

Waste Heat Recovery

with **GT-SUITE**

Highlights:

Model all WHR system components individually or as a complete system (Rankine or Thermo-Electric)

Detailed spatially resolved heat exchanger models

REFPROP properties of refrigerants and mixtures

Robust solver based on Navier-Stokes equations

Sub- and super-critical two-phase systems

Smooth start from any initial condition

Stable even with zero flow and thus “standing water” presents no difficulty

Fast execution (faster than real-time)

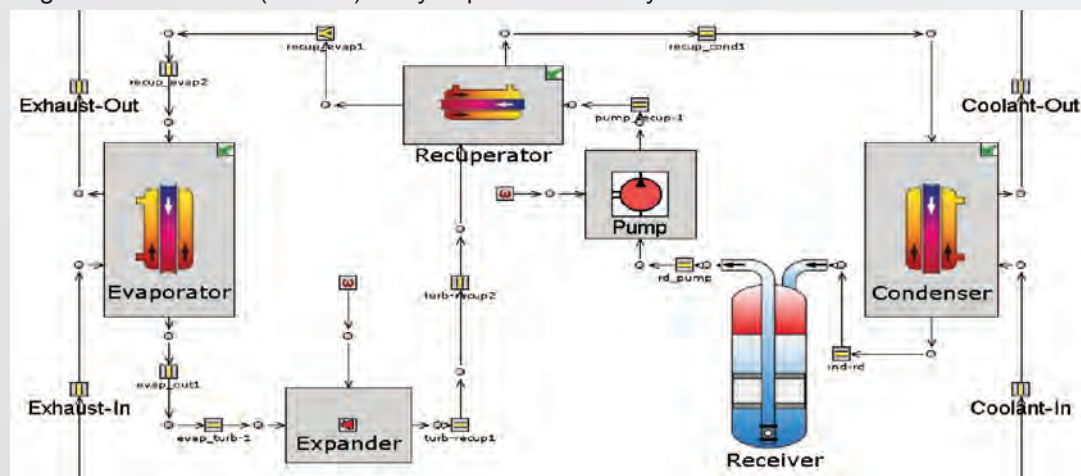
Waste Heat Recovery

Rankine and Thermo-Electric Systems

GT-SUITE is the most advanced system level CAE tool available for the study of **waste heat recovery systems**. GT-SUITE is capable of modeling waste heat systems based on the principles of the Rankine cycle, as well as systems using thermo-electric materials for direct conversion of a temperature difference to electrical power. The real strength of GT-SUITE is the ability to integrate a waste heat sub-system model into a larger vehicle system model such that the energy efficiency of the complete system can be studied and optimized while operating under typical transient conditions.

Rankine WHR Systems

GT-SUITE includes all of the components needed to model any Rankine WHR system, such as evaporators, condensers, recuperators, pumps, piston expanders, turbines, etc. Many of the components can be modeled at various levels of detail according to the needs of the modeling task. The waste heat source may be provided by an **integrated engine model** or by imposed boundary conditions. In a similar fashion, the heat sink may be provided by an integrated fluid circuit (coolant) or by imposed boundary conditions.



GT-SUITE has a **highly advanced capability for solving two-phase flows**, such as those involved in Rankine cycle systems. It is based on the same proven flow solver used for a wide range of fluid simulations in GT-SUITE, such as engine performance, fuel injection and hydraulics. It handles two-phase fluids based NIST REFPROP thermodynamic properties, complemented by a variety of two-phase flow heat transfer and pressure drop correlations. The model is **completely transient**, to allow a broad range of investigations. Because of its strong fundamental flow solution methodology, it is **very robust** and allows the simulations start from an arbitrary starting point. The code execution is **faster than real-time**.

Advanced Features and Applications:

Contains models of:

- condenser
- evaporator
- recuperator
- receiver/dryer
- pump
- turbine
- piston expander
- electrical components
- controls
- vehicle
- engine

Refrigerant pressure drop and heat transfer correlations, including predictive models based on HX geometry

All above models are highly capable, and establish a new level of state-of-the-art

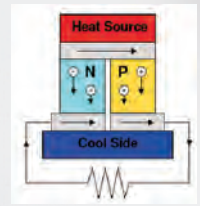
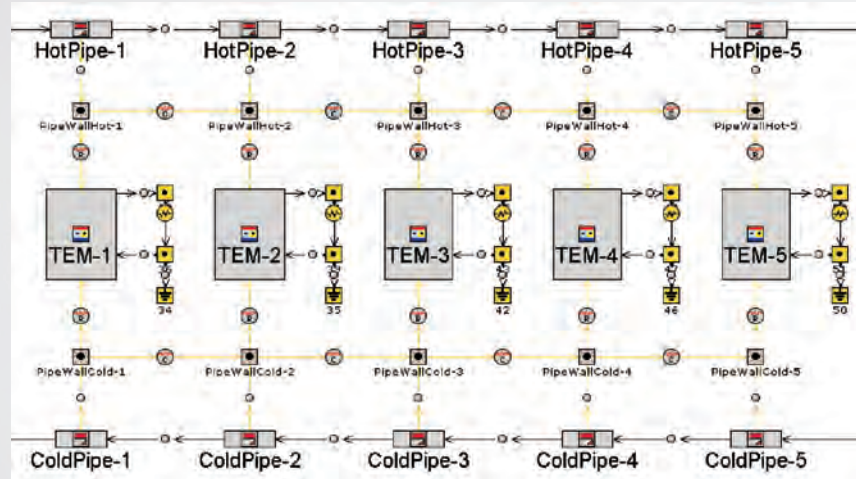
Suitable for driving cycle energy analysis

Seamless integration of vehicle and engine models

These capabilities are included in every GT-SUITE license

Thermo-Electric Generator WHR Systems

GT-SUITE provides a specific template for modeling of thermo-electric modules. This component can be easily placed between two fluid circuits (or structural masses) to generate an electric potential in response to a temperature gradient. Internally, this component predicts the voltage generated based on the Seebeck effect, as well as the internal electrical resistance. Thermally, the internal thermal resistance and the Peltier effect are also handled. In addition to the thermal links for hot and cold temperatures, this component has electrical ports that can be connected to any electrical circuits modeled in GT-SUITE. In this way thermo-electric generator models can be constructed from many basic thermo-electric module elements, predicting the power generation at various operating conditions.



System Integration

Whether modeling Rankine or thermo-electric systems, a key advantage of GT-SUITE is the ability to integrate the WHR sub-system into larger vehicle system models to predict the overall system response, both for steady operation and within transient simulations. This approach inherently accounts for the interaction between sub-systems, and enables realistic assessment of the efficiency potential of a given waste heat recovery concept.

