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Closure of Distributed Element Roughness Modeling for Deterministic Roughness Morphologies Using DNS SAMUEL ALTLAND, HAOSEN XU, XIANG YANG, ROBERT KUNZ, Penn State University, Mechanical Engineering — Design for cooling effectiveness in internal flow systems relies on accurate models for dynamic losses and heat transfer. In these systems (e.g., gas turbine blades, intercoolers), thousands of individual passages of varying configuration and roughness morphology can be present, rendering resolved modeling of each passage using CFD methods impractical. Even RANS modeling requires sublayer resolution, due to the comparatively low Reynolds numbers present and the small geometric scales of the explicitly resolved deterministic roughness elements (e.g., turbulators, wavy fins, etc. . .), and this leads to mesh requirements O(10^4-10^6) degrees of freedom per passage. Accordingly, a volumetric roughness modeling approach, distributed element roughness modeling (DERM) is being developed to enable orders of magnitude lower computational resources in these systems. In this approach, which draws on Eulerian two-fluid modeling, and is akin to Immersed Boundary Methods, the detailed geometry of roughness elements is not resolved, but rather the morphology is represented by volume fraction and volume fraction gradient distributions. Attendant interfacial forces due to drag, turbulence dispersion and recently identified spatial dispersion forces are imparted on the flow. In this work we employ DNS modeling of a host of several different cube arrays and a classic V-shaped turbulator configuration. The DNS statistics are interpreted and applied to calibrate the DERM model for each of the morphologies studied.

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