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Title of thesis: Development of an expander/compressor for the transcritical refrigeration process with carbon dioxide as refrigerant
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Abstract

Introduction and Problem:

It is well known, that the COP of CO₂ transcritical refrigeration processes can be improved by more than 20%, when one replaces the throttle valve of the conventional cycle with a work extracting expander. Such an expander should be reliable, efficient and cost effective. Several different types of expanders (like turbo-, screw- or scroll expanders) have been tried in recent years for this duty without much success.

Solution:

In chapter 3 it is derived, that a low-speed piston expander should be the most promising approach. The piston principle is advantageous because its inherently low leakage and the low speed is important to allow an expansion of the fluid from the supercritical into the two-phase region near the thermodynamic equilibrium.

Following an earlier example of P. Heyl, a free linear type of machine is chosen, where the expander drives a directly coupled second stage compressor. The new approach, of which several details have been patented, uses a three-stage expansion with double acting pistons. The flow to and from the 6 expander volumes is controlled by a main sleeve valve, which again is controlled by an auxiliary sleeve valve. A similar machine principle had been used in the past for the water steam pump of steam locomotives, but the use for an expansion "on the left side of the critical point" is new.

Detailed design considerations and calculations are presented in chapter 4. In chapter 4.2 the energy related topics and in chapter 4.3 the pressure and safety aspects are discussed. Wherever possible it has been aimed to use standard parts. The machine has been built and tested. The machine runs smoothly and reliably. The first performance results are satisfactory. Several points are listed, where further improvements seem possible.

Summary:

Within this thesis a totally new type of machine has been developed, designed, built and tested and it is worldwide the first, which is being operated in a real refrigerator and the predicted improvement has been demonstrated.