5
Concluding remarks

The model of the ORC system was obtained by interconnecting the different subroutines for each of the components and the results gathered in the thermodynamic program were useful to the heat exchangers program.

The steady state model was able to calculate the desired outputs of an ORC system and gave guidance for the sizing of the heat exchangers.

The thermodynamic simulation provided results for both the gaseous and liquid heat sources with system pressure variation, which is of great interest for system design calculations.

Among the working fluids studied for gaseous effluents, R245fa showed best results in power output and thermal efficiency, when compared to R123.

For the working fluids considered to be used with liquid heat sources, two new substances in ORC applications were studied: R1234yf and R1234ze. From these fluids, compared with the traditional R134a, best power output and thermal efficiency results were obtained by R1234ze.

The validation of the thermodynamic model, with real ORC plant data, provided an acceptable error in the prediction of the unknown system parameters under the studied conditions, within less than 5%.

The simulation of the ORC system heat exchangers considered, for either gaseous or liquid heat sources, two different types of exchangers: tube-fin and plate heat exchanger, respectively.

The calculated areas of the economizer, evaporator and superheater were added to obtain the total boiler area for each of the working fluids and for different mass flow rates of the waste heat source.

The calculated boiler areas of the new working fluids were matched with the area obtained with R134a, resulting in a slighter larger area for R1234yf and a smaller area for R1234ze.

The validation of the heat exchangers simulation was conducted by data comparison for the following working fluids: R134a, R123 and R245fa, since only those, of the studied working fluids, were considered in the parametric study. The error for the resulting boiler areas was lower for R134a (<5%), liquid heat source, than for R123 and R245fa, gaseous heat source, indicating that the model for sizing BPHE is more accurate.

A trigeneration system with an ORC bottoming a heat engine has been studied. From the calculated results of the energy analysis, it was demonstrated that the ORC has the highest performance when the waste heat equals the electric power demand.

5.1.
Future Work

The following developments would further improve the simulation tool and, quite possibly, make it more useful to industry:

- In organic Rankine cycles it is quite common to include a regenerator (heat exchanger), which raises the temperature of the working fluid before entering the boiler with heat from the same fluid leaving the expander. The implementation of a regenerator subroutine would broaden the program's application.
- A first approach for the determination of the boiler area was made; however, further improvement in the sizing model of the heat exchangers would facilitate the design of an ORC system.
- The development of an experimental apparatus would help obtaining more data for designing and research purposes.