Appendices of the paper “Experimentation and driving cycle performance of three architectures for waste heat recovery trough Rankine cycle and organic Rankine cycle of a passenger car engine”



Figure A1: Hydraulic scheme of the Rankine for waste heat recovery on exhaust gases

Table A1: Sensors technical data of the Rankine for the R-EG

|  |  |  |  |
| --- | --- | --- | --- |
| Location | Type | Range | Accuracy |
| Evaporator exhaust gas temperature | K | 0-260 C | 2.5K |
| Evaporator exhaust water temperature | K | 0-260 C | 2.5K |
| Evaporator inlet water temperature | T | 0-260 C | 1K |
| Evaporator inlet gas temperature | K | 200-1200C | 2.5K |
| Expander inlet water temperature | K | 0-450C | 2.5K |
| Expander exhaust water temperature | T | 0-260 C | 1K |
| Condenser exhaust water temperature | T | 0-260 C | 1K |
| Cooling water condenser exhaust temperature | T | 0-260 C | 1K |
| Pump supply temperature | T | 0-260 C | 1K |
| Differential pressure evaporator (water) | DP | 0-1.6bar | 0.1% FS |
| Evaporator exhaust gas pressure | rel | 0-500mbar | 0.5% FS |
| Pump exhaust pressure | rel | 0-25bar | 0.5% FS |
| expander exhaust pressure | rel | 0-5bar | 2.5% FS |
| Condenser cooling water pressure | rel | 0-4bar | 0.25% FS |
| Differential pressure evaporator (gas) | DP | 0-1.6bar | 0.1% FS |
| Condenser exhaust pressure | rel | 0-5bar | 2.5% FS |
| Differential pressure condenser (water) | DP | 0-1.6bar | 0.1% FS |
| Water mass flow rate | Coriolis | 0-25g/s | 0.4% FS |
| expander inlet pressure | Rel | 0-25bar | 0.5% FS |
| Lambda sensor |  | NS | 0.1 |
| Expander rotational speed | impulse | 0-15000rpm | 30rpm |
| Fuel mass flow rate |  | 0.3-60kg/h | 1% FS |
| Void pump water exhaust temperature | T | 0-260 C | 1K |
| Void pump water supply temperature | T | 0-260 C | 1K |
| Cooling water condenser (2) supply temperature | T | 0-260 C | 1K |
| Cooling water condenser (2) exhaust temperature | T | 0-260 C | 1K |
| Cooling turbine exhaust temperature | T | 0-260 C | 1K |
| Turbine exhaust temperature | T | 0-260 C | 1K |
| Turbine supply temperature | T | 0-260 C | 1K |
| Turbine supply pressure | Rel | 0-20bar | 1% FS |
| Turbine exhaust pressure | Rel | 0-6bar | 1% FS |



Figure A2: Hydraulic scheme of the test-rig (ORC-CE)

Table A2: Sensors of the test-rig ORC-CE

|  |  |  |  |
| --- | --- | --- | --- |
| Sensor | Location | Scale | Accuracy [%FS] |
| Pressure | Pump in [bar] | [0:7] | 0.5 |
| Pump ex [bar] | [1:51] | 0.5 |
| Evaporator ex [bar] | [0:50] | 0.5 |
| Scroll in [bar] | [0:35] | 0.05 |
| Scroll ex [bar] | [1:11] | 0.3 |
| Condenser in [bar] | [1:7] | 0.5 |
| Differential scroll [bar] | [0:25] | 1 |
| Flow | Refrigerant [kg/s] | [0:0.160] | 0.2 |
| Cooling water [kg/s] | [0:3] | 1 |
| Power | Pump [W] | [0:2000] | 0.5 |
| Compressor/expander [W] | [0:6000] | 0.5 |
| Speed | Expander [RPM] | [0:8000] | 0.2 |



Figure A3: Hydraulic scheme (ORC-EG)

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Figure A4: Performance of the gear pump a) volumetric efficiency b) isentropic efficiency



Figure A5: Evaporator efficiency



Figure A6: Pressure drop of the evaporator: a) Exhaust gas side b) Water side

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Figure A7: Performance of the scroll expander a) Filling factor and b) isentropic efficiency.



Figure 8A: Evolution of the mechanical isentropic efficiency of the turbine with the supply pressure and shaft speed



Figure A9 : Isentropic efficiency of the expander (left: scroll 1, right: scroll 2).



Figure A10: Diagramme T-s



Figure A11: Pump performance (ORC-CE)



Figure A12: Evaporator performance (ORC-EG).