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LOCAL NUSSELT NUMBERS FOR FLOW THROUGH ASYMMETRICALLY HEATED PARALLEL PLATE CHANNELS

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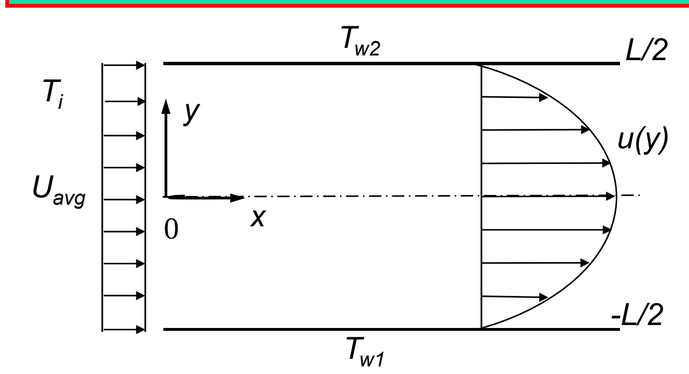
ABSTRACT

Superposition relations to calculate local Nusselt number from the values corresponding to the boundary condition of first kind have been developed for asymmetrically heated parallel plate channels. These relations have been numerically validated.

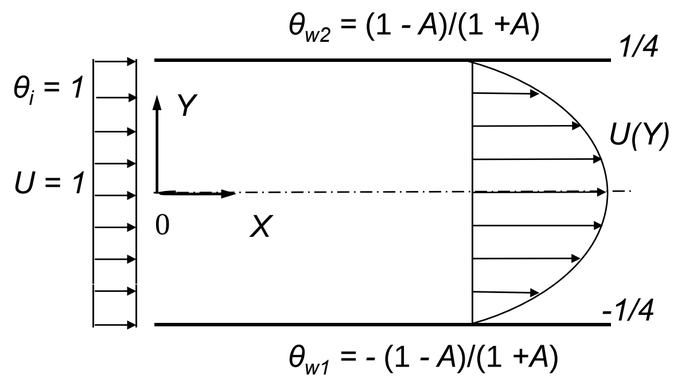
INTRODUCTION

The applicability of the Superposition relations has been mentioned in the literature in obtaining the solutions of energy equation and derived quantities, (such as Nusselt number) for different boundary conditions but, **such explicit relations are not available for the case of constant but unequal temperatures**.

GEOMETRY CONSIDERED



(a) Dimensional



(b) Non-dimensional

Fig. 1 Physical model and the coordinate system

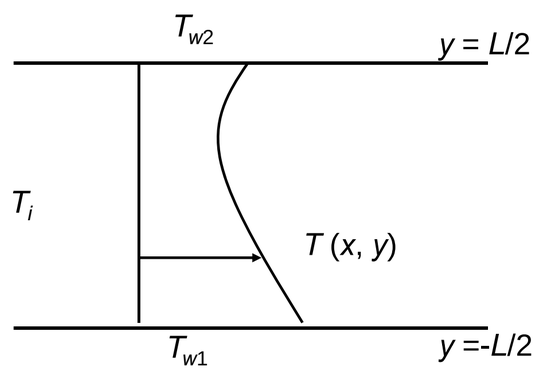


Fig. 2 Representation for a general *A*

SUPERPOSITION RELATIONS

$$\theta(X,Y;A) = 1 + \frac{\{1-\theta(X,Y;A=0)\}}{2}(\theta_{w1}-1) + \frac{\{1-\theta(X,-Y;A=0)\}}{2}(\theta_{w2}-1)$$

$$\theta_1(X, Y) = (T_1(x, y) - T_{w1})/(T_i - T_{w1})$$
$$\theta_2(X, Y) = (T_2(x, y) - T_{w2})/(T_i - T_{w2})$$

$$Nu_{1x} = \frac{Nu_{11}(\theta^* + 1)}{(\theta^* + 1)(A + 1) - 2A} + \frac{Nu_{12}(\theta^* - 1)A}{(\theta^* + 1)(A + 1) - 2A}$$

$$Nu_{2x} = \frac{Nu_{12}(\theta^* - 1)}{(\theta^* + 1)(A + 1) - 2} + \frac{Nu_{11}(\theta^* + 1)A}{(\theta^* + 1)(A + 1) - 2}$$

$$\theta^* = 1 - 2(1 - \theta_1^*)$$

$$\theta_1^* = (T_{b1}(x) - T_{w1})/(T_i - T_{w1})$$
$$\theta_2^* = (T_{b2}(x) - T_{w2})/(T_i - T_{w2})$$

Where $\theta = (T - \overline{T}_w)/(T_i - \overline{T}_w)$

$\theta^* = (T_b - \overline{T}_w)/(T_i - \overline{T}_w)$

RESULTS

(a) Nu_{1x}

(b) Nu_{2x}

Fig. 3 Variation of (a) Nu_{1X} and (b) Nu_{2X} with X^* as obtained by Superposition Relations

VALIDATION

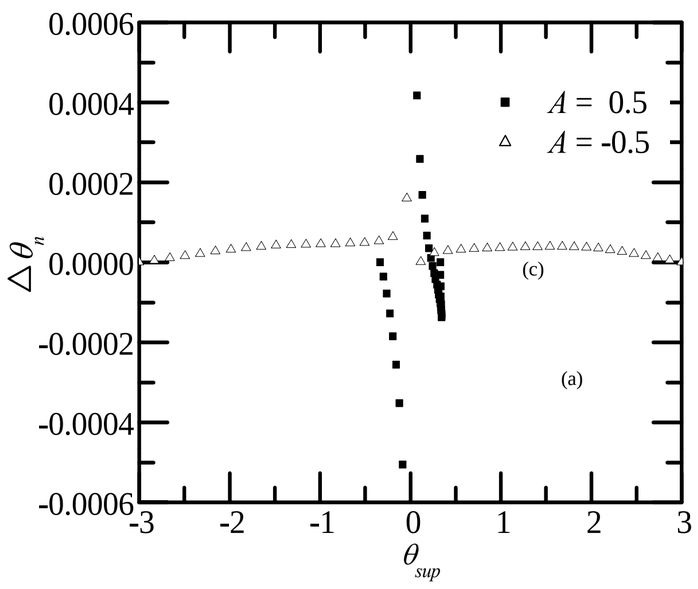
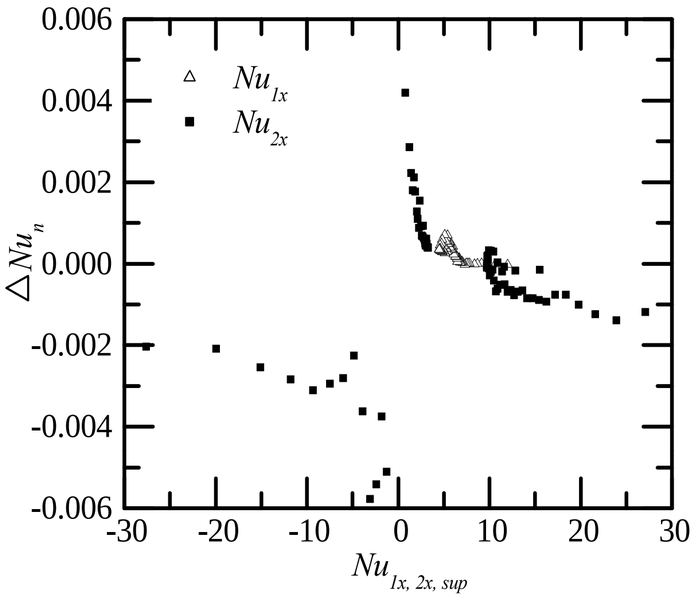
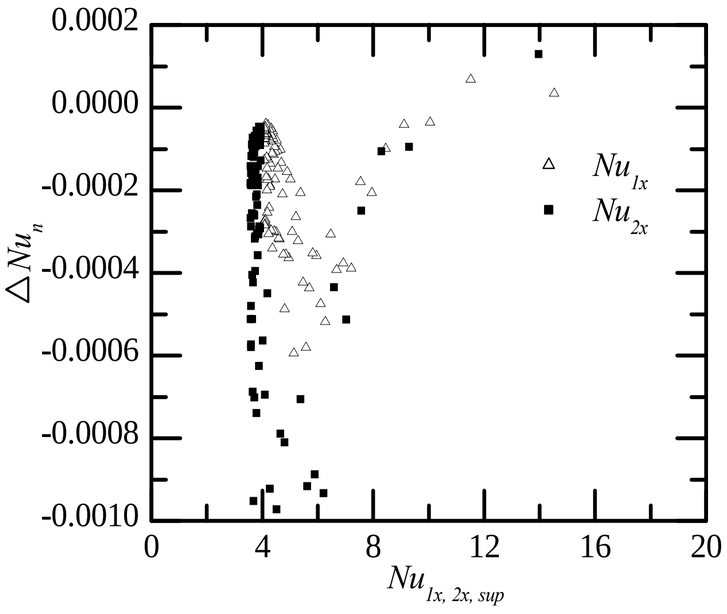


Fig. 4 Normalized difference between the θ values obtained numerically and by superposition



(a) A = 0.5



(b) A = - 0.5

Fig. 5 Normalized difference between the Nusselt number values obtained numerically and by superposition (a) A = 0.5 and (b) A = - 0.5

CONCLUSIONS

- Explicit relations to calculate local Nusselt number values at the two walls for any A from the values for A = 0 have been developed. Where, A is the asymmetry defined as the ratio of the wall temperatures in excess of the fluid inlet temperature.
- The expressions have been validated by comparing with the numerically obtained values employing a simple model.
- The relations can be expected to be of general validity as long as geometric and flow symmetry are preserved.