

Numerical simulation of flow through a twilled Dutch weave mesh

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A metal woven mesh is often used for filtration because of its highly accurate apertures, high pressure and heat resistances, and reusability after cleaning. There are four typical types of woven meshes: plain weave, twilled weave, plain Dutch weave, and twilled Dutch weave meshes. A twilled Dutch weave mesh is superior filter media in terms of their high mechanical strength and tiny apertures. However, because the twilled Dutch weave mesh has high flow resistivity due to its complex flow paths, it is crucial to predict the pressure drop with high accuracy for a filtration process. In the present study, we first proposed a calculation model for estimating the aperture size of the twilled Dutch weave mesh to thoroughly understand the aperture structure. Next, the effect of the aperture structure of the twilled Dutch weave mesh on the flow resistivity was clarified using a numerical simulation. The lattice Boltzmann method with BGK approximation was used for the fluid calculation. The immersed boundary method was applied to the solid boundary conditions of the mesh.

In the twilled Dutch weave mesh, it can be seen that there are three areas that provide apertures: area 1, the space made between two parallel wefts; area 2, the space made between three wefts; and area 3, the space between two wefts and a warp. We proposed the calculation model for estimating each aperture size by considering the maximum diameter of a spherical particle passing through each aperture. As observed in the numerical simulations, the drag force of the twilled Dutch weave mesh increased at the inside aperture where the volume fraction increased, and was trimodally distributed in the thickness direction. The drag force at the center in the thickness direction also varied with the local torsion of the flow path inside the mesh. This local torsion could be calculated using the proposed calculation model for estimating the aperture size. Because of the complex flow path of the Dutch weave mesh, we applied the Kozeny–Carman equation to represent the flow resistivity and derived an equation for estimating the pressure drop. The validity was verified experimentally in a laminar flow.

Based on the above, a twilled Dutch weave mesh could theoretically be designed using the proposed calculation model for estimating the aperture size, and a rational and highly accurate prediction of the pressure drop across the twilled Dutch weave mesh could be made using the derived estimation equation.