(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 362 165 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
31.08.2011 Bulletin 2011/35

(51) Int Cl.:
F25D 11/00 *(2006.01)*

(21) Application number: **11001282.0**

(22) Date of filing: **17.02.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **23.02.2010 IT TO20100132**

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(54) High-efficiency refrigerating apparatus

(57) A high-efficiency positive temperature refrigerating apparatus is described, comprising a compression system and a condensating system, such compression system comprising at least one compressor with low evaporation pressure and such condensating system being without any condensating fan.

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Description

[0001] The present invention refers to a high-efficiency and high-performance positive temperature refrigerating apparatus.

[0002] The prior art proposes refrigerating apparatuses equipped with a refrigerating plant that provides for the use of a condensating fan, since it is not possible to dispose of heat to the condenser with usual heat exchangers with natural convection, without obtaing a condensation pressure that cannot be supported by the compressor (usually with condensation temperatures greater than 55°C when operating and 65°C of peak). Moreover, the compressors responsible for the necessary power of the compression systems currently used in this type of apparatuses are normally, but not only, of the type with medium/high evaporation pressure, since ventilated evaporators with winged pipe, usually but not exclusively used, take the normal working range to values greater than - 10°C, upper limit of the class of low-pressure compressors.

[0003] However, the presence of a component for operating such apparatuses, such as the above condensating fan, generates some types of complications that are even more increased if, as detected by the Applicant, such component can be omitted though keeping the same cold-generating performances.

[0004] In particular, the presence of the condensating fan creates an increase of costs of the refrigerating apparatus and a greater operating noise.

[0005] Moreover, the possible lack of operation of the condensating fan generates a generalised malfunction of the apparatus, requiring additional maintenance and related costs.

[0006] Moreover, the possible lack of operation or operation under anomalous conditions of the condensating fan can damage other apparatus components.

[0007] Moreover, the presence of the condensating fan generates a higher energy consumption of the apparatus and a higher global environmental impact, also linked to the construction of the fan itself.

[0008] Documents EP-A-0438023, WO-Al-2008/148852 and US-A-2157754 disclose refrigerating apparatuses according to the preamble of claim 1.

[0009] Therefore, object of the present invention is solving the above prior art problems, by providing a refrigerating apparatus with positive temperature of the commercial type with high efficiency, characterised by a high refrigerating power and by its condensation without fans.

[0010] Another object of the present invention is providing a refrigerating apparatus with positive temperature of the commercial type with high efficiency without condensating fan and equipped with a low-pressure compressor, though keeping refrigerating performances similar to those of prior art apparatuses.

[0011] Moreover, an object of the present invention is providing a refrigerating apparatus with positive temperature of the commercial type with high efficiency that, being free of condensating fan, is less noisy and less expensive with respect to prior art apparatuses.

[0012] The above and other objects and advantages of the invention, as will result from the following description, are obtained with a refrigerating apparatus as claimed in claim 1. Preferred embodiments and non-trivial variations of the present invention are the subject matter of the dependent claims.

[0013] It will be immediately obvious that numerous variations and modifications (for example related to shape, sizes, arrangements and parts with equivalent functionality) can be made to what is described, without departing from the scope of the invention as appears from the enclosed claims.

[0014] The present invention will be better described by some preferred embodiments thereof, provided as a non-limiting example.

[0015] To be brief, herein below the descriptions will be omitted that are related to operating modes of common components with other vertical refrigerating apparatuses with positive temperature and necessary for the basic operation of the apparatus itself, that are anyway deemed widely known in the art, such as, for example, electric supply, compression, condensation, evaporation and chanalisation systems for refrigerating gases, etc., in order to describe in detail the aspects and components that characterise the refrigerating apparatus according to the present invention.

[0016] The present invention therefore refers to a high-efficiency positive temperature refrigerating apparatus equipped with a compression system advantageously comprising at least one compressor with low evaporation pressure as replacement of the compressor with medium/high evaporation pressure of prior art systems and a condensating system without any condensating fan.

[0017] In fact, depending on the following energy considerations, the Applicant has managed to obtain a refrigerating apparatus that, though keeping similar refrigerating performances as of comparable prior art apparatuses, through an inventive synergic optimisation of the various components, is free from the condensating fan and uses a compressor with low evaporation pressure: in fact, the low-pressure compressor, due to the reduced consumption in terms of electric power (it must be noted that the limit to low evaporation pressures implies, with the same compressor displacement, a lower refrigerating power in the working range, with respect to a medium/high power compressor, and therefore a lower electric consumption in the working range), manages to dispose, up to higher sizes with respect to medium/high pressure compressors, of the heat developed by the electric motor of the apparatus and the gas compression in a static environment, without obtaining, with this, excessively high thermal values of electric windings, that would risk to generate a decrease of the insulation capability of motor coil paints, or of gas delivery, that would risk to modify the characteristics of necessary oils for lubrifying the airtight

compressor.

[0018] The Applicant has then evaluated that the heat to be disposed of to the condenser is the sum of the refrigerating power and the compression power and, in order to reduce such value, has provided a refrigerating apparatus equipped with a compressor with low evaporation pressure characterised by a Coefficient of Performance (COP, defined as the ratio between the developed refrigerating power and the necessary electric power) that is better with respect to medium/high pressure compressors of prior art apparatuses, since the more advantageous COP values of currently known compressors are in fact those of low-pressure compressors for house environments, that join the lack of venting needs, inside the working range, to a reduced direct energy consumption.

[0019] Other elements to be taken into account for evaluating the working conditions of the low-pressure compressor of the apparatus according to the present invention are:

- the temperature of compressor suction gases, that, together with the mass flow-rate, higher at high evaporation temperatures, allows better cooling the compressor itself;
- the compression ratio, that depends by definition on the condensation and evaporation pressure and that increases when the evaporation temperature decreases, taking to low evaporation temperatures at a reduced limit in the maximum condensation temperature with respect to high evaporation temperatures, due to the low iso-entropic efficiency of the compressor deriving from a high compression ratio (namely, the curve of the iso-entropic efficiency decreases at high compression ratios);
- the increase, following the previous item, of the discharge temperature when the suction pressure decreases and the condensation pressure increases.

[0020] Preferably, the refrigerating apparatus according to the present invention can belong to any one of the two types of apparatuses for commercial refrigeration with positive temperature that follow:

- vertical cabinet with volume included between 400 and 800 gross liters;
- vertical show window with volume included between 300 and 650 gross liters, equipped with a light,

with a reference value of the polyuretane insulation of 40 mm, namely a transmission coefficient approximately equal to 0.48 W/Km^2.

[0021] For example, in case of a refrigerating apparatus according to the present invention made as a cabinet of about 600 gross liters, it is possible to take into account the value of thermal dispersion for a 40-mm insulation of rigid polyuretane of about 100 W under the following conditions:

- K = 0.47 W/Km^2;
- S = 6 m^2;
- ΔT = 30 K (temperature difference between apparatus interior and exterior);
- internal fan consumption = 10 W;
- gasket dispersion $\approx$ 5 W.

[0022] It must further be assumed that the refrigerating apparatus according to the present invention is equipped with an evaporator made as an evaporation plate, with a surface of about 0.4 m^2, and the evaporation temperature of about -15°C (ΔT = 15 K between room and evaporation) is taken into account.

[0023] In order to define the refrigerating power, a thermostating percentage condition of 50% must be taken into account, for keeping the suitable margin to keep the required internal temperatures even under harder conditions (thermal load insertion, doors opening, higher external temperature). This takes to consider a necessary refrigerating power of 200 W at the evaporation temperature of -15°C. Under evaporation conditions, therefore, the condensation conditions are then defined; in case of static condensation, it is normal to obtain ΔTs between 15 K and 25 K with respect to ambient temperature; therefore, 55°C can be take as limit worse condition.

[0024] In order to determine the consumption of the low-pressure compressor of the apparatus according to the present invention, it is necessary to locate the compressor's COP under the conditions detected with respect to a standard compressor:

- medium/high pressure standard compressor: COP substantially equal to 1.12 W/W
- low-pressure compressor: COP substantially equal to 1.87 W/W.

[0025] From what is stated above, the following consumption values are derived:

- medium/high pressure standard compressor: 178 W
- low-pressure compressor: 107 W

[0026] Therefore, with respect to the refrigerating apparatus according to the present invention that, due to the adoption of the low-pressure compressor, has a decrease of energy consumption of 71 W, similar prior art refrigerating apparatuses have an energy consumption greater by about 66%. Moreover, in the refrigerating apparatus according to the present invention equipped with low-pressure compressor and with high efficiency, it is necessary to dispose of 307 W to the condenser, versus about 400 W that instead would occur in case of a prior art refrigerating apparatus equipped with standard compressor and fan, that would then have an increase of about 30%.

[0027] Moreover, in prior art refrigerating apparatuses with positive temperature of the commercial type, the rear

surface has no functions: advantageously, then, the rear wall of the refrigerating apparatus according to the present invention can be equipped with at least one condenser on a wall, for example of the type with pipes and wires, or any other dissipator with compatible surface to be placed in the above position and suitable for such purpose, taking then into account that, for these condensers with natural convection, in the version with pipe pitch of 50 mm, for a surface with about 0.6 m^2 with a 4.76-mm pipe, an exchange coefficient of about 10 kcal/hK is obtained, and such an exchange coefficient, for a value to be disposed of 264 kcal/h, implies a $\Delta T > 25$ K. Therefore, the use, with an approximately equal engaged surface, of a pipe pitch of 25 mm, generates an exchange coefficient that can be estimated as 13 kcal/hK, with a $\Delta T = 20$ K. It must be noted that, instead, in case of a prior art refrigerating apparatus, with 344 kcal/h to be disposed of on the condenser, a $\Delta T > 25$ K (in particular 26.5 K, outside the working range) would be obtained.

[0028] As regards the lamination member of the refrigerating apparatus according to the present invention, it must obviously be suitable to keep the correct pressures, concurring, together with the refrigerating gas charge, to reduce undercooling to a minimum (1 K), in such a way as to keep the condensation pressure as minimum as possible (maximum internal condensation volume), though allowing that the evaporation is performed till the end of the evaporator piping by correctly supplying it, such piping preferably baving an internal diameter substantially equal to 1.2 mm and a length substantially included between 3 m and 4 m with a regenerating exchanger having a length substantially equal to 1 m, in such a way as to keep the temperature of sucked gases at a value substantially equal to 32°C. Obviously, such values can also be sized through suitable design evaluations.

[0029] The Applicant has further experimentally verified that the refrigerating apparatus according to the present invention makes, for the above types and perfoming the tests required by EN23953 or EN441 standard, the M1 class (namely, tests performed with all test packs, simulating the refrigerated goods, of a weight of 0.5 kg equipped with thermocouple at their geometric centre, with the refrigerated volume suitably loaded with packs, at a temperature included between -1°C and +5°C), for a time length of 12 hours with an opened door followed by 12 hours with a closed door, at 30°C - 55% RU, namely class 4: what is stated above is the check of the capability of the refrigerating apparatus according to the present invention of keeping the most restrictive specification for storing goods at positive temperature, both next to 0°C and due to temperature uniformity in test packs.

[0030] Obviously, in order to reduce the value of heat to be disposed of on the condenser, it could also be possible to limit external heat additions inside the refrigerating apparatus by increasing the iso-thermics of the structure and/or by limiting the addition of internal loads by using fans, necessary for obtaining the temperature homogeneity for class M1, with high efficiency.

[0031] In particular, the removal of the condensating fan with the adoption of the low-pressure compressor has allowed obtaining the following advantages:

- lower cost of the refrigerating apparatus according to the present invention;
- removal of problems connected to a possible lack of operation or anomalous operation of the condensating fan;
- lower energy consumption, lower noise and lower environmental impact.

[0032] Concluding, the proposed system, in addition to exploiting high-efficiency electric components (internal fan and compressor), allows removing the condensation ventilation by eliminating an electric load, with a further energy saving, and the fan saving not only as regards costs, but also evaluating the life cycle (including maintenance). Finally, take into account that a suitable fan that would lower the condensation by about 15 K, would imply a consumption reduction of about 13 W, value that, in order to be compensated, would have the need of a further high-efficiency fan.

[0033] Some preferred embodiments of the invention have been described, but obviously they are subjected to further modifications and variations within the same inventive idea. In particular, the skilled person in the art will immediately notice numerous variations and modifications, functionally equivalent with the previous ones, that fall within the scope of the invention as claimed in the enclosed claims.

Claims

1. High-efficiency positive temperature refrigerating apparatus comprising a compression system and a condensating system, said compression system comprising at least one compressor with low evaporation pressure, namely whose working range is at values lower than -10 °C, said condensating system being free from any condensating fan, **characterised in that** it further comprises: a rear wall equipped with at least one dissipator or condenser for a wall, and a lamination member equipped with an evaporator piping, preferably having an internal diameter substantially equal to 1.2 mm and a length substantially included between 3 m and 4 m, with a regenerating exchanger having a length substantially equal to 1 m.

2. Refrigerating apparatus according to claim 1, **characterised in that** it is a vertical cabinet with volume included between 400 and 800 gross liters.

3. Refrigerating apparatus according to claim 1, **characterised in that** it is a vertical show window with a

volume included between 300 and 650 gross liters.

4. Refrigerating apparatus according to claim 2 or 3, **characterised in that** it has a reference value of the polyuretane insulation substantially equal to 40 mm or a transmission coefficient substantially equal to 0.48 W/Km^2.

5. Refrigerating apparatus according to claim 2, **characterised in that** said low-pressure compressor has a value of the Coefficient of Performance, COP, substantially equal to 1.87 W/W.

6. Refrigerating apparatus according to claim 1, **characterised in that** said condenser is of the type with pipes and wires.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0438023 A **[0008]**
- WO 2008148852 A1 **[0008]**
- US 2157754 A **[0008]**