NATURAL REFRIGERANTS

Used at lower temperature applications

Jan Boone

MAYEKAWA EUROPE S.A.,Leuvensesteenweg 605, 1930 Zaventem, Belgium

Tel. 32-2-757-9075, Fax. 32-2-757-9023

ABSTRACT

This paper focuses on the natural refrigerants which strongly contribute to the reduction of consumption of fossil fuel and significant reduction of the CO2 emissions.

The different system applications are presented in the 'NATURAL 5 LINE-UP'.

The paper presents the results of operation in the field of a CO2/NH3 cascade refrigeration system installed in a meat processing company in the Netherlands.

The contractor ENGIE Refrigeration Netherlands installed a CO2-NH3 cascade plant, with the NH3 part only located in the machine room and on the roof.

The plant uses standard and high pressure screw and reciprocating type compressors.

The supply of the freezing and the cooling is done with CO2 at -51°C (2900 Kw) -35°C and -12°C.

In addition heat is recovered on different temperature levels for process water, heating of rooms and floors.

The paper is supported with technical details and photo's of each system.

As closure for the paper the use of compressor technology is mentioned for demonstrating the feasibility of controlled thermonuclear fusion for power production.

(Note : the indicated figures are subject to revision after that full details will be generated)

FIELDCASE.

The contractor ENGIE Refrigeration b.v. in the Netherlands proposed to the customer to install a CO2-NH3 plant in order to replace the existing R22 installation.

The old R22 plant has been in operation since 1997 and was converted in capacity and freezing temperature from 1300 kW at -42°C to 2900 kW at -51°C. The new plant processes meat frozen during the process, operating 24hrs per day per workweek by using :

process working room chilling requiring -12°C,

4 plate freezers each 550 kW, 1 quick freezing tunnel of 600 kW and a spriral freezing tunnel of 600 kW requiring -51°C,

frozen food stores requiring -35°C.

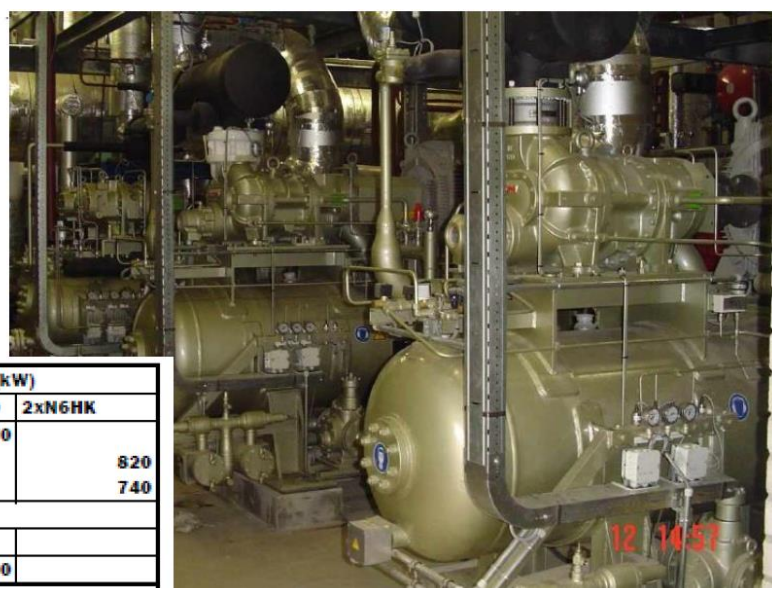
In addition heat recovery is required to obtain 55°C hot water for the process,
35°C water for floor-/office-/load dock-/expedition room heating,
12-14°C water for bottom floor freezing rooms,
and condensing temperature must not exceed 10°K above wet bulb temperature (authority requirement).

The ammonia parts of the plant are located in the machine room and partly on the roof (condensors).

The supply of freezing on low temperature and cooling (-31°C and -51°C, -12°C) shall be done with CO2.

The new plant has been completed and handed over during 2005 and has several advantages compared to a common plant with the synthetic refrigerant R507.

View on the 50 bar CO2 screw compressor, CO2 screw compressor machine room and capacities.



LOW TEMPERATURE SIDE : FREEZING CAPACITIES (kW)			
CO2 LIQUID T°(°C)	1xGH160	2xC200WMD	2xN6HK
-51	630	2870	
-41	900		820
-31	960		740
HIGH TEMPERATURE SIDE (TC = 32°C)			
NH3 TE (°C)	3xN250VLD	1xN200VLD	
-18	4180	800	

Considerations :

CO_2 is a high pressure refrigerant. This means that without any problems a refrigerant temperature of -51°C can be obtained. R507 has at this temperature an evaporating pressure of 0.8 bar(a).

As the pressure of CO_2 is so much higher, the vapor lines have much smaller diameters and also the compressors are sized smaller.

CO_2 and NH_3 are natural refrigerants.

The new plant is significantly more efficient than a R507 plant.

The calculated savings amount to 23% on energy and 49% on CO_2 emmision equivalent.

In addition the plant is executed with following energy saving options :

Heat recovery

High efficiency motors

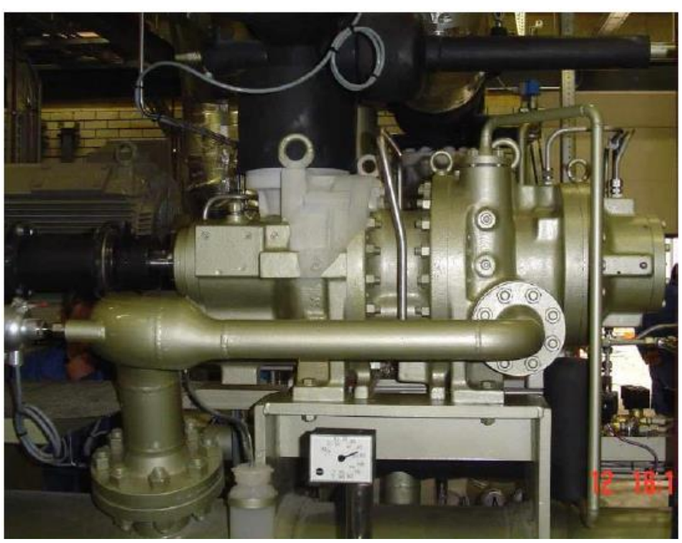
Hot gas defrosting

Frequency convertors

Energy saving condensors.

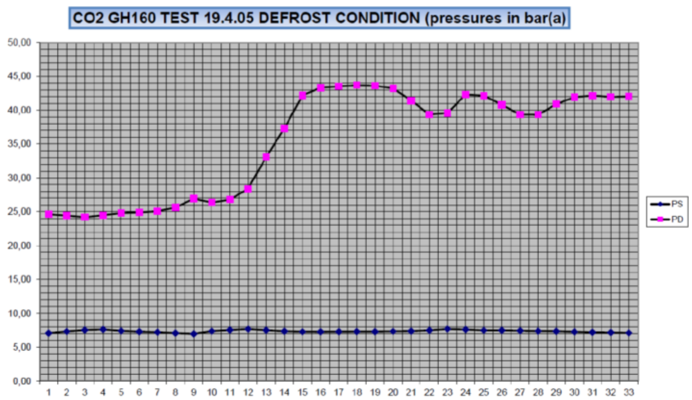
ENGIE Refrigeration b.v concluded that this chosen CO_2/NH_3 cascade concept is much cheaper than the R507 solution.

Underneath photo of the GH160 screw compressor used for -51°C CO_2 production and hot gas for defrosting.



The compressor suction and discharge gas pressures are plotted in the graph underneath.

The compressor runs continues to produce CO2 at -51°C and automatically switches to defrosting mode when demanded.



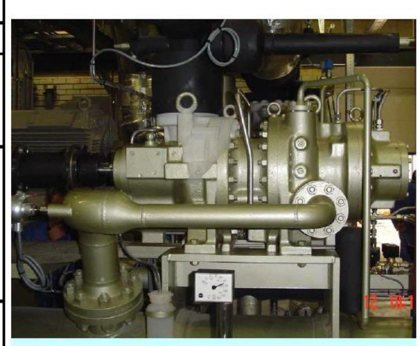
At the completion and the acceptance of the new CO2/NH3 plant TNO reported that the CO2/NH3 plant is significantly more efficient than a comparable plant with R507.

In reality it was possible to run the NH3 high stages at considerable lower condensing temperatures than initially design. The average yearly condensing temperature is 25°C instead of the 32°C initial designed resulting in a yearly saving of 906 MWh. This represents a cooling COP increase of nearly 9% or a yearly saving of 90600€ for the customer.

For 12 years of operation of the 9 compressors the costs for used parts, service works and lubrication oil amount to approx. 275 000€ which is nearly 7% of the installation investment done in 2005, including 1 bare compressor GH160S 50 bar)

The table hereunder shows the actual number of operating hours after 12 years of the upgrading to the CO2/NH3 cascade installation.

OVERVIEW INSTALLED COMPRESSORS				
natural refrigerant	unit nr	compressor		
		type model	installation year	running hours 2/11/2017
CO2	5	C6HK	2005	92765
CO2	6	C6HK	2005	15964
CO2	7	CGH160	2005	80630
CO2	8	C200VMD	2005	68539
CO2	9	C200VMD	2005	13813
NH3	1	N250VLD	1997	98149
NH3	2	N250VLD	1997	50411
NH3	3	N250VLD	1997	48004
NH3	4	N200VLD	2005	107737



AND LAST BUT NOT LEAST

An impressive reference to mention is CERN (European Organisation for Nuclear Research).
The LHC (Large Hadron Collider), which is the world's largest and most powerfull particle accelerator uses a 27 kilometer ring of superconducting magnets and was realised in Geneva.
The particles are brought on an unlimited way by using the magnets at very high speeds before they collide and must be cooled down close to -271,3°C to minimize the losses with 2 stage Mycom screw compressors using superfluid helium to obtain access to the high energies needed to test fundamental theories of particle physics.
Picture : CERN view in Genf

Picture : MYCOM screw compound package

In July 2012 the Higgs boson was discovered as first major result of LHC research.

In 2013 the NOBEL PRICE in PHYSICS was awarded jointly to Francois Englert and Peter Higgs for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, confirmed through the discovery of the predicted fundamental particle, by the experiments at CERN's particle accelerator.

One of the most ambitious energy projects in the world to-day is a test plant presently under construction in Europe and is the world largest magnetic device (Tokamak) to prove the feasibility of fusion on a large-scale and carbon-free source of energy, based on the same principle that powers our sun and stars, to demonstrate the feasibility of controlled thermonuclear fusion for electricity production.

In the tokamak the energy produced by fusion of atoms is absorbed as heat in the walls of the vessel to obtain plasma of 1 300 000 °C which will be used to produce steam and electricity with turbines and generators.

The test plant is designed to produce a 10-fold return on energy or 500 MW of fusion power
from 50 MW of input power.

This experimental campaign is crucial for advancing fusion science and to prepare the way for fusion power plants to-morrow.

Cryogenic technology will be used to create and maintain low temperature conditions for the magnets. The very large superconducting magnets will be cooled with supercritical helium at 4 K in order to operate at high magnetic fields necessary for the confinement and stabilization of the plasma.

The screw compressor units for the helium cooling have been delivered by the contractor
ENGIE Refrigeration in France in November 2017.

Picture : shows the compressor on the Mayekawa Japan factory test-bench.

The first commissioning phase is scheduled for 2024-2025.

The first Plasma-production is scheduled for 203

Mayekawa thanks the contractors

ENGIE REFRIGERATION bv Mr.Willy van Leeuwen in the Netherlands,
&
ENGIE REFRIGERATION Mr.David Buisson in France

for their positive contribution which allowed us to issue this paper on their realizations
using NATURAL REFRIGERANTS at lower temperature applications.