KONVEKTA Thermo Systems

Bus Air Conditioning – Type P7744

Research for more efficiency and climate protection

Development of an environment-friendly air conditioning unit with the refrigerant CO_2 (carbon dioxide)

The effects of synthetic substances on the earth's atmosphere are identified as increasingly problematic. These synthetic refrigerants will especially become a problem if they reach the environment due to accidents, maintenance or leakage of the air conditioning unit. The negative impacts on the greenhouse effect are 1300 times higher with the fluorocarbon "R134a" than with carbon dioxide.

The replacement of the previously used artificial refrigerant with the natural substance carbon dioxide provides a huge opportunity in the area of air conditioning and refrigeration. Carbon dioxide has already been used as a refrigerant at the end of the 19th century, however in slow operating, huge compressors with a subcritical operational mode.

Initially, today's fast operating small vehicle compressors could not be used for this high pressure refrigerant. Here new gaskets, oils, and substances had to be found. The design of the air conditioning units for high pressures makes the use of the refrigerant CO_2 even in the supercritical pressure range (higher 73 bar) possible. The so-called transcritical operational mode henceforth offers a sufficient capacity and efficiency when these air conditioning units are operated up to ambient temperatures of 50 degree Celsius. In subcritical operational mode, the capacity and efficiency decreases if outside temperatures higher than 25 degree Celsius are reached.

Due to the transcritical operational mode there is no liquid phase of the refrigerant in the high pressure part but only supercritical gas. This requires a different system architecture. The redesign of the refrigerant-carrying components leads to smaller dimensions, which makes the application in vehicles possible. On the other hand, the high operational pressures demand a great deal of the used valves, compressors and heat exchangers.

In contrast to conventional air conditioning units, with the transcritical CO_2 unit it can be used for heating purposes due to the circulation reversal (heat pump). Carbon dioxide has the highest heating capacity of all the refrigerants and is ready for use in a broad evaporation temperature range from +20 to -55 degree Celsius. No other current refrigerant can fulfill that task.

- CO_2 is an alternative to HFKW R134a and R404A
- Regarding capacity and efficiency CO_2 is competitive due to better compressor performance, better heat transfer and lower effect in case of pressure losses.
- Performance testing with CO_2 prototypes deriving from production units confirm this

- The operation of optimized CO_2 prototypes in field tests respectively in long-time tests with more than 6000 operating hours demonstrate the everyday suitability.

- With CO_2 as refrigerant greenhouse gas emissions can be saved.

Model character

The developed air conditioning units and transport refrigeration units with carbon dioxide were presented on the IAA '94 respectively IAA'98 as the first units world-wide with this new technology and a few years later they were tested in vehicles on the road.

Since summer 1996, a public-transport bus with a CO_2 air conditioning unit has been in daily use. At the beginning of 1997 the second bus was put into operation. These buses are equipped with mobile measurement to conduct a comparison with an R134a unit in parallel. The operational experience of more than 10 years and the evaluation of the field test show the good applicability of CO_2 as a refrigerant. Due to this experience, Konvekta plans on achieving the series-production readiness of CO_2 units. Since August 2002 the first transport refrigeration unit with a CO_2 compression circulation has been used by ALDI. In cooperation with the company Volkswagen, a CO_2 air conditioning unit for a midibus was developed and tested in detail.

Advantages CO_2 - R134a

Environment

• no direct greenhouse gas emissions
• lasting, long-term available and permitted refrigerant at low prices
• nontoxic, no toxic decomposition products
• fire-proof, fire extinguishant
• carbon dioxide is world-wide available at a low price

Cooling capacity

• comparable with R134a units; according to ambient temperatures CO2 has a 15-20% higher capacity

Air capacity

• identical to R134a units

Pipes (suction and pressure)

• approx. 30% smaller diameter
• reduced weight
• lower relative drops in pressure

Installation size / design

• presently comparable with an R134a unit

• Reduction of the installation size is realizable on short notice

• high-strength components designed for refrigerant pressures up to 15 MPa offer the same reliability and security as conventional units

Operating expenses – CO_2 units

• fuel saving at a comparable cooling capacity in the European annual mean

• clear reduction of the service costs (LCC costs) (see chart)

Environment relief

When it was confirmed in the 80s that the commonly used refrigerant CFC destroys the ozone layer of the atmosphere, Konvekta consequently pushed the development of air conditioning units with a more compatible refrigerant. The result was that at the end of 1989 the first air conditioning units with the fluorocarbon free from chlorine were produced Europe-wide. Until 1992, all air conditioning units of the company had been converted to R134a. This refrigerant is still used world-wide today.

However, soon it was obvious that this refrigerant has a very high greenhouse potential. As a basis for the Global Warming Potential (GWP) carbon dioxide is assumed with the factor 1. The world-wide used refrigerant R134a has the factor 1300. Moreover it is a synthetically produced gas and harmful long-term effects on the environment cannot be excluded. Researches are known which describe the splitting up of this refrigerant into tri-fluorine acetic acid and hydrofluoric acid in the atmosphere. The caustic tri-fluorine acetic acid is persistent or not degradable at all, hydrofluoric acid is highly toxic and carcinogenic. The optimistic estimation of the greenhouse gas emissions by the DG-Environment of the European Commission assumes that there are approximately 30 megatons of CO_2 equivalents because of the air conditioning units of the more than 200 million vehicles in the EU. Therefore, Konvekta was convinced that the currently used polluting refrigerant R134a had to be replaced.

Thereupon, a team of our development department systematically tested 25 possible refrigerants to detect an environment-friendly refrigerant. The result according to these criteria was carbon dioxide (CO_2), a natural gas, which is found in the atmosphere and thus is completely harmless. In addition to this, carbon dioxide is a by-product in the production of technical gases and therefore available world-wide at a low price. Before the use of this refrigerant, comprehensive analysis had to be carried out. Then it was detected: The operational pressure of CO_2 in an air conditioning or refrigeration unit is five to six times higher than the pressure of the present refrigerant. Therefore it is necessary that all of the components are constructed entirely new or are reconstructed. The development was conducted by two medium-sized manufacturers of components in the area of refrigeration engineering under the system leadership of Konvekta.