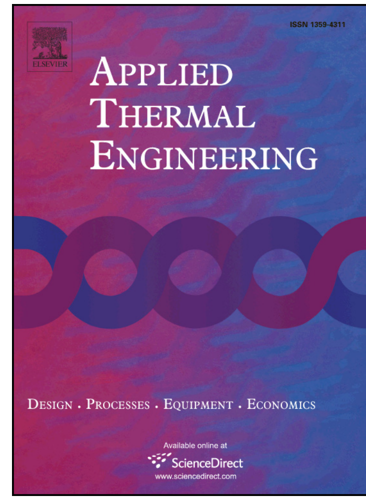

Convective heat transfer of turbulent decaying swirled flows in concentric annular pipes

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Convective heat transfer of turbulent decaying swirled flows in concentric annular pipes

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Abstract

The heat transfer characteristics of turbulent decaying swirled flows in concentric annular pipes is investigated numerically by means of CFD simulations using the OpenFOAM package. The simulations are performed for different Reynolds numbers and swirl angles at the duct inlet. By including cases with large temperature differences between the fluid and the wall, also the effects of radial temperature gradients on the velocity distribution are accounted for. A novel correlation, holding locally, is proposed and is presented in a form similar to the classical Sieder-Tate correlation, including an additional term to address the influence of the swirled flow. In a similar fashion, a correlation for the friction factor is given in the form of the Petukhov formula, yet with an additional swirl-related term. Also a formula assessing the swirl decay rate is presented. This allows global correlations to be extracted by solving the local ones over the pipe length in a system and integrating.

Keywords

Convective heat transfer, Friction factor, Decaying swirled flow, Concentric annular pipe, OpenFOAM

1 Introduction

Heat transfer and its enhancement are widely investigated research topics due to their importance in a huge number of practical engineering applications. While for laminar flow in simple geometries analytical and numerical solutions are available, heat transfer coefficients in turbulent flow usually rely on empirical equations based on experimental or numerical data. Thus, a number of correlations, relating the Nusselt number to the Reynolds and to the Prandtl numbers for different geometries and flow conditions, have been proposed over the years and are available in the literature.

Recalling the basic relationship for heat transfer by convection,

$$\dot{Q} = hA\Delta T \;, \tag{1}$$

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