NATURAL REFRIGERANTS

NH_3 heat pumps for hot water production.

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LINE-UP OF 'NATURAL 5'.

Mayekawa was founded in 1924 and is to-day one of the world's largest industrial refrigeration companies. It actively promotes the 'NATURAL 5' refrigerants, including ammonia, CO_2, hydrocarbon gasses, air and water. Mayekawa is active in ammonia compressors for more than 85 years, for hydrocarbons and CO_2 for more than 40 years.

The 'NATURAL 5' refrigerants cover the full application range -100°C/+100°C from cryogenics, freezing, cooling, air conditioning up to heating.

AMMONIA HEAT PUMP

REASON FOR BUILDING THE HEAT PUMP PLANT

This field case concerns a Bakery plant producing frozen bake-off bread products,also known as premium butter viennoiserie (plain croissants, chocolate rolls, swirls, etc.) located in Mouscron-Belgium requiring a hot water production heat pump for extension of the production capacity, reducing energy consumption/energy costs and contributing to the sustainability program.

To produce hot water of 65°C in an energy efficient way a heat pump shall be used with ammonia as refrigerant, which is most natural with an ODP=0 and a GWP=0, with condensing temperature at 67°C corresponding with a pressure of 29.5 barg.

The heat pump uses the ammonia refrigeration system condenser heat as heat source giving a positive impact on the condenser load and recovering the residual heat for hot water production for sanitary water at 65°C and process water for dough proofer to provide ideal warmth and humidity for rising of the bread-products in the plant.

DEMANDS

The Bakery plant needs to produce 1000 m3/day hot water of 65°C with a heating capacity of 300 kW per hour on a continuous basis.

For the dough proofer 70 m3/day warm water of 25°C is needed with a heating capacity of approx.. 65kW.

The cooling demand for the plant is 2,5 MW at -30°C and 1 MW at -10°C.

On the -30°C freezing part NH3 pump circulation + direct expansion is used, while for the -10°C cooling part NH3 direct expansion.

PRINCIPLE SCHEME

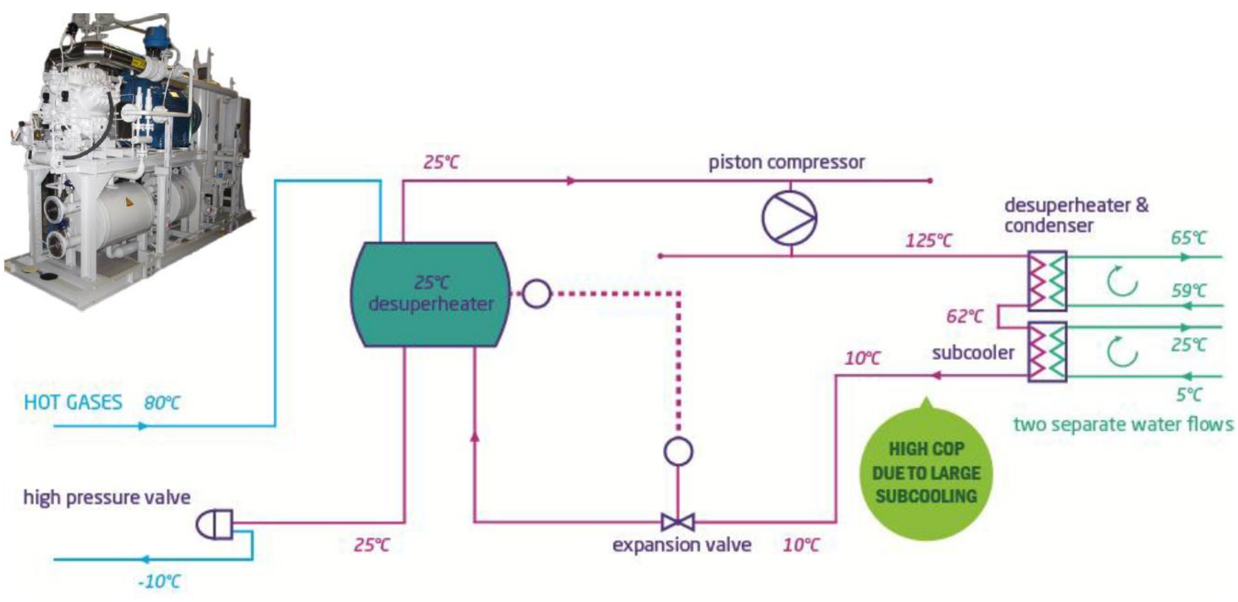
The principle scheme shows the heat pump piston-type compressor which is connected on the low pressure side to the open flash heat source tank, and to the condenser on the high pressure side.

After the condenser the liquid subcooler is mounted to optimize the COP of the unit.

Two separate water circuits are heated up by the heat pump :

the process water for the dough proofer is warmed up in the liquid subcooler from 5°C to 25°C by subcooling the NH3 liquid from 62°C to 10°C,
and the hot sanitary water is heated up from 59°C to 65°C by condensing the NH3 from 125°C to 62°C.

This arrangement results in an optimized COP because of the large subcooling of 55°C which is realized. Of course, the subcooling is only applicable when the corresponding water circuit is active which is possible in batch operation mode (majority of the operation)



EQUIPMENT

The piston type compressor model N6HK is used in the heat pump unit equipped with frequency convertor for capacity control.

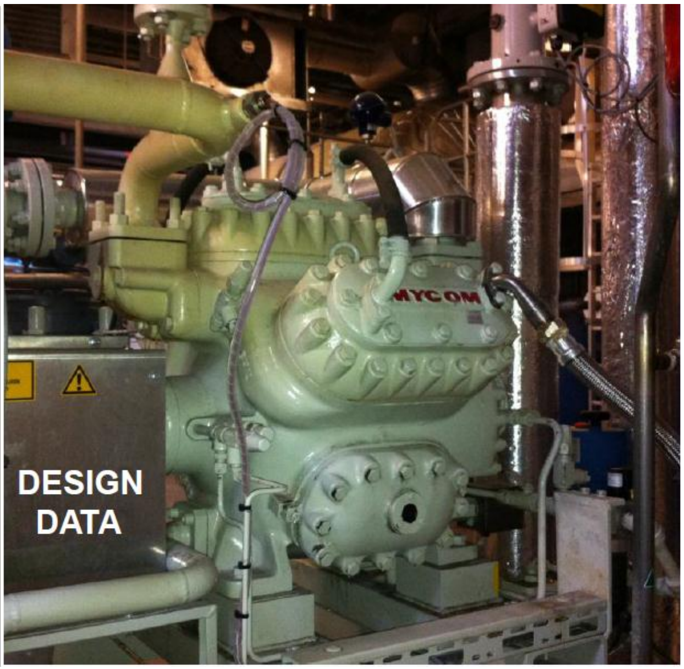
The compressor has mechanical cylinder banks which can be unloaded in steps of 33% for the design conditions evaporating-/condensing temperature of +25&+30°C/+67°C.

The design compressor performance is 375kW heating capacity with an absorbed shaftpower of 48 resp.55kW depending on the evaporating temperature and rotation speed.

The final design coefficient of heating performance corresponds with 7,7 at 30°C evaporating temperature.

The actual operating hours on 21/1/2015 amount to 7186.

MODEL		**N6HK**	
QTY		**1**	
SITE LOCATION COUNTRY TOWN		BELGIUM MOUSCRON	
REFRIGERANT		NH3	
TE	°C	30	25
TC	°C	67	67
PS	barg	10,7	9,0
PD	barg	29,9	29,5
RPM	rpm	1000	1150
QC	kW	375	375
BKW	kW	48	55
COP-H		**7,7**	6,8
OPERATING HOURS		21/01/2015	
HP	hrs	7186	



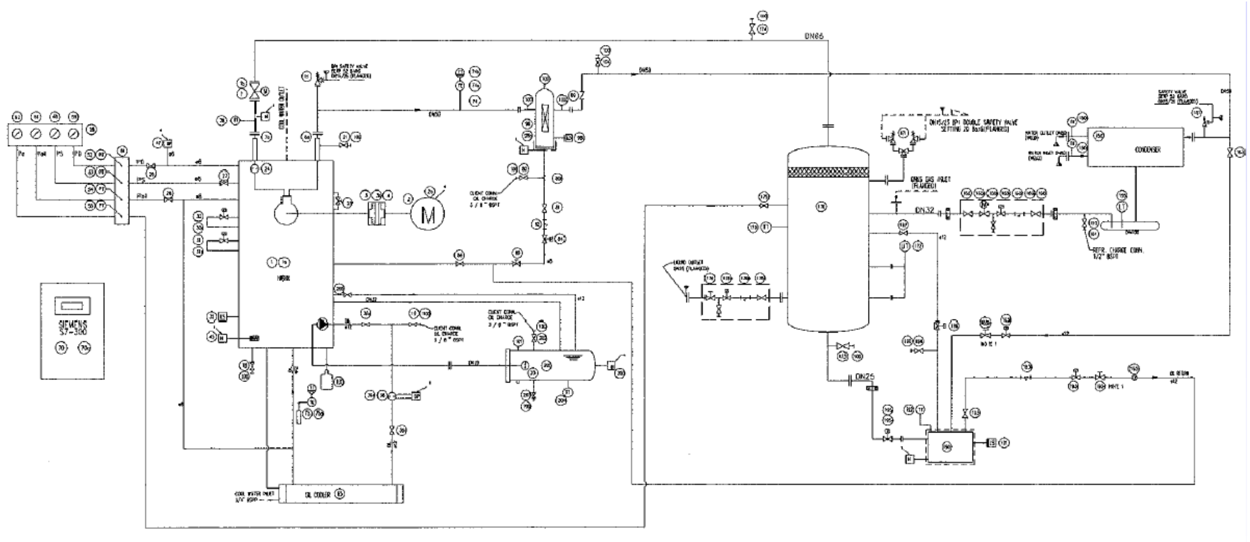
UNIT PID

The scheme shows the compressor with complete oil system on the left part;

The oil system contains an oil pump(integrated in compressor), oil filter, external oil tank, a watercooled oil cooler and a fine oil separator on the gas outlet of the compressor.

On the right hand side the condenser is shown with receiver and the expansion control devices to the heat source flash tank shown in the middle.

On the flash tank the gas inlet from the refrigeration plant is visible and the oil recovery vessel.



UNIT LAYOUT

The photo shows the compressors with main drive motor make WEG 315S/M 75kW installed in the machine room. The insulated line on top of the machine is the suction line with automatic closing valve mounted to be closed at compressor standstill.

The installation was done in February 2013 and operation is approx.. 8760 hrs on yearbasis.

The efficiency of the power drive is in the range of 97 to 98%.

The main drive motor efficieny varies around 93.7 to 93.2 at resp.100%,50% load.

OPERATION SAVINGS.

Based on a constant load of 8760 hours at 375kW and an average nominal heat pump evaporation temperature of 30°C (being the refrigeration plant condensing temperature) the comparison is made between conventional heating with gas and the heat pump.

Based on an efficiency of 90% the boiler system energy input will be 365000 m3 natural gas, (3.650.000 kWh at 10 kWh/m3 natural gas) what means a COP-H of 0.9.

This gas boiler has an energy cost of 109.500 € based on a gas price of 0.30 €/m3 natural gas.

For the heat pump the electrical energy input amounts to 533.000 kWh based on an electrical consumed energy COPh of 6,16 (obtained from COP-h of 7,7 minus 20% motor losses)

The energy cost for the heat pump amounts to 53.300 € based on an electricity price of 100 €/mWh, representing a saving of 56.200 € or 51% of the energy cost.

For a heat pump installation cost of 150.000€ and 8.760 hours of operation per year this represents a return of investment of less than 3 years.

The CO_2 emission is reduced from 645 tons to 267 tons per year, what means a reduction of 378 tons or 42%.

CONCLUSION : this field case shows that the annual savings can be listed as follows :

Energy cost 56.200 €

CO_2 emission 378 tons

Not including watersavings & treatment + condenser fan power

Refrigeration power consumption.

Natural waste heat and condenser.

The return of investment within 3 years.

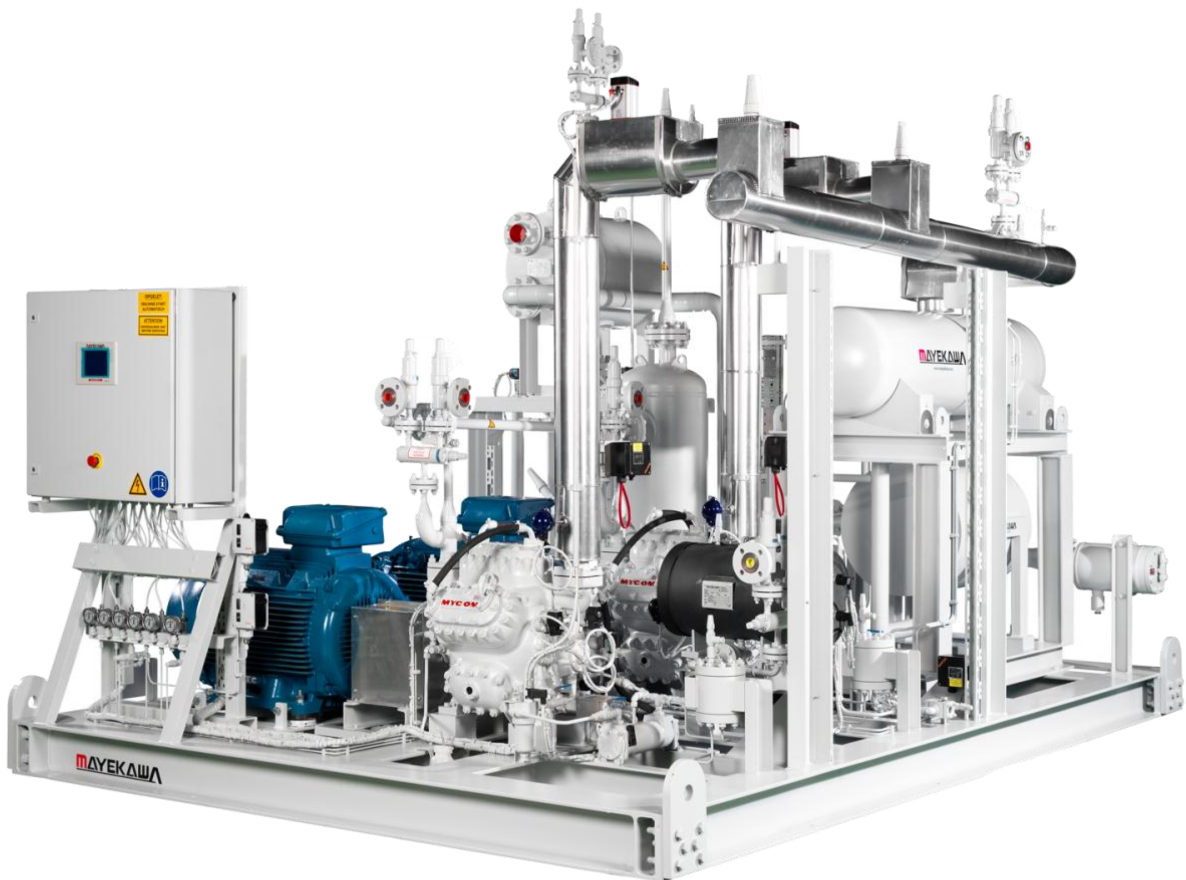
The efficiency of the heat pump is higher than when applying other comparable technologies.

The heat pump has a long life time (more than 25 years) and has low maintenance costs.

Excluding Governmental Funding/Grants

NEXT HEAT PUMP MODULE.

The next heat pump with double capacity of the previous shown field-case is under installation and will be operational very soon again with small footprint and now available as a standard product enable to install the unit at site with minimized site works.



Two compressor and drive motor sets are installed on the compact steel base structure next the condenser and subcooler producing the hot water. On the back side the heat source evaporator and separator is visible. On the front the control panel is visible.

SPECIAL THANK-WORD.

For Mr.Koen Demerie , the contractor COFELY AXIMA GDF-SUEZ Antwerp-Belgium, who installed the plant and gave us access to all details of this heat pump plant.