Small Oilfree Compressor for Carbon Dioxide

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Among the natural working fluid substitutes for synthetic hydrofluorocarbons (HFC) carbon dioxide is of particular interest for domestic water heating applications with heat pumps due to its nonflammability and its thermodynamic properties. However the compression of carbon dioxide to supercritical pressures in conventional oil lubricated compressors is not without problems due to the mutual solubility of the carbon dioxide and the lubricating oil. An oilfree compressor would overcome these problems but a suitable one was not on the market.

The project Small Semihemeric Oilfree CO\textsubscript{2} Compressor is the Swiss contribution towards the efforts of developing CO\textsubscript{2} heat pumps for supercritical heat pump processes with large temperature spans, a project within the frame of the International Energy Agency (IEA)\textsuperscript{1}. The key elements of the compressor (Figure 1) are based on the experience with a small high pressure compressor used in natural gas refuelling appliances. The new compressor has a suction gas cooled, highly efficient permanent magnet synchronous motor, dry running clearance seal piston/cylinders which seal with a minimal gap of a few microns in-between, and the flat sealing plastic plate valves with flat springs.

Figure 1: Cross section through the functional model of the new, oilfree CO\textsubscript{2} compressor. TE Temperature measuring points on the compressor [from final report].

\textsuperscript{1} Swiss contribution within the scope of the Annex 27 (Selected Issues on CO\textsubscript{2} as a Working Fluid in Compression Systems) of the Implementing Agreement for a Programme of Research, Development, Demonstration and Promotion of Heat Pumping Technologies of the International Energy Agency.

The new compressor with four cylinders (bore 10mm, stroke 16mm) focuses on domestic water heating applications. The functional model was performance tested on a test bench: Figure 2. The CO\textsubscript{2} gas was compressed from 35 bar (boiling temperature approx. 0.3°C) to supercritical pressures of 80 to 150 bar and temperatures up to 190°C (critical point of CO\textsubscript{2} is at 73.8 bar and 31.1°C) with
speeds from 750 to 2900 RPM and electrical power consumptions from 150 to 950 W. Figure 3 shows the measured isentropic efficiencies. This value characterizes the deviation from the thermodynamically ideal compression. The measured values are in the same range as conventional oil lubricated compressors. This equivalent energetic efficiency despite the absence of a lubricating sealing film between piston and cylinder has been a remarkable success! With this development a small oilfree compressor for the CO₂ heat pump technology will be available. A focused further development will hopefully result in a Serial Compressor Model going into production soon.

Figure 2: Functional model (left) on the test bench at the Zurich University of Applied Sciences (ZHAW), CH-8400 Winterthur [from final report].
Figure 3: Isentropic compressor efficiency of the functional model in relation to the pressure ratio, at a suction pressure of 35 bar for steel-cylinderheads and reinforced plastic-cylinderheads, without losses of motor and frequency converter [from final report].

Further information:

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Detailed final report of this SFOE-research project:


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