CHAPTER V
CLOSING

5.1 Conclusion

The wall function heat transfer coefficient is not distributed uniformly around the U-bend circumference. The outer wall (Line A-A') develops a sharp, localized peak caused by centrifugal impingement of the high-momentum core flow, and this peak grows several times faster than the general Reynolds-number-driven baseline as Re increases. In contrast, the inner wall (Line B-B') consistently shows the lowest heat transfer coefficient among the four walls, since the same centrifugal effect pulls the core flow away from this surface, and the gap between the outer and inner walls widens, rather than narrows, as Reynolds number increases.

The two side walls (Lines C-C' and D-D'), meanwhile, behave similarly to each other and show a moderate, gradual rise through the bend, falling between the outer- and inner-wall extremes, which confirms that the side walls are driven mainly by the tangential component of the Dean vortices rather than by direct impingement or recirculation.

This spatial pattern is further supported by the nanoparticle concentration contours, which show progressive migration toward the outer wall as Reynolds number increases, confirming that the outer-wall heat transfer peak is caused by genuine particle redistribution, not flow acceleration alone. Taken together, these findings indicate that Reynolds number governs the magnitude of enhancement at each wall, while U-bend curvature governs where that enhancement is concentrated around the pipe's circumference a distinction that constitutes the key finding of the study and provides practical design guidance for U-bend heat exchangers using nanofluids.

5.2 Suggestions

For future researchers, it is recommended to apply second-order or higher-order discretization schemes (such as QUICK) for all governing equations to improve accuracy in resolving steep gradients within the bend region and minimize numerical diffusion in the thermal boundary layer. In addition, the physically implausible pressure magnitudes observed at the critical wall-adjacent cells for higher Reynolds number indicate that future work should incorporate finer local mesh refinement, tighter residual convergence criteria, and reduced DPM source-term under-relaxation factors to resolve this numerical instability. Additionally, future studies should investigate the effect of varying nanoparticle mass fractions beyond the single value used in this study, for example at $\varphi = 0.5\%$, 2.0%, and 4.0%, to comprehensively map the relationship between concentration, Reynolds number, and heat transfer coefficient while also accounting for the increased viscosity penalty at higher fractions.