KTH ROYAL INSTITUTE
OF TECHNOLOGY

Low Temperature Waste Heat Recovery in IC Engines

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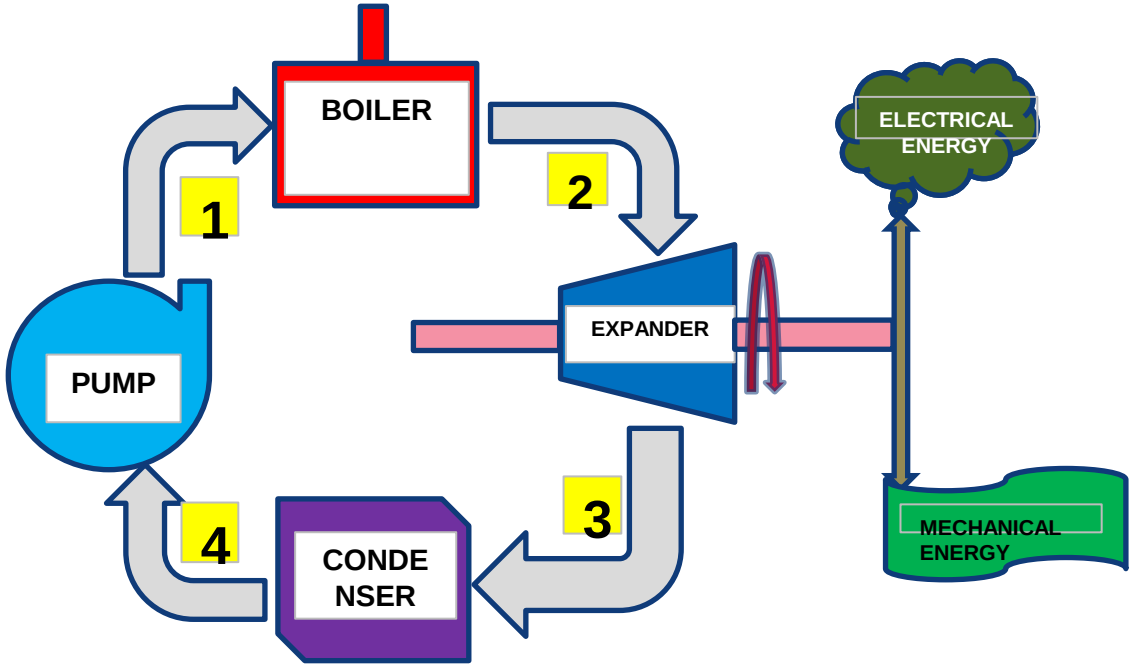
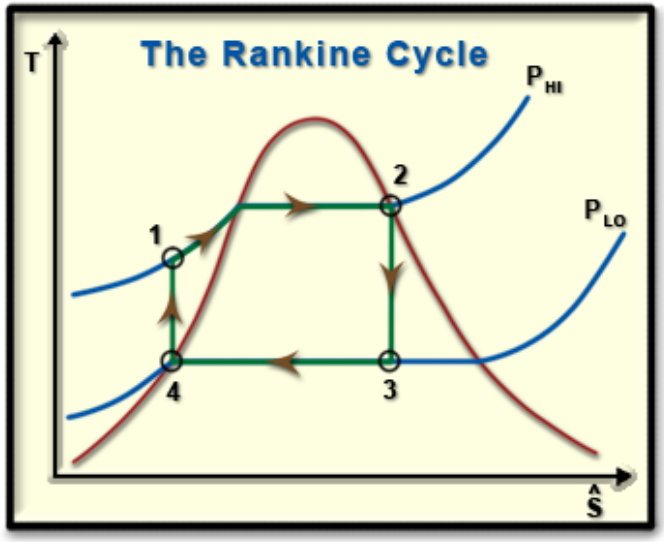
RANKINE CYCLE / ORGANIC RANKINE CYCLE (ORC) WHR SYSTEM

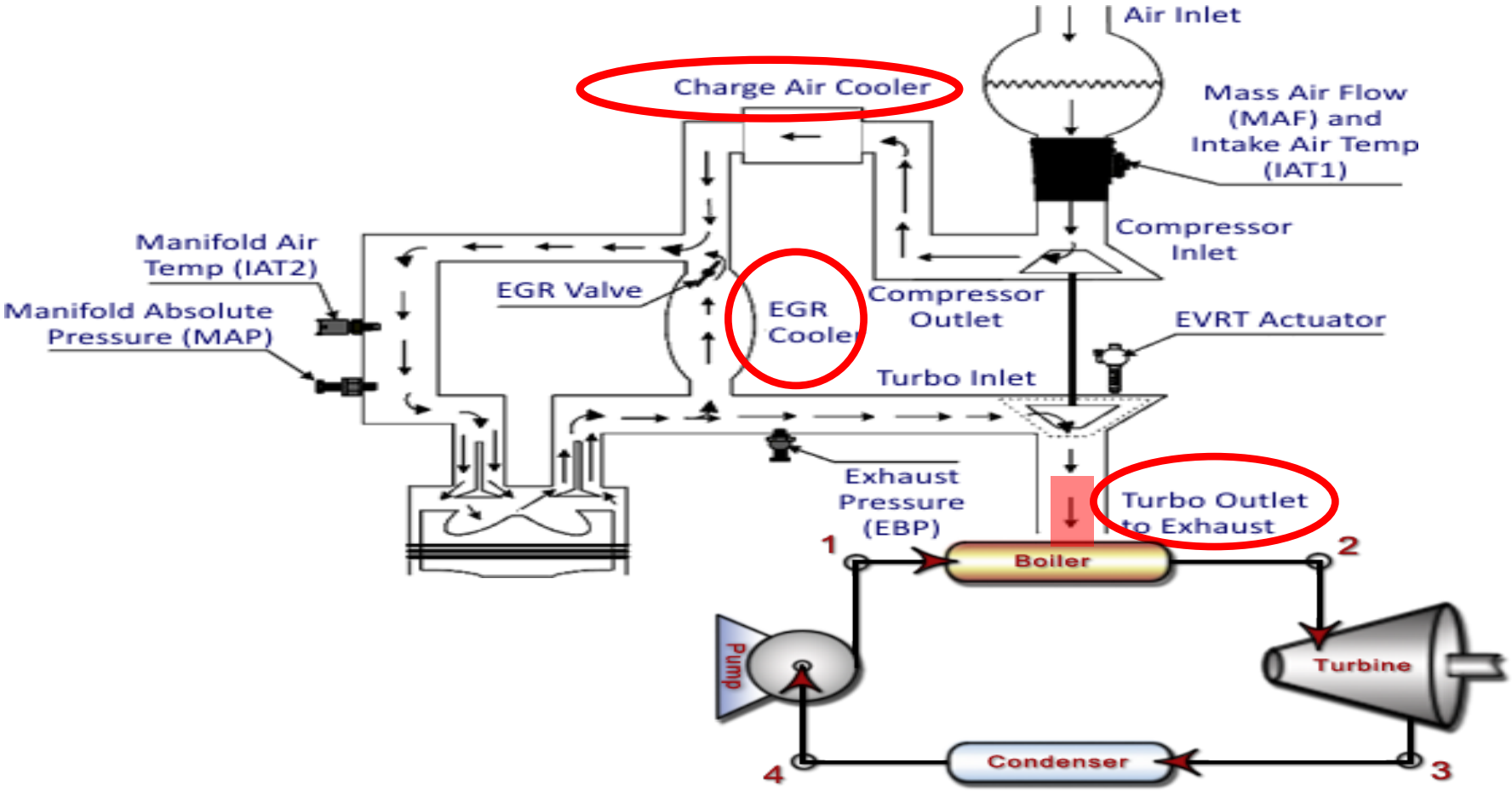




http://www.learnthermo.com

WASTE HEAT SOURCES IN THE ICE

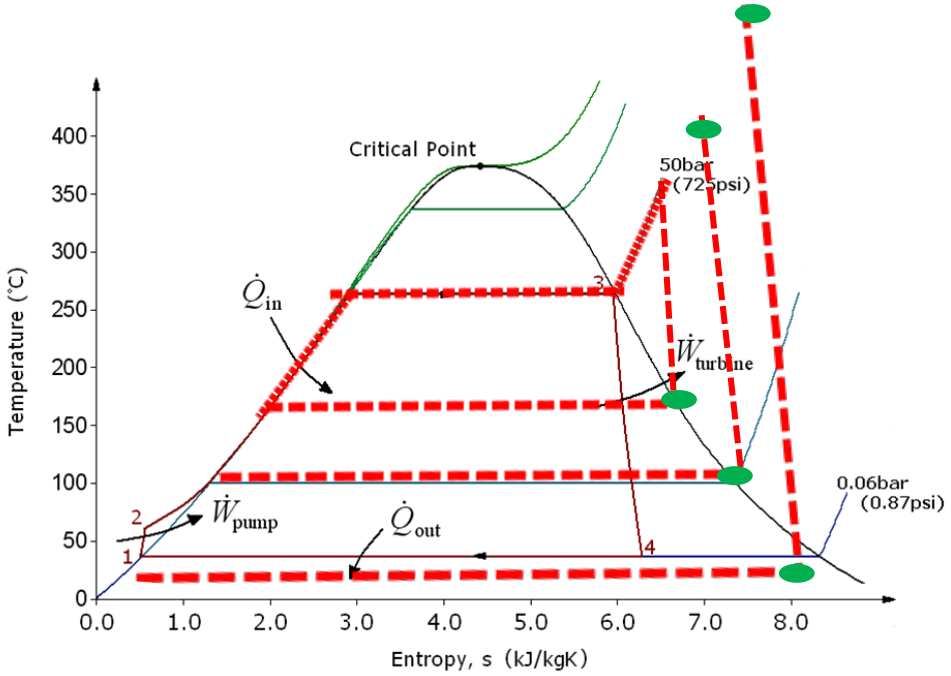
How to integrate the WHR system with the primary engine system?



Adapted from https://www.dieselnet.com/tech/engine_egr_control.php & http://www.learnthermo.com

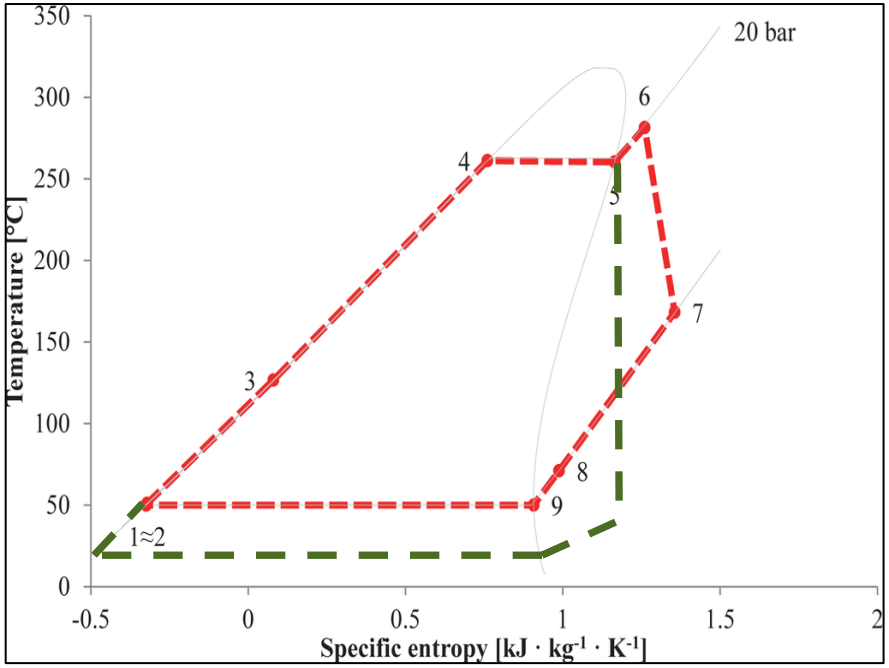
WET FLUIDS – RESEARCH QUESTIONS

- Optimum heat source temperature
- Degree of superheating
- Effect of droplet formation on turbine efficiency
- Expanders at two-phase
  Eg. Screw & scroll
- Increasing evaporation pressure & decreasing condenser pressure

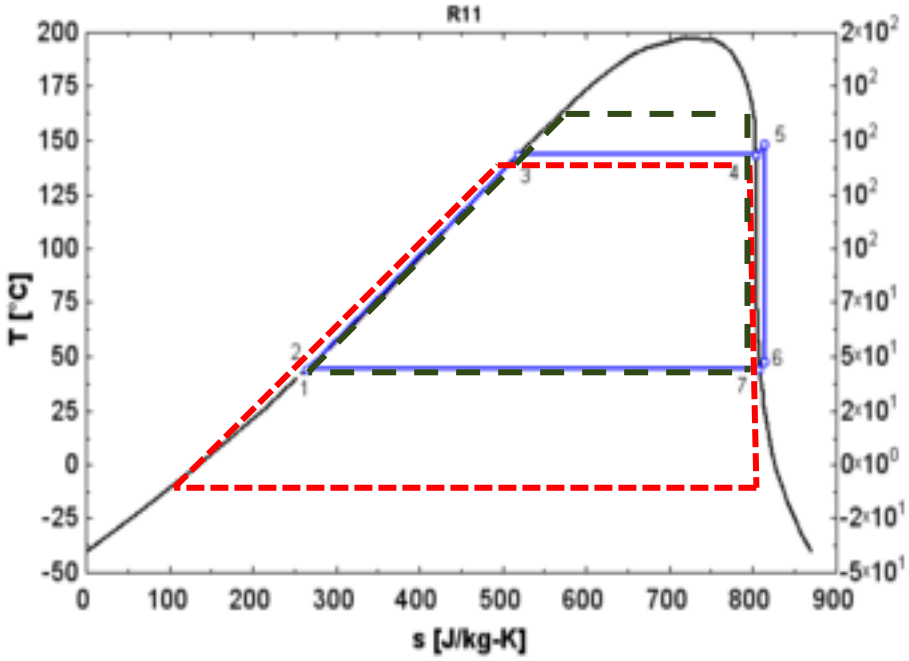


Adapted from https://en.wikipedia.org/wiki/Rankine_cycle

DRY & ISENTROPIC FLUIDS – RESEARCH QUESTIONS



Adapted from Pierobon, L., Nguyen, T-V., Mazzucco, A., Larsen, U., & Haglind, F. (2014). Part-Load Performance of a Wet Indirectly Fired Gas Turbine Integrated with an Organic Rankine Cycle Turbogenerator. Energies, 7, 8294-8316. DOI: 10.3390/en7128294 (http://www.mdpi.com/1996-1073/7/12/8294/htm)



Adapted from https://en.wikipedia.org/wiki/Saturation_vapor_curve

- Degree of superheating dry fluids
- Increase in evaporation temperature & decreasing in condenser pressure
- Identifying suitable expander - Eg. Piston, radial turbine, etc.

PROPERTIES OF EXPANDERS

- ✓ **High flow rates , low pressure ratios or vice-versa (e.g. axial & radial turbines)**
- ✓ **Low & high power output ranges (e.g. scroll & piston expanders)**
- ✓ **Sizing & packaging (e.g. Axial turbine expanders)**
- ✓ **Off-design efficiency (e.g. radial turbine expander)**
- ✓ **Two phase expansion (e.g. Screw & scroll)**
- ✓ **Minimum frictional and leakage losses**
- ✓ **High temperature & pressure ranges (e.g. Piston expanders)**
- ✓ **Volumetric efficiency (e.g. vane expander)**

RESEARCH QUESTIONS

- Optimum Working fluid and expander combination ?
- Contribution of expanders towards thermodynamic changes?
- Improving expander efficiency?