Flow Restrictor Input Definition

There are two options:

- Simplify filter into 2D surface with porous jump procedure,
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By choosing restrictor type you define consequent inputs required. No heat transfer assumption is made and all the inputs related to heat transfer are left default. User is free to adjust it according his needs.

Flat 2D surface

Required inputs are:

Exit Wizard Back Next

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 |

Fluent output window - TUI

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

TabularData	
Velocity [m/s]	Pressure [Pa]
1.1;1.1;1.1	500;2500;15190

Apply Cancel

ACT

SVS FEM PorZo ANSYS ACT

Define Inputs

Flow Restrictor

Perforated Plate Inputs

Choose restrictor type: 3D volume

Cell zone name(s) porousz

Which restrictor? Custom

Direction dependent? Yes

Direction 1 1;0;0

Direction 2 0;1;0

Porous zone thickness [m] 1;1;1

Fluid Density [kg/m3] 1.21

Dynamic Viscosity [kg/m-s] 1.7894E-05

Choose data input metho... Table

Table Tabular Data Input required.

Help

SVS FEM Your partner in computing

Flow Restrictor Input Definition

There are two options:

- Simplify filter into 2D surface with porous jump procedure,
- Employ porous zone definition for complex 3D zone with directional pressure loss anisotropy.

By choosing restrictor type you define consequent inputs required. No heat transfer assumption is made and all the inputs related to heat transfer are left default. User is free to adjust it according his needs.

Flat 2D surface

Required inputs are:

Exit Wizard Back Finish

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

ACT

SVS FEM PorZo ANSYS ACT

Define Inputs

Flow Restrictor

Perforated Plate Inputs

Velocity [m/s] 5

Pipe diameter [m] 0.3

Dynamic viscosity [kg/m-s] 1.7894E-05

Density [kg/m³] 1.225

Choose method and plate Staggered

Hole distance 1 [m] 0.07

Hole distance 2 [m] 0.07

Hole diameter [m] 0.025

Surface name(s) wall-fluid-porous

Help

Staggered

Required inputs are:

- Hole distance 1 [m] – Distance between two horizontal holes (from center to center)
- Hole distance 2 [m] – Distance between two vertical holes (from center to center)
- Hole diameter [m] – Hole diameter

Arrangement: [2] Flow area ratio: [2]

$f = \frac{1.5705D^2}{C_1 C_2}$

Exit Wizard Back Finish

ACT

SVS FEM PorZo ANSYS ACT

Define Inputs

Flow Restrictor

Perforated Plate Inputs

Velocity [m/s] Input required.

Pipe diameter [m] Input required.

Dynamic viscosity [kg/m-s] 1.7894E-05

Density [kg/m³] 1.225

Choose method and plate General

Area of holes [m²] Input required.

Area of free channel [m²] Input required.

Surface name(s) Input required.

Help

SVS FEM Your partner in computing

Perforated Plates Input Definition

While choosing the Perforated Plates option in PorZo wizard, you are required to provide several inputs:

- Velocity [m/s] – Bulk velocity in front of porous zone.
- Pipe diameter [m] – Channel hydraulic diameter where porous zone is placed.
- Density [kg/m³] – density of the fluid when experimental pressure loss was obtained.
- Dynamic viscosity [kg · m⁻¹ · s⁻¹] – viscosity of the fluid when experimental pressure loss was obtained.
- Choose method and plate – will be discussed in next chapter.
- Surface name(s) – copy name(s) separated by semicolon (;) from boundary

Exit Wizard Back Finish

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:

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

- Inertia resistance (C2) holds:

$$C_2 = \frac{2b}{\rho \cdot \Delta m}$$

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 < 10⁵:

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

- 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>

Jiří Vondál

jvondal@svsfem.cz

www.svsfem.cz



Thank you

