Porous media: Script to calculate parameters

In fluid dynamics simulations, porous media is modeled as a momentum loss, characterized by resistance coefficients. Porous media is applicable in a wide range of applications such as fluid flow through filters, packed beds, perforated plates, flow distributors, and tube banks. This document provides a guide on how to calculate and define the resistance coefficients using a script or spreadsheet calculator for isotropic porous media in ANSYS Discovery.

/ Solution

Porous conditions[1] can be used to model a wide variety of applications, such as fluid flow through filters, packed beds, perforated plates, flow distributors, and tube banks. The porous medium is modeled as a momentum loss, the magnitude of which involves resistance coefficients.

Porous media condition can be used in Explore as well as Refine mode.

$S_i = -(\mu/\alpha\, v_i + \frac{1}{2} C_2 \rho |v| v_i)$

where

- S_i is the momentum source which accounts for the porous loss
- C_2 is the inertial resistance
- α is the permeability
- μ is the fluid viscosity
- ρ is the fluid density
- $|v|$ is the velocity magnitude
- v_i is the velocity vector of the i^{th} component in the medium

For low-Reynolds number flows, the viscous loss typically dominates, and the inertial resistance coefficient can often be set to 0. For turbulent flows, the inertial loss typically dominates, and the viscous resistance coefficient can often be set to 0.

If you have experimental tabulated data of pressure drop as a function of velocity for a porous medium of thickness Δx, you can derive the resistance coefficients:

$\Delta P/\Delta x = -(\mu/\alpha\ v + \frac{1}{2} C2\rho v2)$

DISCOVERY SCRIPT:

Please use attached discovery script to automatically calculate the porous media coefficients and apply them. While a more comprehensive tool is under development, with the attached tool, you can calculate the isotropic porous media coefficient, that is Inertial and Viscous resistance in the streamline direction.

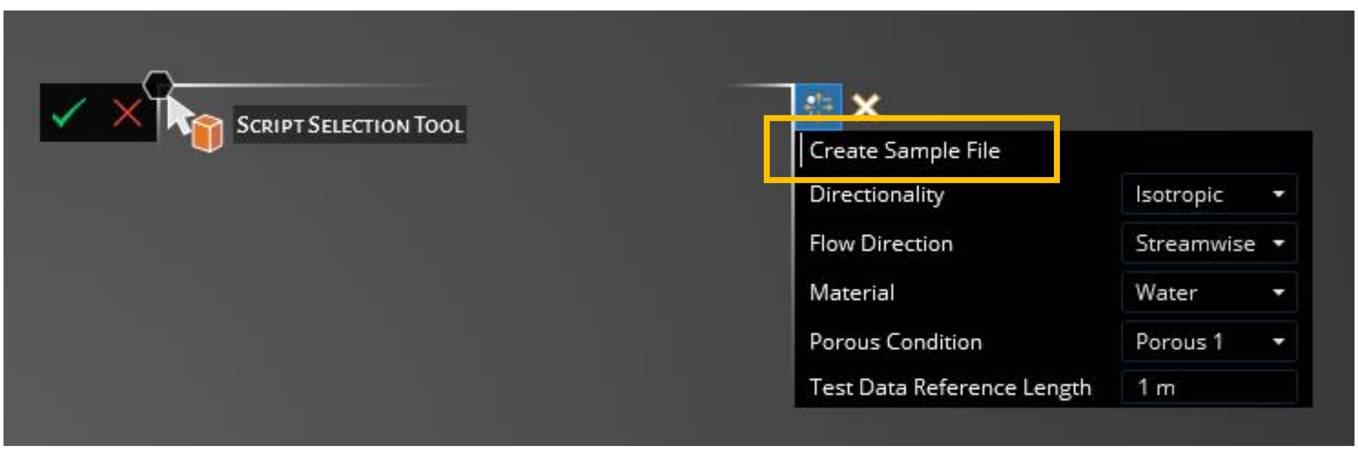
Please follow the following steps to use the script.

Step 1: Download the script file (Porous_Media_Coefficient_Isotropic.dscript) and the test_csv file (pressure velocity plot to calculate the inertial and viscous resistance coefficients).

Step 2: You can embed this script in two ways. A. Go to File Menu > Script Editor, open the script you have downloaded, and publish it as explained in the documentation[2]. B. Copy the downloaded script to the Published Scripts directory, located at <local-drive>\AppData\Roaming\Discovery\Published Scripts. After restarting Discovery, you should see the Porous Media add-in in the Add-In tab. If the add-in tab does not appear, go to File Menu > Settings > Customize > Ribbon Tabs > unhide </> Add-in.

Step 3: Once Discovery is restarted, open the .dsco file you want to work with. Prepare it for porous media simulation and define the boundary conditions, such as inlet/outlet velocity. Define the porous media region with isotropic properties (Viscous coefficient = 0/1 m^2 and Inertial coefficient = 0/1 m^-1). It is necessary to define the boundary conditions completely to use the add-in. You can refer to the Porous Media tutorial[3] to learn how to set up the boundary conditions.

Step 4: Click on the add-in, and a pop-up should appear as shown below. Select the porous media region by triple-clicking on the body. Keep the Directionality same (isotropic) and ensure the porous condition is the same as the one you have defined. Define your flow direction (Streamwise or Crossflow) and hit enter or click on the green tick mark.



Step 5: This will ask for the csv file with pressure and velocity values. Select the file and ensure you have created the file in the same format as the test.csv file provided. You can also create the sample file with the "Create Sample File" option provided in the previous step image. Note that the pressure and velocity values must be in Pa and m/s, respectively.

Step 6: The script will calculate the inertial and viscous resistance coefficients and apply them to the porous media region. You can view the results and make adjustments as necessary.

Limitations:

1. Currently, only isotropic porous media can be used with this script. A comprehensive script for bidirectional and orthotropic porous media[4] is under development. In case you want to use bidirectional or orthotropic porous media, you can use the spreadsheet calculator to calculate the inertial and viscous resistance coefficients in crossflow direction based on the experimental velocity pressure plot in the crossflow direction for your porous medium. You can then input these coefficients in the porous media definition manually.
2. The pressure and velocity values must be in Pa and m/s, respectively.
3. The script only provides a steady-state solution.
4. Treat this script like a beta features. Make sure to have a saved state of your simulation setup before using the script. It might have unexpected side effects that can corrupt your simulation.
5. Ansys cannot provide support that exceeds this document for any macros or commands that are not part of the documentation on ansyshelp.ansys.com.

/ Attachments

Filename	Description
Porous_Media_Coefficient_Isotropic.dscript	Discovery Script for Porous media coefficient calculation
test_csv	Spreadsheet as input data for the script, as pressure velocity plot to calculate the inertial and viscous resistance coefficients
Porous_Media_coefficient_calculator.xls	Excel sheet to calculate the porous media coefficients manually

/ References

[1]Documentation for Porous media:
https://ansyshelp.ansys.com/Views/Secured/corp/v231/en/discovery/UDA/user_manual/physics/fluids/topics/c_fluids_porous_curve_fit.html

[2]How to Publish a script:
https://ansyshelp.ansys.com/account/secured?returnurl=/Views/Secured/corp/v231/en/discovery/UDA/user_manual/scripting/topics/t_scripteditor_publish.html

[3]Porous Media tutorial: https://share.vidyard.com/watch/vBinSjFxoJL9B5ibPLEjxv?

[4]Bidirectional and Orthotropic Porous Media:
https://ansyshelp.ansys.com/Views/Secured/corp/v231/en/discovery/UDA/user_manual/physics/fluids/topics/r_fluids_porous_birectional.html

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