ENERGY SAVING

90°C hot water NH_3 heat pumps in Dairy Plants.

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 energy-consumption and significant reduction of the CO_2 emissions.

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

The second part presents the use of natural refrigerants with high pressure compressors in an industrial plant.

The plant belongs to an international Dairy Group installed in Denmark by the contractor Svedan Industri Koleanlaeg A.S. and was installed in 2013 for 3 mW hot water production at 90°C by applying high pressure NH_3 compressors.

The NH_3 compressors are installed as second stage ammonia heat pumps on the water chillers producing approx. 2mW at 1.5°C using the heat rejection from the chillers as heat source for the hot water heat pump.

The total heating performance coefficient is designed at 6,64.

The paper evaluates the results of this plant after 8000 hours of operation and is supported with technical details and photos of the system including energy efficiency, investment and operating costs summary.

By using this high stage hot water heat pump the energy cost for production of hot water was reduced to a quarter compared to a conventional gas boiler system.

1.INTRODUCTION

Starting point for the project was to produce 2Mw chilled water at 1,5°C and 3Mw hot water at 90°C to be operational from February 2014. The choice was made for 2 sets 2 stage NH_3 reciprocating compressor system in complete factory produced modules with minimum site installation works, using the N8M 30 bar piston as low stage and the N6HS 66bar piston compressor as high stage. Time frame

The picture 1. shows the hot water buffer tanks of each 150.000 liters for the chilled water and the hot water.

Picture 1.

2. OVERCOMPRESSION HOT WATER HEAT PUMP

The table 1. Shows the equipment with design data.

Total Cooling capacity: 2060 kW
Outlet water temperature : 1.5 C

Total Heating capacity : 2950 kW
Outlet water temperature : 90 C

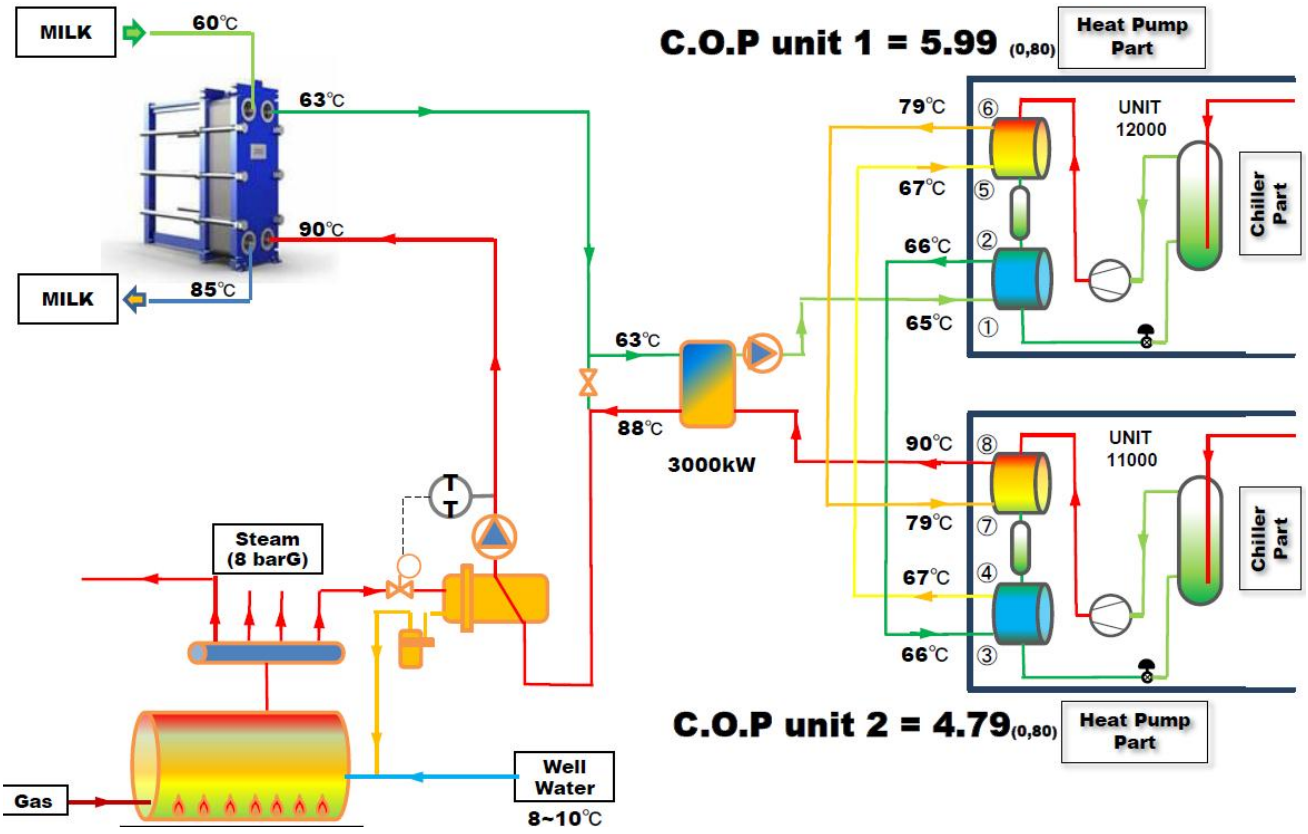
		UNIT 1	UNIT 2	TOTAL
CHILLER PART				
Cooling Capacity	[kW]	1030.1	1030.1	2060.2
Evaporative Temperature	[C]	0.0	0.0	
Inlet Water Temperature	[C]	10.0	10.0	
Outlet Water Temperature	[C]	1.5	1.5	
Intermediate Temperature	[C]	45.0	45.0	
HEAT PUMP PART				
Heating Capacity	[kW]	1452.6	1496.0	2948.6
Condensing Temperature	[C]	81.0	92.0	
Condenser				
Inlet Water Temperature	[C]	67.1	78.7	
Outlet Water Temperature	[C]	78.7	90.0	
Liquid Sub Cooler				
Inlet Water Temperature	[C]	65.0	65.7	
Outlet Water Temperature	[C]	65.7	67.1	
C.O.P cooling	[-]	4.22	4.22	4.22
C.O.P heating	[-]	7.49	5.99	6.64

3. PRINCIPLE

The production process requires heating of milk from 60°C to 85°C.

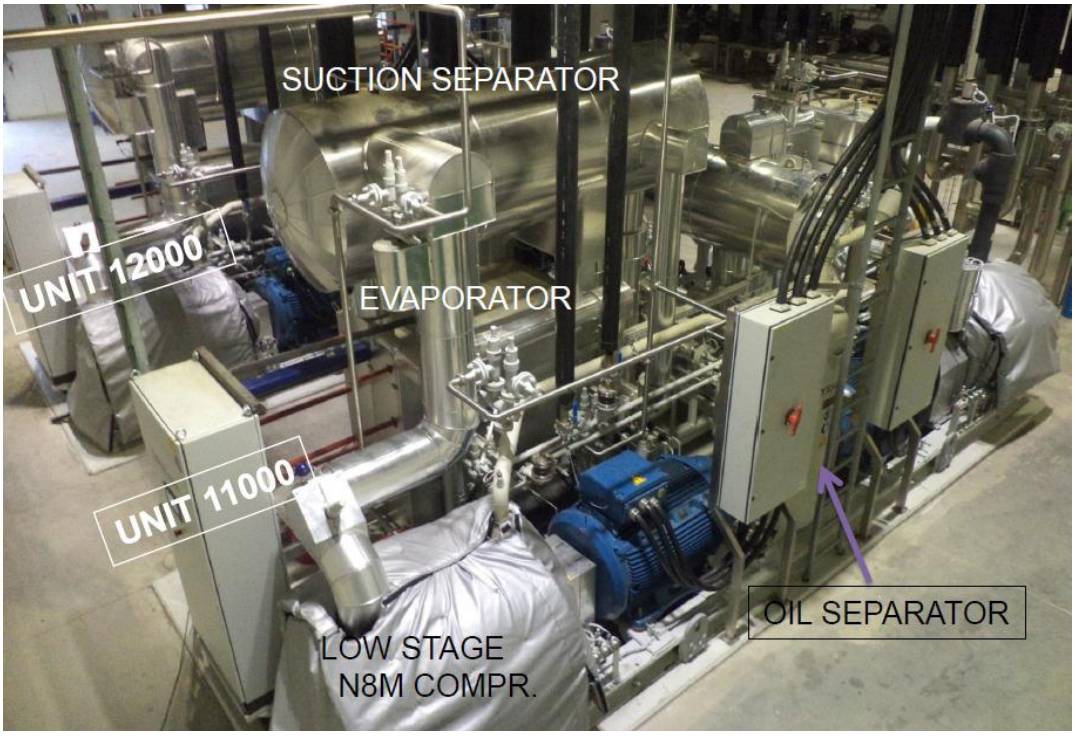
The 2 chillers are used in parallel to cool down the water from 10°C to 1,5°C. The heat rejection of the low stage is used as heat source for the heat pump. The high stage condensors + subcoolers heat up the water in serial flow from 65°C to 90°C as is illustrated in picture 2.

Picture 2.

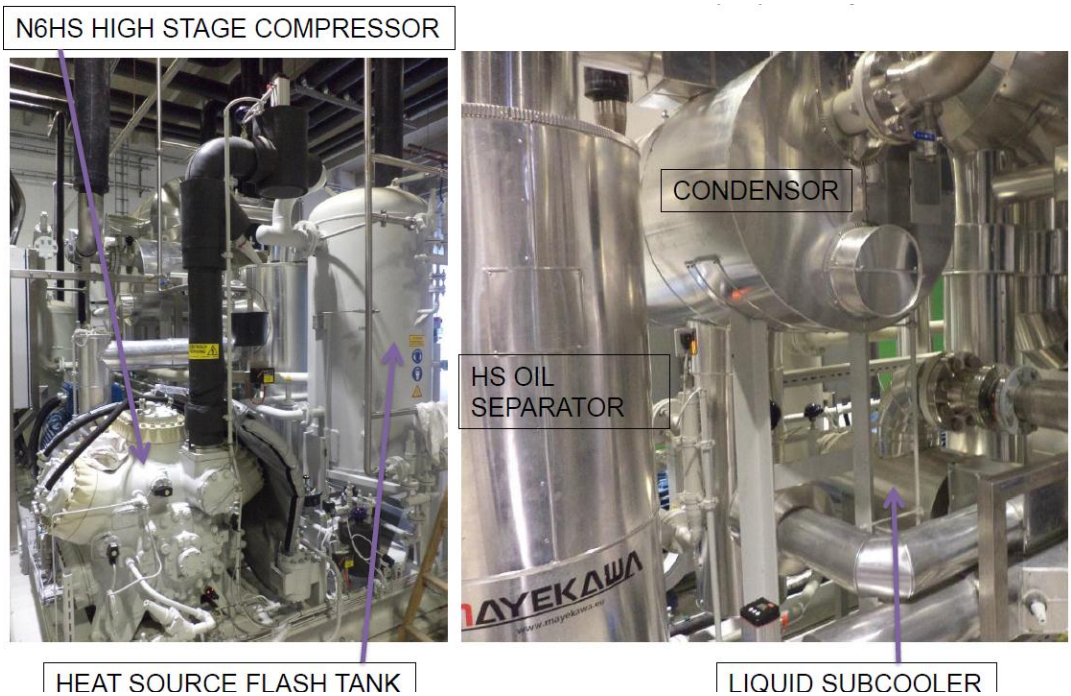


The overall COP of the compression hot water heat pump is calculated at 5,31.Each compressor is executed with suitable oil system (cooler,filter,separator), evaporator(plate heat exchanger with external suction separator for chiller) and openflash intermediate vessel or heat source tank (heat pump). Plate in shell heat exchangers are used for the condenser and liquid subcooler on the heat pump part. Unit layout is visible on picture 3 and 4.

Picture.3

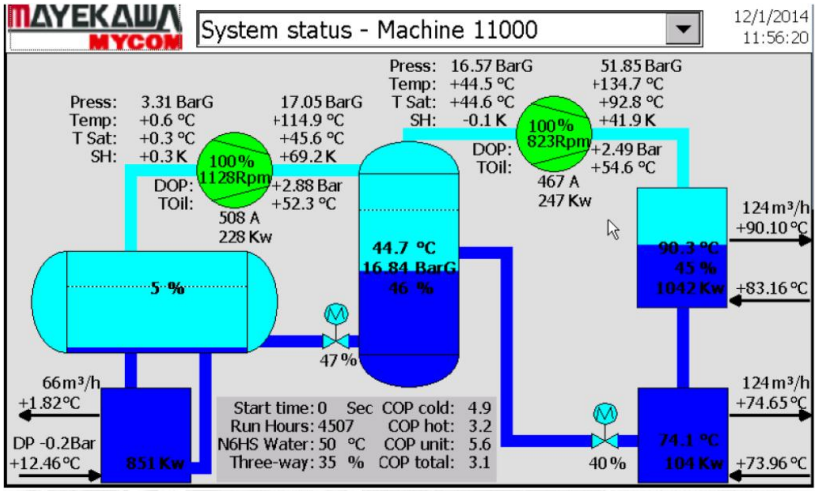


Picture 4.



4. OPERATION

To-day the units have operated approx.. 10.000hours. The picture underneath shows the screen shots of the control boards showing detailed operation data.



5. MERIT OF HIGH STAGE HEAT PUMP

When comparing the conventional gas boiler system with the hot water heat pump for 1 year operation 20hrs/day, 310 days/year with a heating capacity of 2948 kW per hour the yearly energy consumption will be 21.507.296 kWh for the gasboiler and 3.607.000 kWh for the heat pump.

Based on an energy cost of 0.064 €/kWh for gas and 1,184 €/kWh for electricity this represents a yearly running cost of 1.376.462€ for the gas boiler and 367.040€ for the heat pump or a merit of 1.009.422€ !