Proceedings of the 10th International Conference on Fluid Flow, Heat and Mass Transfer (FFHMT'23)
Canada – June 07-09, 2023
Paper No. 125
DOI: 10.11159/ffhmt23.125

Single Augmented Swirling and Round Jet for Improvement of Impingement Heat Transfer from a Flat Plate

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Extended Abstract
We propose a geometrical mechanism that generates an augmented swirling and round jet for impingement heat transfer from a heated flat plate which is predicted using 3-D RANS numerical simulations. Important parameters such as jet-plate distance (H/D), Reynolds number (Re) [1,2] and the split ratio (SR) which defines the percentage of flow through the axial and tangential ports each resulting in a single augmented jet (swirling and round jets) of diameter D = 30mm. Also, Numerical simulations for the conventional round jets and swirling jets [3] generated by the geometrical vane-swirler (at three different vane angles θ = 45^0, 60^0, and 30^0) each of jet diameter D = 30 mm is performed for the Reynolds number (Re = 6000 - 15,000) and at a jet-plate distance (H = 1.5D – 4D). A comparative study of their impingement heat transfer characteristics is studied with the proposed augmented jet. It is inferred that at a smaller jet-plate distance H =1.5D or H/D =1.5, the proposed augmented jet and vane swirler jets showed an improved heat transfer from the impingement surface (heated flat plate). The conventional round jets showed maximum heat transfer at H = 4D. From the numerical analysis, for the proposed augmented jet, at an optimized jet-plate distance H=1.5D and split ratio (SR-4), the average Nusselt number (Nu_{avg}) is enhanced by 88% than the conventional round jet and 101% than the vane-swirler jet counterpart. Similarly, an enhancement in the stagnation Nusselt number (Nu_{stg}) of 189% than the round jet is predicted for the proposed augmented jet at SR-4.

Keywords:
Jet impingement, Augmented heat transfer, RANS, round & swirl jet.

Objective and scope:
The objective of this work is to enhance jet impingement the convective heat transfer from a heated flat plate using this augmented jet mechanism. The augmented jet is a combination of swirling and round jet at 4 different split ratios, resulting in a single jet of 30mm for which impingement heat transfer is studied using numerical simulations based on RANS model [4] at different jet-plate distance (H/D) and Reynolds number (Re). The results are compared with round and swirling jets of 30mm.

Results:
The important parameters are the jet-plate distance (H/D), and the Reynolds number (Re) and split ratio (SR) and its effect on heat transfer is presented for the proposed augmented jet. Figure 1 presents the effect of SR, Re, and H/D on heat transfer. The optimal conditions for maximum heat transfer are at SR-4 corresponding to a 50% of total mass flow rate of air (through central axial inlet port) and 50% (through 3 tangential ports), and at H/D = 1.5. Also, the results from the comparative analysis are presented. Figure 2 presents the comparative plots of average and stagnation Nusselt number (Nu_{avg}, Nu_{stg}) for all the jets at different Reynolds number (Re) and Jet-plate distances (H/D).

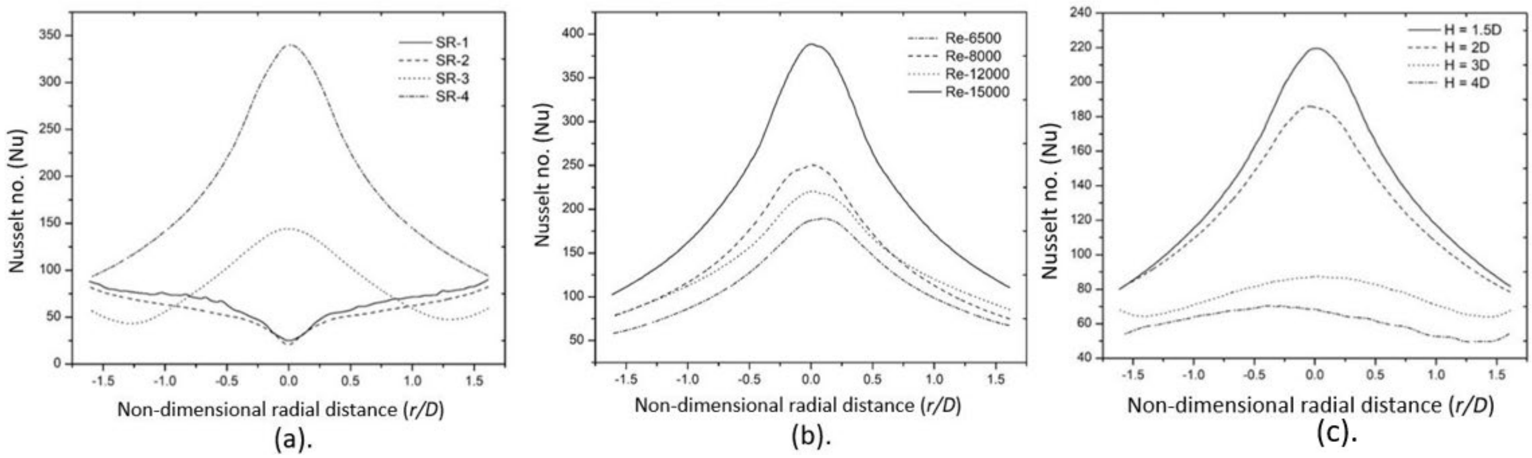

Fig.1. (a). Effect of split ratio for the proposed augmented jet at Re-12000, and H/D =2. **(b).** Effect of Reynolds no. (Re) for the proposed augmented jet at SR-4. **(c).** Effect of jet – plate distance (H/D). [5]

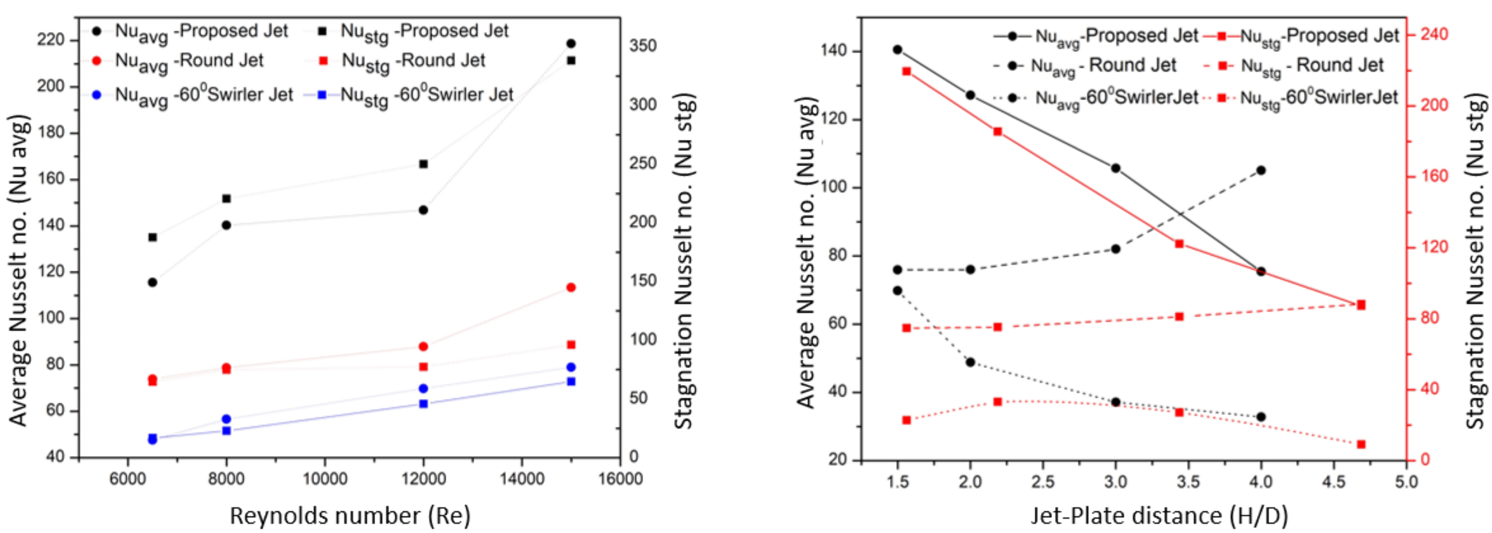

Fig.2. Comparative analysis of Nusselt number (average & stagnation) **(a).** At different Reynolds number (Re) (**b).** At different jet – plate distance (H/D).

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