# Exhaust Heat Recovery Rankine System for passenger cars: modelling and design


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## Abstract:

Nowadays, in average, one third of the fuel energy consumed by an engine is wasted throughout the exhaust gases. The recovery of this amount of energy would enable a reduction of the fuel consumption. One solution is to integrate an exhaust heat recovery system based on a Rankine cycle. The first and most crucial step in the design is the definition of its architecture, the definition of the rated operating conditions and the sizing of the different components whilst considering the heat recovery over customer driving cycles.

This paper presents a steady-state model of a steam Rankine cycle built by interconnecting sub-models of the heat exchangers, the pump and the expander. All the models were developed under EES (Engineering Equation Solver) environment.

The models of heat exchanger are developed using the ε-NTU method. A heat exchanger is subdivided into three zones, each of them being characterized by both the exhaust gases and water side pressure drop as well as heat transfer coefficient. The evaluation of the two-phase zone pressure drop and heat transfer with respect to the vapour quality was carried out. The model of rotary piston expander describes the evolution of the fluid through the device and was split into three global steps: pressure drop across the supply port, isentropic and isochoric expansion, internal and external heat transfers.

The overall simulation model is finally used to predict the performance of the heat recovery system as the operating conditions and geometrical characteristics of each component are modified. An optimal sizing of the system is proposed and the underlying methodology is discussed. The analysis of the results pointed out that the levels of high/low pressure and the amount of superheat are the main parameters that impact the performance of the cycle and the sizing of the components.



## Keywords:

Rankine cycle, heat recovery, heat exchanger, automotive engine