CHAPTER 7

CONCLUDING REMARKS AND SCOPE FOR FUTURE WORK

7.1 Conclusions

Experimental and numerical analyses for hydrothermal performance in the tubular heat exchanger with an enhancer (modified twisted tape and tapered wire coil) using different mono/hybrid nanofluids at volume concentration ranging from 0.01 to 0.1% have been conducted on energy-exergy-economic viewpoint. Based on the results obtained, the following conclusions can be listed:

- Al_2O_3+CNT hybrid nanofluid is better in terms of heat transfer characteristics as compared to all other studied nanofluids with the penalty of pressure drop. However, Al_2O_3+PCM/water performs better in term of entropy generation.
- The use of PCM is beneficial if there is phase change during the process (i.e., the melting point of PCM is between inlet and outlet temperatures).
- The heat transfer coefficient and pressure drop considerably increase with an increase in the nanofluid flow rate and particle volume concentration. Both the Nusselt number and friction factor increase with decreasing the nanofluid inlet temperature.
- For twisted tape insert, heat transfer coefficient and pressure drop of nanofluids are higher than that of the DI water and increase with decreasing the twist ratio, increase in depth ratio and decrease in width ratio in the case of all working fluids.
- For modified coil insert, the D-type wire coil promotes higher heat transfer than that of the C-type and C-D type because it provides a higher contact surface area between fluid and wall surface when the fluid deaccelerates through the D-type wire coil.

- The ratio $h_i/\Delta p$ decreases with an increase in the nanofluid flow rate for all working fluids. The ratio $h_i/\Delta p$ increases with decreasing twist ratio, increase in DR, decrease in WR. C-type wire coil inserts exhibit the highest value of ratio $h_i/\Delta p$ than that of other coil configurations. When the volume concentration increases, the ratio $h_i/\Delta p$ increases by using twisted tape; while using the wire coil, this ratio decreases. Also, with an increase in inlet temperature, the ratio $h_i/\Delta p$ decreases by using V-cut twisted tapes, whereas this ratio increases by using wire coil inserts.
- The entropy generation of all working fluids is less than that of DI water. Among all working fluids, Al_2O_3+PCM shows the lowest entropy generation using an enhancer. With the increase in volume concentration, the entropy generation decreases. The total entropy generation rises with an increase in twist ratio, a decrease in depth ratio and an increase in width ratio. D-type wire coil insert shows a lower entropy generation among all working fluids. Also, with an increase in inlet temperature, the total entropy generation increases for the same volume flow rate.
- Among all enhancers, the D-type wire coil shows a higher value of effectiveness. As compared to the plain tube with DI water, the effectiveness of the double pipe heat exchanger enhances around 39.41 % using D-type wire coil and hybrid nanofluid. In the case of shell and tube heat exchanger, Al_2O_3+CNT hybrid nanofluid shows a higher value of effectiveness among all working fluids. The maximum effectiveness was obtained as 0.164 at the Reynolds number of 1520.
- The parameter enhancement is more predominant for using enhancers (twisted tape and wire coil) as compared to using nanofluids, which implies that the change in flow structure by the use of enhancers is much more significant as compared to property enhancement and slip mechanism by using nanofluids.

- The requirement of coolant mass flow rate in power plant condenser can be reduced by using hybrid nanofluid. The effectiveness is also enhanced by using hybrid nanofluids. Pumping power in the power plant condenser can be reduced by using hybrid nanofluids. The irreversibility decreases and second law efficiency increases with the addition of nanoparticles.
- The operating cost can be reduced by using hybrid nanofluids in the power plant condenser. However, the payback period is considerably high, which can be reduced by reducing nanoparticle cost and increasing nanofluid stability.

7.2 Scope for future work

- Due to the lack of understanding of the mechanism of nanofluid at the atomic level, many experimental studies are needed to consider several important issues such as Brownian motion, particle migration and thermophysical properties.
- Further experimental studies must be performed with metallic and non-metallic nanoparticles with different concentrations and different tube layout in the tubular heat exchanger.
- More experimental studies must be conducted with novel ternary nanofluids and nanofluids with different shape particles in the tubular heat exchanger.
- Few experiments have been conducted on shell and tube heat exchanger equipped with baffles using nanofluids; this may be received attention in future studies.
- Cost and stability analyses of heat exchanger using nanofluids need more attention as it is essential before practical implementation.