TECHNISCHE UNIVERSITÄT DRESDEN

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

Vapor Injection

Performance tests of a vapor injected scroll compressor in an economized vapor compression cycle

Thomas W. Moesch (thomas.moesch@tu-dresden.de) // Ullrich Hesse

Introduction

Vapor injected (VI) scroll compressors have an extended operating range due to their reduced discharge temperature. Combined with an economizer cycle as represented by the internal heat exchanger (IHX) the VI compressor may also increase the specific cooling capacity of a refrigeration machine and thus improve its coefficient of performance (COP).

In this study the performance of a VI compressor was tested at different operation conditions and injection conditions using a modified compressor calorimeter [1].

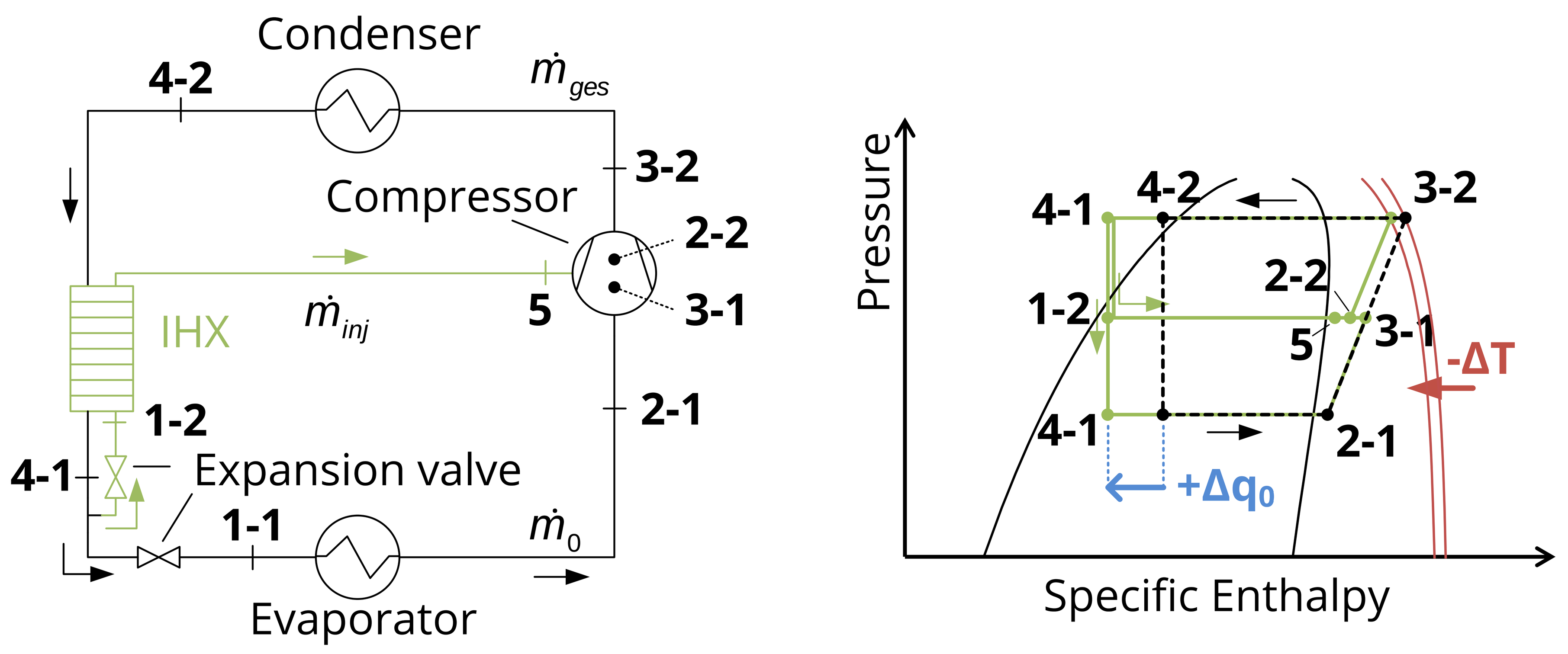

Fig. 1: Economized vapor compression cycle (left) with a VI compressor and its qualitative p-h diagram (right)

Performance Test Setup

The utilized compressor calorimeter is a regular vapor compression cycle. It allows the control of the condensing and evaporation temperatures ϑ_C and ϑ_0, the suction superheat ΔT_{SH}, and the compressor chamber temperature ϑ_{amb} and enables the measurement of the cooling capacity $\dot{Q}_0$ and the compressor power P_{el}.

The modification (green) represents the economizer cycle and enables a control of the injection mass flow rate using an electronic expansion valve (EXV). This leads to different injection pressures p_{inj} and different injection superheat values $\Delta T_{SH,inj}$, respectively.

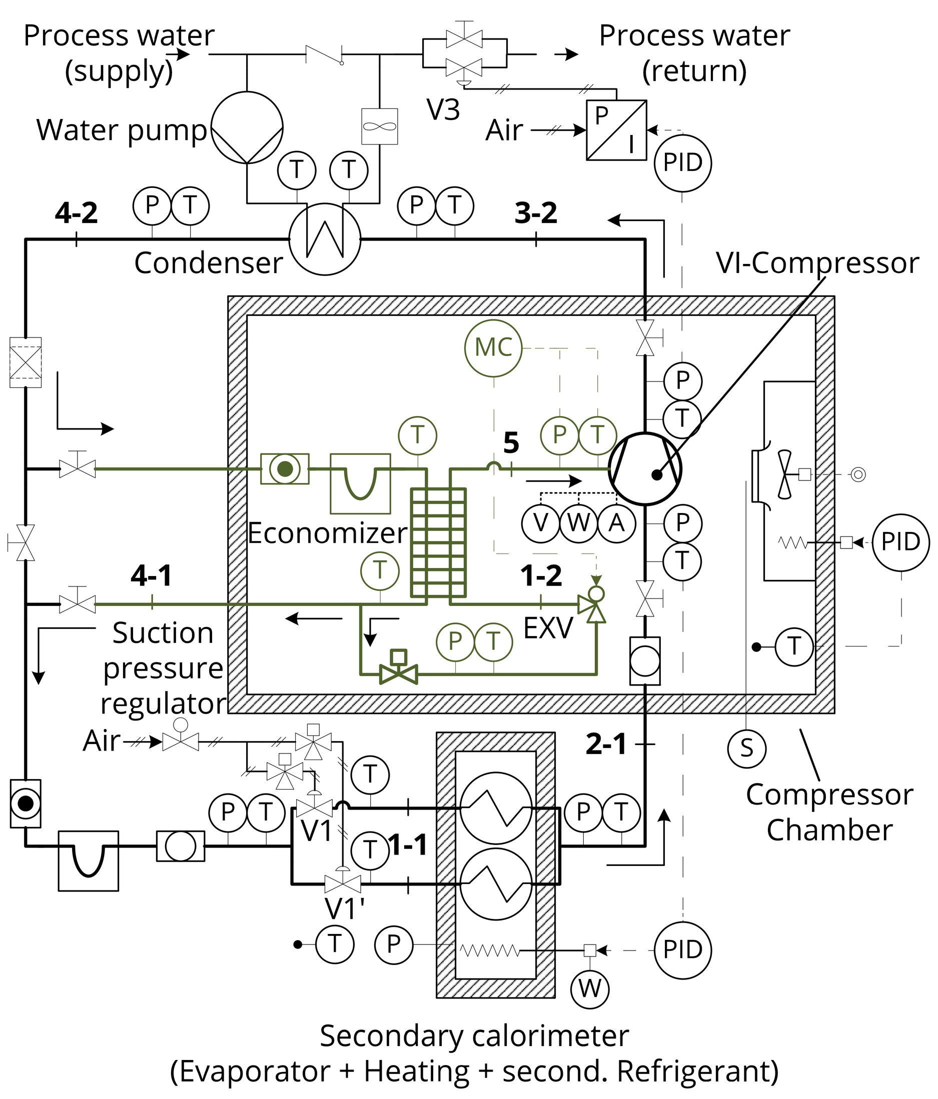

Fig. 2: P&I diagram of the modified compressor calorimeter

Test Matrix and Results

The performance tests were carried out for a 67cc VI scroll compressor with R-407C. The suction superheat and the compressor chamber temperature were kept constant at ΔT_{SH} = 11.1 K and ϑ_{amb} = 35 °C. The scroll compressor was tested with and without vapor injection at the operating condition ϑ_0 = 4.5 °C and ϑ_C = 48.9 °C.
The results of the injection tests represent each value relative to its baseline test value (BL) as defined by the following equations.

$$Y^{rel} = \frac{Y - Y^{BL}}{Y^{BL}} \quad for\ Y \in \left\{\dot{Q}_0, P_{el}, COP_0, \lambda, \eta\right\}$$

$$T^{rel} = T - T^{BL}$$

The results indicate an increase of $\dot{Q}_0$ by 10 to 20 %, a reduction of $T_{3\text{-}2}$ by up to −2.5 K, and an improved cooling COP (up to 2.5 %) during vapor injection. For two phase injection $T_{3\text{-}2}$ is reduced even further (here by −20 K). However, this also leads to a declined cooling COP and compressor efficiency η. During injection the volumetric efficiency λ and η are reduced, which indicates increased internal losses.

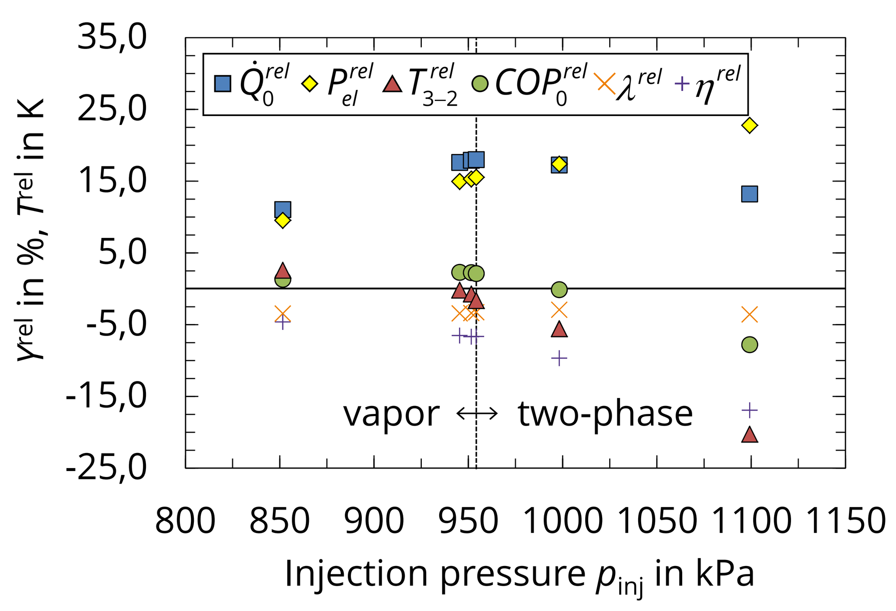

Fig. 3: Relative performance data of the tested VI compressor

Conclusions and Further Research

The tested unit (VI compressor and economizer cycle) can be used to reduce the discharge temperature and improve the COP of a vapor compression cycle. In regard to COP and cooling capacity optimization, saturated vapor injection seems favorable. A proper characterization of a VI compressor requires the injection pressure as a parameter in future performance test matrices.

Further research on the characterization of VI compressors [2], the application VI compressors in A/C systems and the corresponding cycle models [3] were carried out at the Purdue University (West Lafayette, IN, USA).

Literatur:

1 MOESCH, Thomas W.; BAHMAN, Ammar M.; GROLL, Eckhard A. Performance Testing of a Vapor Injection Scroll Compressor with R407C. 2016.

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