Abstract

Heat pumps have been identified as an efficient alternative to traditional boilers for the production of sanitary hot water (SHW). The high water temperature lift (usually from 10°C to 60°C) involved in this application has conditioned the type of used solutions. On the one hand, transcritical cycles have been considered as one of the most suitable solutions to overcome the high water temperature lift. Nevertheless, the performance of the transcritical CO_2 heat pump is quite dependent on the water inlet temperature, which in many cases is above 10°C. Furthermore, performance highly depends on the rejection pressure, which needs to be controlled to work at the optimum point in any condition. On the other hand, for the subcritical systems, subcooling seems to be critical for the heat pump performance when working at high temperature lifts, but there is not any published work that optimizes subcooling in the SHW application for these systems. Therefore, the subcritical cycle should require a systematic study on the subcooling that optimizes COP depending on the external conditions, in the same way as it has been done for the rejection pressure in the transcritical cycle.

The aim of this thesis is to investigate the role of subcooling in the performance of a Propane water-to-water heat pump for SHW production, in the application of heat recovery from any water source. Two different approaches to overcome the high degree of subcooling were designed and built to test them in the laboratory:

1) Subcooling is made at the condenser: The active refrigerant charge of the system is controlled by a throttling valve. Subcooling is controlled independently at any external condition.
2) Subcooling is made in a separate heat exchanger, the subcooler. Subcooling is not controlled, it depends on the external condition and the heat transfer at the subcooler.

The heat pumps were tested at different water temperatures at the evaporator inlet (10°C to 35°C) and condenser inlet (10°C to 55°C), while the water production temperature was usually fixed to 60°C. The obtained results have shown that COP depends strongly on subcooling. In the nominal condition (20°C/15°C for the inlet/outlet water temperature at the evaporator and 10°C/60°C for the inlet/outlet water temperature in the heat sink), the optimum subcooling was about 43 K with a heating COP of 5.61,

which is about 31% higher than the same cycle working without subcooling. Furthermore, the system with subcooling has been proved experimentally as being capable of producing water up to 90°C and has shown a higher COP than some CO_2 commercial products (catalog data reference).