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Drag reduction and heat transfer in turbulent channel flow over circular dimples: shifting the deepest point of dimples

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Dimples have shown reduction in drag and enhancement in heat transfer in turbulent channel flows. However a region of flow recirculation usually occurring at the upstream portion of the dimple limits this drag reduction and heat transfer enhancement. Although shallower dimples can minimise the flow recirculation that occurs, the amount of drag reduction and heat transfer enhancement is also limited due to the shallow dimple depth. A potential solution may be to shift the deepest point of the dimple downstream to reduce the upstream wall slope, thereby reducing the flow recirculation that occurs. Numerical results for circular non-axisymmetric dimples in a fully developed turbulent channel flow show that shifting the deepest point of the dimple downstream reduces the flow recirculation at the upstream portion at the expense of greater flow impingement at the downstream portion. This stronger flow impingement and increased fluid ejection at the downstream edge results in greater heat transfer enhancement. However, large shifts in the deepest point of the dimple downstream generates significant flow impingement and the accompanying form drag, resulting in increased drag and pressure loss. A parametric study is conducted to determine the optimal shifting of the deepest point to reduce drag and enhance heat transfer. Variation in the Nusselt number due to shifting of the deepest point of the dimple is presented as well as a detailed analysis of the shear drag and form drag contributions to the overall drag induced by the shifting of the deepest point of dimples downstream. The overall heat transfer efficiency in terms of the volume goodness ratio is also presented to show the variation in heat transfer efficiency as the deepest point is moved.