THERMAL DESIGN OPTIMIZATION AND PERFORMANCE EVALUATION OF HEAT EXCHANGER WITH LOW GRADE ENERGY UTILIZATION

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By

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Chapter 8

Concluding remarks, future scope recommendations

8.1 Conclusions

Experimental investigations are conducted on geometrical optimized heat exchanger using prepared ternary hybrid nanofluids of different nanoparticles and three different concentrations. For energy, exergy improvement, passive device inserts, twisted tape inserts (TTI), and perforated twisted tape inserts (PTTI) are used. Design optimization of perforated tube inserts is also investigated numerically. Also, the prepared THNF is used as engine coolant and the coolant energy is utilized for the preheating of the prepared blended biodiesel as a waste energy utilization for a real-life-based application. The engine and emission performance are investigated with load for preheated fuel temperature and energy utilization is investigated under different geometrical conditions at a fixed load.

From the present investigations, the main conclusions can be summarized as:

- Ternary hybrid nanofluid is more suitable to be used as a coolant compared to investigated hybrid nanofluid and conventional fluid.
- Passive device inserts (TTI, PTTI) are recommended to be used for heat transfer enhancement in a heat exchanger than hybrid nanofluid. PTTI shows 28%, 15%, 2.8%, and TTI shows 19%, 11%, 1.9% higher heat transfer, entropy change, and exergy efficiency at the lowest Reynolds number, 3200, with 0.12% volume fraction of Ternary hybrid nanofluid than water as coolant without inserts. Due to these reasons passive device inserts are recommended.
- Passive device inserts succesfully improved heat transfer and require more running cost and higher carbon discharge to the environment. PTTI in HX requires 2.4 times more operating cost, TTI requires 2.07 times higher operating cost while PTTI releases 2.14

times, and TTI releases 1.7 times higher carbon discharge to the environment with 0.12% volume fraction of ternary hybrid nanofluid than water as coolant without inserts.

- On combining both heat transfer and pressure drop, the PEC is greater than unity that concludes that the heat transfer is dominant at lower Reynolds number than pressure drop. Thus, it is conclusive to use passive device inserts at low Reynolds number. PEC is highest at the lowest Reynolds number (3200) for PTTI followed by TTI
- It is concluded that configured geometrical set as lowest perforated pitch 20mm, higher perforated diameter 4mm, and lowest Reynolds number is the best suitable geometrical and fluid flow conditions obtained for PTTI using CFD and Taguchi-Grey investigation.
- Preheating successfully improve the engine performance and lowers the emissions effectively. On preheating of fuel, extracted coolant energy, at 5.6kW applied load, BSFC reduces by 6.3% and 5.9%, BTE increases by 3.3% and 3.2%, HC emissions reduces by 3.9% and 3.5%, CO emissions reduce by 4.2% and 2.5%, NO emissions increase by 3.2% and 2.6% compared to unheated fuel to the preheated fuel, for the case of biodiesel and diesel, respectively.
- Use of biodiesel and diesel has shown a marginal energy distribution difference in coolant energy and exhaust energy. The energy distribution chart shows the coolant energy ranges between 21-26% and exhaust energy ranges between 26-29% in the case of diesel. Also, in the case of biodiesel, coolant energy ranges between 20-25% and exhaust energy ranges between 26-30% of the fuel energy.
- For 5.6kW load, and constant flow in practical application, coolant energy is 12.8% and 10.8% higher obtained in PTTI with 0.12%(v/v) THNF, for diesel and biodiesel, respectively, compared to without inserts and water as coolant.
- Based on energy utilization and distribution it is concluded that energy of coolant is utilized effectively. Low grade energy utilization: maximum 6.6% of coolant energy is utilized at

5.6kW load conditions with D-30%OPB biodiesel. And 6.1% of coolant energy is utilized for diesel at 5.6kW load conditions.

- Based on the investigation it is concluded that preheating reduces the fuel consumption successfully and requires prolonged run of engine for cost recovery. On the combination of radiator and engine, using waste energy of coolant for fuel preheating, less fuel is consumed for the same power generation and ultimately recovers the cost of heat exchanger in 599 hours using diesel and 503 hours with biodiesel.

8.2 Future scope recommendations

- Present work dealt with the TTI and PTTI passive device inserts and obtain significant heat transfer improvement by changing the perforated diameter (circular shape). In future work recommendation, investigation on energy and exergy enhancement of the heat exchanger using with tube inserts of different perforation shape inserts like trapezoidal, sinusoidal grooves and rectangular shapes can be examined. These heat exchangers are suitable to be use in the automobile industry for cooling of their engine components.
- Present work also dealt with energy economic and exergy economic investigation of heat exchanger with different inserts like TTI, PTTI. It is recommended as a future work to analyse the energy economic and exergy economic investigation of heat exchanger with half inserts that can be performed, examined, and optimized.
- In the present work, low grade energy of coolant (below 70°C) is utilised and successfully preheat the biodiesel to 43°C. It can be recommended to use some other suitable energy utilisation of coolant using suitable phase change material of operating temperature below 70 °C.
- In the present work, preheating is done for D-30%OPB biodiesel and resulted in better engine performance. For future study, it is also recommended to prepare different biodiesel

and preheating effects on the engine performance can be performed using the energy of coolant at different load conditions.

8.3 Limitation and weakness of present work

- Use of nanofluid is recommended to use but the major problem comes the settlement of nanoparticles. The nanoparticles settle within seven days; hence sonication is required before the nanofluid is utilised for the practical application.
- Based on the fin and tube heat exchanger, in parametric investigation, it is assumed that the ratio of frontal area to total area is kept fixed. However, it may vary when fin pitch changes. So, results are accepted for the assumption considered.
- Use of passive device inserts and hybrid nanofluid are advisable to use at lower fluid flow conditions. The use of hybrid nanofluid is limited to be applicable at low fluid flow for better PEC.
- The coolant energy to be utilized for preheating has shown a very limited 6.6% of coolant energy can be extracted for heating of fuel, which is quite less on the attachment of heat exchanger.