CHEMICAL ENGINEERING TRANSACTIONS

VOL. 35, 2013

A publication of AIDIC
The Italian Association of Chemical Engineering
www.aidic.it/cet

Guest Editors: Petar Varbanov, Jiří Klemeš, Panos Seferlis, Athanasios I. Papadopoulos, Spyros Voutetakis

ISBN 978-88-95608-26-6; **ISSN** 1974-9791

The Modified Analogy of Heat and Momentum Transfers for Turbulent Flows in Channels of Plate Heat Exchangers

Olga P. Arsenyeva [a], Leonid L. Tovazhnyanskyy [b], Petro O. Kapustenko *[b], Oleksiy V. Demirskiy [a]

[a]AO SPIVDRUZHNIST-T LLC, 2 Krasnoznamenny Per., 61002, Kharkiv, Ukraine
[b]National Technical University "Kharkiv Polytechnic Institute", 21 Frunze Str., 61002, Kharkiv, Ukraine
petro.kapustenko@kpi.kharkov.ua

Plate Heat Exchangers (PHEs) are one of the efficient types of contemporary heat exchangers with intensified heat transfer. Their application in process industries save space and construction material, increase reliability and operability compare to conventional shell and tubes heat exchangers. The heat transfer processes in PHE takes place in the channels of complex geometry, formed by plates pressed from sheet metal. The form of plate corrugations strongly influences the heat and hydraulic performance and the whole heat transfer efficiency of the PHE. The investigations on heat transfer in PHE channels, available in literature, generalize data in form of empirical correlations. In these correlations the influence of fluid velocity and its properties is usually accounted by functions of Reynolds and Prandtl numbers. The forms of such functions and predicted by them character of this numbers influence are significantly varying and are specific for investigated channels geometries and the range of experimental conditions. To establish such functions in straight tubes and channels the different forms of analogy between heat and momentum transfers proved helpful.

In present paper the modification of Von Karman analogy for turbulent flow in PHE channels is proposed. The resulting equation enables to calculate film heat transfer coefficients in PHE channel on a data of hydraulic resistance of the main heat transfer field of the channel, accounting for the influence of channel geometry, flow velocity and fluid properties. The comparison with experimental data for water flow in models of PHE channels main corrugated fields is presented. It is shown the good accuracy of prediction for film heat transfer coefficients. In the limiting case, where corrugations are parallel to plate axis, the results of calculations by proposed Equation are in excellent agreement with Equation published for straight tubes and channels by Gnielinski (1975). The maximal discrepancy 5% in all the range of that Equation applicability ($2300<Re<105$, $0.6<Pr <104$), which was confirmed in more recent publications. On the other hand at $Pr=1$ the results of calculations are in good agreement (biggest discrepancy 7 %) with Equation proposed by Arsenyeva et al. (2012), which is based on modified Reynolds analogy and proved accurate for PHE channels in a wide range of corrugations forms. The analysis of the Prandtl number influence on heat transfer in PHE channels is performed. It explains the difference of Pr powers, which varies from 0.6 to 0.3 at correlations reported in different experimental papers on heat transfer in PHEs. The proposed Equation can be used for modelling of PHEs heat transfer performance in a wide range of different applications in process industries.

The paper proposes the Equation, based on Von Karman analogy of heat and momentum transfer, gives good prediction of the influence on heat transfer of Prandtl number in channels of PHEs. It allows extrapolation of empirical correlations obtained for a limited range of Prandtl numbers for wider applications and can be used for optimization of PHEs in different process conditions.

Acknowledgements

Financial support from EC Projects INTHEAT (contract № FP7-SME-2010-1-262205) and EFENIS (contract № ENER-FP7-296003) is sincerely acknowledged.