Impact of Rankine cycle WHR on passenger car engine fuel consumption under various operating conditions

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Abstract:
This study presents a comprehensive analysis of the effect of a waste heat recovery (WHR) system using the Rankine cycle on passenger car engine fuel consumption. In reciprocating engines more than 60% of fuel energy is lost as heat. The engine studied here is a 2.0liter four-cylinder direct injection diesel engine developed for a passenger car. The maximum engine output power is 101kW at 4000rpm and the maximum torque is 320Nm at 2000rpm. An engine computational model built with the advanced simulation code AVL Boost was used to estimate the engine output power and exhaust gas parameters over the whole operating range. A physical model of the Rankine cycle was also developed, comprising a discretized 0D model of the heat exchanger. Based on the model, a computational code was developed in Python (x,y). The working fluid parameters were determined with the open-source platform CoolProp. The Rankine cycle simulation was conducted over the engine operating map with water as the working fluid. The engine operating points at vehicle speeds ranging from 80km/h to 160km/h were determined by means of a road test and vehicle simulation. The effect of the Rankine cycle (RC) WHR was estimated from the engine fuel consumption. It was found that there is a 7.57% decrease in the fuel consumption at the engine operating point corresponding to a car speed of 160km/h and a decrease of 1.5% at the point corresponding to a speed of 130km/h.

Keywords:
Diesel engine, Fuel consumption, Waste heat recovery, Rankine cycle, Passenger car, Simulation.