TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Mechanical Science and Engineering Bitzer Chair of Refrigeration, Cryogenics and Compressor Technology

Zeotropic Refrigerant Blends

Experimental Investigations on a Heat Pump Tumble Dryer

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Motivation

Zeotropic blends are refrigerants that show a temperature glide during the evaporation and condensation process. The glide results from the different vapor pressures of the blended components. Depending on the application, a higher or lower glide can be realized adjusting refrigerants and mass fraction, as shown in figure 1.

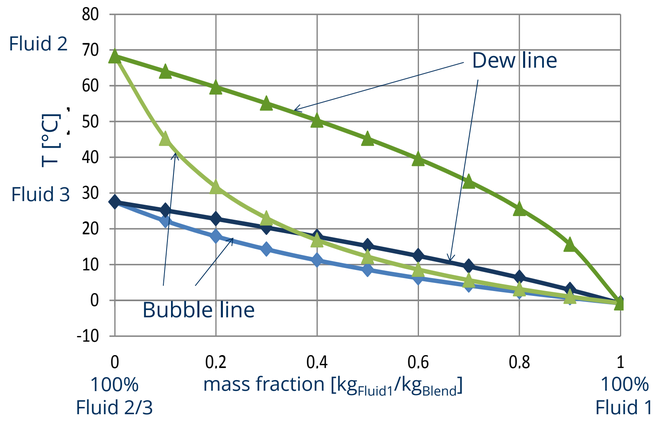

Fig. 1: zeotropic blends.
Green: high difference in boiling point.
Blue: low difference in boiling point.

The refrigerants used for heat pump tumble dryers have a constant temperature during the phase change in the evaporator and condenser (like R134a). Air as secondary fluid increases or decreases in temperature due to heat absorption or heat dissipation. Figure 2 on the left side shows the exergy losses in the heat exchanger by using a pure refrigerant, approximated through the Carnot cycle. The right picture illustrates an example of a zeotropic refrigerant blend whose temperature change during the phase change is optimized according to the air temperature change. This behavior can be approximated with the Joule cycle. Thus, exergy losses can be minimized.

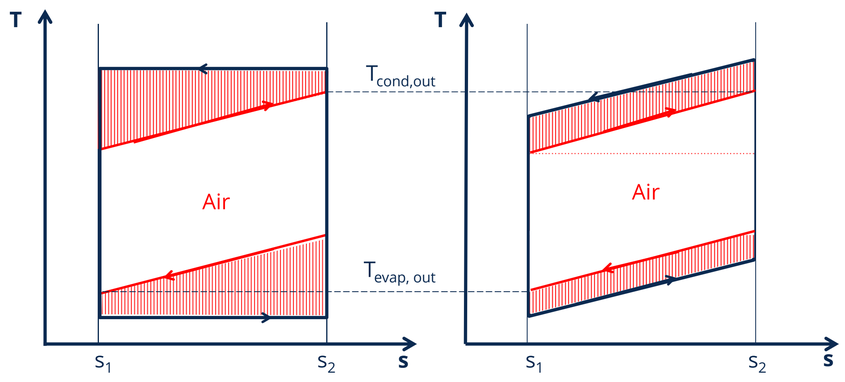

Fig. 2: Temperature-Entropy diagram.
Left side: Carnot cycle. Right side: Joule cycle.
Red stripes: exergy losses.

Tumble Dryer Test Rig

A test rig was set up to compare R134a with the new blend regarding:

- Pressure level
- Temperature level
- Compressor performance
- Tumble dryer performance
- Heat exchanger performance

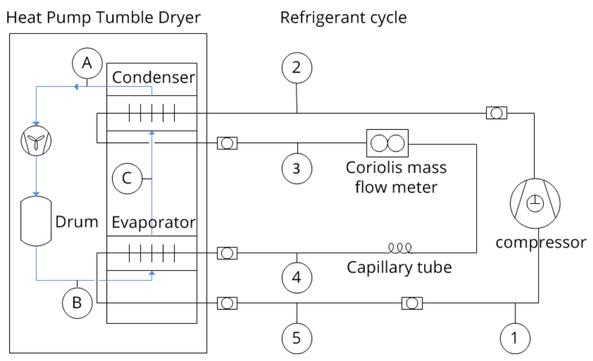

Fig. 3: Scheme of the test rig with measuring points

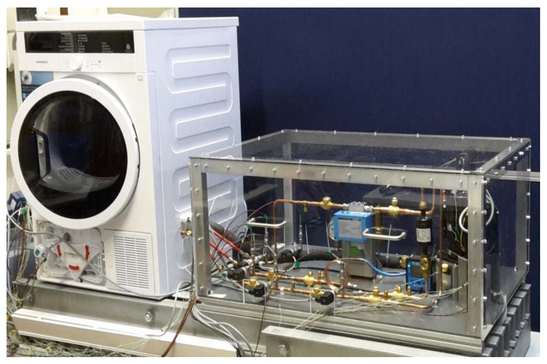

Fig. 4: Heat Pump Tumble Dryer Test Rig

Measurement results

Figure 5 and 6 show exemplary measurement curves for the pressure and temperature variation during a drying cycle.
As the temperature rises slowly, the high and low pressure level also rise.
The striking peaks in both curves result from a stop of the drum. At the same time, the refrigerant cycle is still running while the air flow over the heat exchanger is suspended.

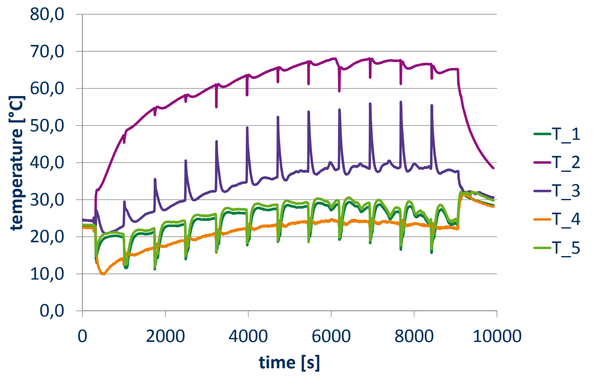

Fig. 5: Temperature curve for drying cycle

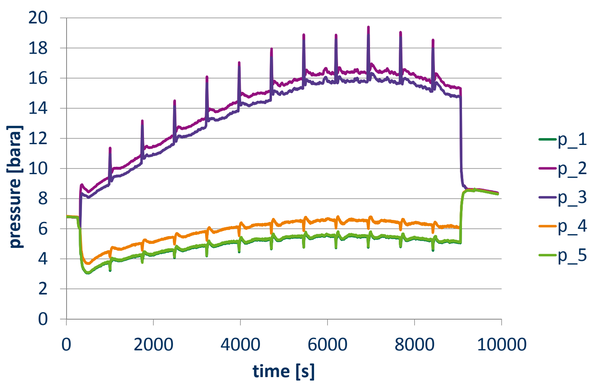

Fig. 6: pressure curve for drying cycle

Heat exchanger

The transferred heat is calculated from the measured mass flow rate and the specific enthalpy deriving from the logged pressure and temperature. Overall, the heat flow across both heat exchangers is higher when employing the zeotropic mixture instead of R134a.
In this specific case the heat flow in the evaporator is 1311 W with the regular refrigerant R134a compared to 1629 W with the new zeotropic blend. The heat flow in the condenser is 1464 W for R134a and 1763 W for the zeotropic mixture. Fig 7 and 8 show the temperature behavior of air (green) and the refrigerant (blue; left: R134a; right: zeotropic mixture).

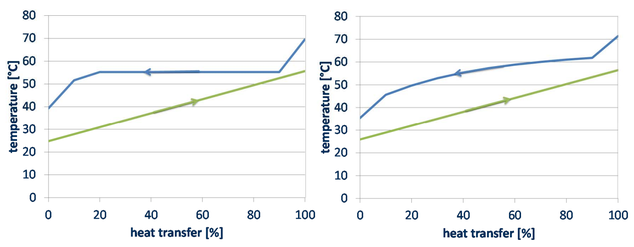

Fig. 7: Comparison of the transferred heat in the condenser
(left: R134a, right zeotropic mixture)

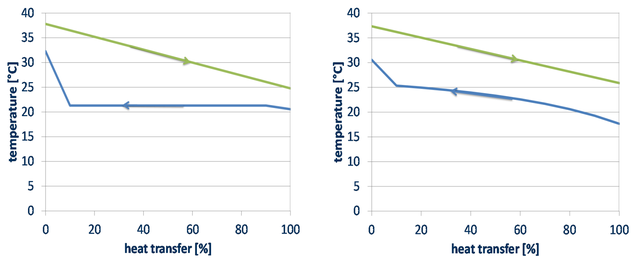

Fig. 8: Comparison of the transferred heat in the evaporator
(left: R134a, right zeotropic mixture)

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