



Predictive Waste Heat Recovery (WHR)

Challenges and solutions:

In the WHR-system a safety margin to avoid condensation of the working fluid in the turbine and possible consecutive damage of the turbine limits the utilisation potential. This condensation could occur for instance as result of sudden change in load.

Optimal superheating control using preview information from eHorizon can reduce the safety margin while still making sure to stay within safe operation states.

Therefore the idea is to use predictive information on the load profile to reduce the requirement for safety margin.

IMPERIUM's contributions:

It was investigated on the DAF vehicle with simulations performed by Ricardo that indeed it was possible to increase the efficiency of the WHR-system by optimisation of the set-points.

In the IVECO vehicle the WHR model has been integrated in the vehicle model. Component models have been developed and the Rankine cycle has been represented by taking into account the thermodynamic properties of the selected working fluid. The system has been integrated by means of a rerouting of the coolant flow. The engine exhaust gas mass flow rate and temperature after SCR are used as an input to the WHR evaporator. To account for the additional pressure loss on the exhaust line, a pressure loss element tuned with the experimental values has been added downstream of the SCR. The output torque of the WHR is delivered to the main shaft through a geared connection element with a fixed gear ratio.

Volvo uses the traces from the predictive hybrid powertrain simulation, the input to the WHR is the exhaust mass flow and exhaust gas temperature after the EATS. The output is the effective power from the WHR taking into account the internal pump and auxiliary cooling power losses. The WHR supplies electrical power to the high voltage side of the hybrid electric system. By addition of WHR to the predictive hybrid powertrain, the additional electric energy recuperated in the VECTO cycle is approximately 3kWh. The fuel consumption gain in the predictive hybrid powertrain without traffic is in this specific cycle 2.7%. This is a quite close to the initial potential of 2.5% considering the uncertainties in the model. Considering that the engine has no EGR and is operating in a hybrid powertrain, the 2.7% is in line with the expectations.

Impact / what's next:

The use of waste heat recovery is a proven solution to gain additional benefits beyond the theoretical maximum thermal efficiency of internal combustion engines. While still the cost is high it is a potential for CO₂ reduction and the results of the IMPERIUM project shows increasing potential in combination with eHorizon system.

WHR-systems will be investigated further in the future as part of the technologies that can be used for meeting the future CO₂-reduction standards. The robustness of these systems is an important point of attention and how the optimum balance can be found between robustness (reliability) and fuel-savings (and the enablers for that). This could be a topic of further study in a next project.