Optimization of organic rankine cycle power systems for waste heat recovery on heavy-duty vehicles considering the performance, cost, mass and volume of the system

The use of organic Rankine cycle power systems for waste heat recovery on internal combustion engines of heavy-duty vehicles can help to mitigate the greenhouse gases and reduce the fuel consumption of the vehicle. However, designing an organic Rankine cycle system for this application is a complex process involving trade-offs among factors such as performance, space/weight restrictions, and cost. This paper presents a multi-objective optimization study of an organic Rankine cycle unit for waste heat recovery from heavy-duty vehicles from techno-economic and sizing perspectives. The optimization was carried out for seven different working fluids using the genetic algorithm to minimize the cost, volume and mass, and maximize the net power output of the organic Rankine cycle unit. The organic Rankine cycle performances for a driving cycle of a truck were also evaluated. The results indicate that the mass, volume, cost and net power output of the organic Rankine cycle system increase with the evaporation temperature. Moreover, the results suggest that when the condensation temperature was decreased from 60 °C to 40 °C, the net power, weight, cost and volume of the organic Rankine cycle unit increases by 22%, 12%, 46%, and 12% respectively. The maximum net power output, both at the design and off-design conditions, is obtained with pentane as working fluid. For this design, the net power output of the organic Rankine cycle unit is 10.94 kW at design condition and 8.3 kW at off-design (in average) condition, and the mass, volume, and cost of the organic Rankine cycle system are 129 kg, 1.077 m³, and 8527 €, respectively.

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