ROBUR®
caring for the environment

Air conditioning systems with gas absorption heat pumps

Natural gas/LPG fired

Civil Engineering
Arco (Trient), Italy

Innovative air conditioning systems

Thermal and cooling energy supply through a single gas fired water-ammonia absorption thermodynamic cycle has been installed in this innovative application, a valid alternative to traditional compression systems.

A building placed in a small business area, consisting of side by side industrial buildings, is the new headquarters of the Engineering Office "Studio Civil Engineering", a building including offices, a large open space and a conference room.
Close to other industrial buildings on 3 of 4 sides, the Engineering Office was intended to be equipped with heating and cooling system, allowing for air-exchanges for those rooms not overlooking outdoor. The first difficulty in installation of a whole air conditioning system was due to the fact that the whole industrial building is not equipped neither with thermal station nor with indoor equipment room.
Overcoming this problem, systems for the production of heating and cooling energy have been installed outdoor, on the accessible flat roof.
The air handling unit has been installed in the false ceiling on the first floor, using the ceiling space for installation of fresh air intakes with suitable duct.
Given low domestic hot water demand, typical in premises applications, a small electric system for the production of domestic hot water instead of a gas boiler has been installed, thus avoiding internal gas distribution and building charges due to flue system.

BUILDING DESCRIPTION

Surface	504 m^2
Volume	1728 m^3
Summer project temperature	internal: 25 °C, 50% R.U.
	external: 31 °C, 45% R.U.
Winter project temperature	internal: 20 °C
	external: -11 °C
Air capacity	1500 m^3/h
Nominal heating capacity installed	105.9 kW
Cooling capacity of the new system	50.7 kW
Air treatment system	air handler unit: 4 rows of 31.7 kW; air capacity 4500 m^3/h (30% from external air)
Fan coil system	boh built-in and wall hanging unit, with vaiable speed ventilator

The chiller-heaters choice

Defined the position, the type of system ought to be chosen among the wide range of products available on the market. Three appliances were taken into consideration:

- air-water heat pumps powered by electric engine;
- modular condensing boilers for outdoor installation combined with electric chiller group;
- gas fired reversible absorption heat pumps.

The first application was rejected, because of winter extreme temperatures (note that external project temperature in winter in Trient is down to -11 °C). The second application consists of an electric chiller combined with a condensing boiler, preferred to traditional ones, since in the Province of Trient forgivable loans up to 25% of the purchase price are available, a measure intended to promote installation of low consumption and highly efficient systems. This application involves greater complexity, since on the same system a boiler group together with an electric chiller group ought to be installed, working alternatively either in summer or in winter. The Robur reversible gas fired absorption heat pumps could solve these problems, proving to be good-value.
In compliance with the Province of Trient regulation, Robur systems are eligible for loans both for heating and cooling technology and not only for the heating technology.

Management costs: a valid reason

The choice of reversible gas-fired absorption heat pump technology is the result of an economic evaluation.
Considering the thermodynamic cycle used in winter as well as in summer mode, the average seasonal efficiency and the electric power and gas costs, a rapid return on investment, less than 2 years, is achievable.
In fact, absorption heat pumps heating efficiency, at an external air temperature of -11 °C (project temperature), is 107%, a value increasing proportionally according with external temperature.
Considering that offices are open during the day, with an average working temperature up to 7 °C, the average seasonal efficiency is 35% higher than condensing boilers and 45% higher than high efficiency boilers.

The chiller-heaters

Given project heating capacity up to 90 kW and cooling capacity up to 50 kW, three Robur GAHP-AR units have been installed (each one equipped with circulation pump), working parallel on a primary circuit. The circulation pump installed on every unit allows to keep constant outlet water temperature constant according to seasonal peak load, thus varying units in operation and water capacity.
Placed on the flat roof, the chiller-heaters have been installed on a single frame provided with steel joints

Fig.1 - Installation of reversible absorption heat pumps on the building roof.

Fig. 2 - Detail of internal water outlet and inlet manifold.

(see picture nr. 1) and linked to 2 outlet and inlet manifolds. The system here described, managed by Direct Digital Controller (DDC), turns out to be a single group for the production of either hot or cold water, working in both cases in cascading operation and with 3 operation modes.

Variable capacity and constant temperature

The primary hydraulic circuit, linking the 3 units and the secondary circuit water distribution manifold, has a variable capacity, with a temperature gap in heating mode up to 10 °C (55/45 °C), a gap reduced to 5 °C (7/12 °C) in summer with the same water capacity on the working units. Variation in capacity (due to the switching off circulation pumps correspondent to the units, once close to set point values) prevents mixing of outlet and inlet water from units switched off.
Two large horizontal manifolds, linked to by-pass stop valve (see picture nr. 2), stands for capacity balancing system between primary and secondary circuits (necessary in case of variable capacities). The secondary circuit consists of two distribution systems (each one equipped with pump): one fitted out for the air handler unit and one for a series of built-in fan coils and ceiling hanging units.

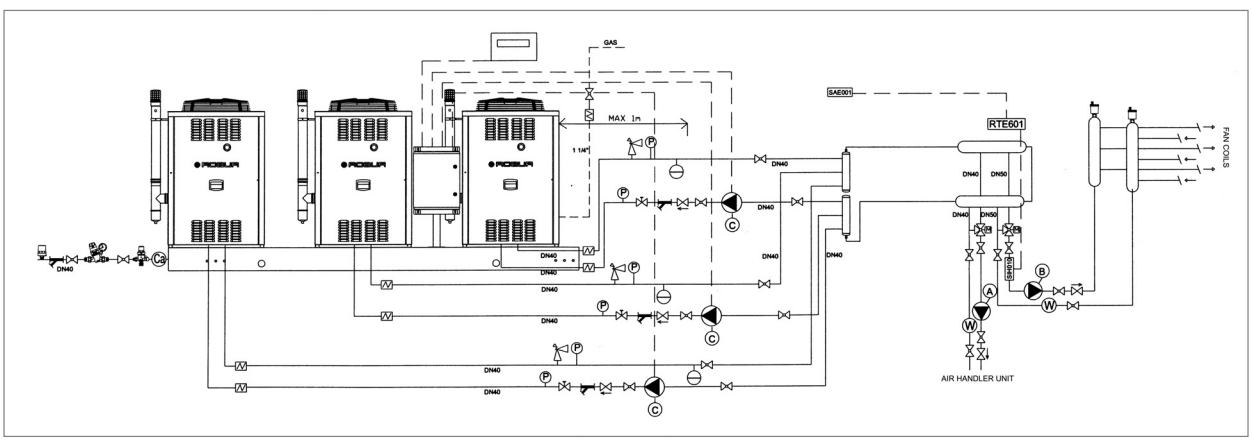
Air ventilation distribution

The building was in need of external air exchanges in order to ensure clean air and natural ventilation in rooms without windows. The system consists of a ceiling built-in air handler unit, with air capacity of 4500 m^3/h, 1500 m^3/h of which drawn from external air to the office rooms via air ducts.
The distribution system offers high standard of comfort, without compromising appearance and functionality. For the air distribution system it was used a steel air duct with air intakes on the bottom. In every room, built-in fan coils have been installed to manage the different temperature needs. They are control a centralized system. Picture nr. 3 represents the hydraulic scheme.

Conclusions

Installation of gas fired absorption heat pumps meets comfortable cooling and heating requirements thanks to an innovative technology with high growth potential. Although reliability should still be tested, consider that water-ammonia absorption technology has been widely adapted in air-conditioning applications for the last decade.
During a standard heating season this heat pump installation would permit to save about 1200 m^3/year of natural gas compared to standard condensing boilers.

Fig. 3 - Robur RTAR 180-360 hydraulic scheme.



Temperature and energy efficiency trend

In the table below, heating efficiencies generated by the above mentioned gas heating systems (Robur absorption heat pumps, high efficiency boilers and condensing boilers) calculated according to the average monthly temperature trend in the province of Trient, are highlighted.
Comparing system performances, absorption heat pumps, recovering heat through thermodynamic cycle, are more efficient than gas boilers.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Seasonal
Avarage outside air temperature	12.7	6.4	1.7	1.5	4.7	9.2	13.4	7.0
Gas efficiency (outlet water temperature = 50 °C)	1.48	1.39	1.27	1.27	1.34	1.44	1.48	1.38
Traditional boiler efficiency	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Condensing boiler efficiency	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02

			RTAR [1] 180-360
OPERATION IN HEATING MODE [2]			
Heating capacity [3]		kW	105.90
G.U.E. heating efficiency based on gas consumption			1.40
Water flow rate	nominal (ΔT = 10 °C)	m³/h	9.12
	maximum	m³/h	15
	minimum	m³/h	4.2
Pressure drop at nominal flow rate		kPa	31
Outside air temperature dry bulb	maximum	°C	35
	minimum	°C	-20
Inlet water temperature	maximum	°C	50
	minimum	°C	2
Maximal outlet water temperature (ΔT = 10 °C)		°C	60
OPERATION IN COOLING MODE [4]			
Cooling capacity [5]		kW	50.7
G.U.E. cooling efficiency based on gas consumption			0.67
Water flow rate	nominal (ΔT = 5 °C)	m³/h	8.7
	maximum	m³/h	9.6
	minimum	m³/h	7.5
Pressure drop at nominal flow rate		kPa	33
Outside air temperature	maximum	°C	45
	minimum	°C	0
Inlet water temperature	maximum	°C	45
	minimum	°C	6
Minimum outlet water temperature		°C	3
BURNER FEATURES			
Nominal heating input		kW	73.6
Gas consumption	natural gas G20 [6]	m³/h	8.01
	natural gas G25 [7]	m³/h	9.05
	LPG G30/G31 [8]	kg/h	5.88
ELECTRICAL DATA			
Required voltages			400 V 3N - 50 HZ
Nominal electrical power [9]	standard version	kW	3.21
	low noise version	kW	3.3
INSTALLATION DATA			
Weight in operation		kg	1450
Sound pressure at 10 meters [10]	standard version	dB(A)	59
	low noise version	dB(A)	54
Dimensions	width	mm	3610
	depth	mm	1240
	height - standard version	mm	1400
	height - low noise version	mm	1650

[1] Values for CC version (with indipendent circulation).
[2] Nominal conditions according to EN 12309-2 norm, table 12.
[3] Features under nominal conditions: outside air temperature dry/wet bulb 7/6 °C; outlet water 50 °C.
[4] Nominal conditions according to EN 12309-2 norm, table 5.
[5] Features under nominal conditions: outside air temperature 35 °C; outlet water 7 °C.
[6] Lower heating value 34.02 MJ/m³ (9.45 kWh/m³) at 15 °C - 1013 mbar.
[7] Lower heating value 29.25 MJ/m³ (8.13 kWh/m³) at 15 °C - 1013 mbar.
[8] Lower heating value 46.34 MJ/kg (12.87 kWh/kg) at 15 °C - 1013 mbar.
[9] ±10% tolerance to allow for different electrical voltage and power absorption of the electrical motors.
[10] Free field, frontally, direction factor 2.

NOTE: the technical table is taken from the Robur GAHP catalogue, edition 02/2007.

Due to continuous product innovation and development, Robur reserves the right to change product specifications without prior notice.