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(54) Refrigeration appliance with two evaporators in different compartments

(57) A refrigerator having a refrigerating circuit with a compressor (1), a condenser (2) and two evaporators (6,10) placed in different compartments (RC,FC) of the appliance comprises valve means (3) for alternatively directing refrigerant flow towards one of the evaporators (6,10). One of the evaporators (6,10) is in heat exchange relationship with a phase change material (8).

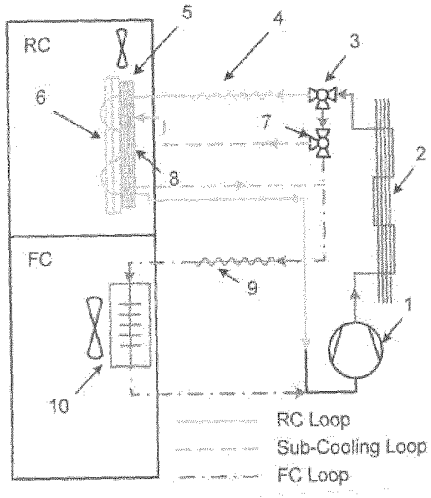

Fig. 1

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Description

[0001] The present invention relates to a refrigeration appliance having a refrigerating circuit with a compressor, a condenser and at least two evaporators placed in different compartments of the appliance, a three-way valve being provided for alternatively directing the refrigerant flow towards one of the two evaporators.

[0002] The above kind of refrigerating circuit is also known as "sequential dual evaporator" (SDE) system and allows the design of refrigerators having high energy efficiency.

[0003] It is an object of the present invention to further enhance energy efficiency of refrigeration appliances using the SDE cycle. Another object of the present invention is to stabilize temperature in the refrigeration compartment where one of the evaporators is placed.

[0004] The above objects are reached tanks to the features listed in the appended claims. According to the invention, energy consumption improvement is reached by introducing a phase change material (PCM) in contact with the first evaporator inside the refrigeration compartment. According to a preferred embodiment of the invention and additional sub-cooling loop is provided for shifting cooling capacity from refrigeration compartment to freezer compartment. As phase change material any suitable composition can be used which has a liquid-solid phase change temperature below temperature of the refrigeration compartment and high enough to avoid freezing in the refrigeration compartment at minimum load. Example of suitable PCMs can be mixtures of water and glycol or eutectic gels. According to the invention, temperature of the refrigeration compartment becomes more stabilized because of higher thermal capacity of such compartment and therefore an extended ON/OFF period of the compressor is obtained. According to a further preferred embodiment, a second electro valve is used downstream the first in order to avoid additional heat gains of the appliance. Such second electro valve allows decision making when to use a sub-cooling loop or not. The system design according to the invention also offers a possibility of quick defrosting the first evaporator (i.e. the evaporator of the refrigeration compartment).

[0005] Further features and advantages according to the present invention will become clear from the following description, with reference to the attached drawings, in which:

- Figure 1 is a schematic view of the refrigeration circuit according to a first embodiment of the invention;
- Figure 2 is a view similar to figure 1 and referring to a second embodiment of the invention, and
- Figure 3 is a diagram pressure vs. specific enthalpy showing the thermodynamic effect of the sub-cooling according to the invention on the cooling capacity.

[0006] With reference to figure 1, a sequential dual evaporator system is shown with a first evaporator 6 used in the refrigeration compartment RC and a second evaporator 10 used in the freezer compartment FC. System comprises also a shared compressor 1, a condenser 2 followed by a bi-stable electro-valve 3 directing flow either to the first evaporator 6 or to the second evaporator 10. Each evaporator has dedicated capillary tube, respectively 4 for the first evaporator 6 and 9 for the second evaporator 10. Of course any expansion device different from a capillary tube can be used as well. The first evaporator 6 is connected to a reservoir or container 5 of phase change material. During the operation of RC evaporator 6 the PCM 5 is charged. When FC evaporator 10 is switched ON (i.e. by diverting the flow towards the evaporator 10 by means of the electro valve 3) the liquid refrigerant is directly expanded in capillary 9 (in the configuration where the second electro valve 7 does not divert the flow into the sub-cooling loop.

[0007] It is important to notice that in having a sub-cooling PCM 8 inside of the refrigeration compartment RC additional appliance heat gains from ambient are avoided. Sub-cooling loop enters the refrigeration compartment RC and exchanges heat with PCM in such compartment. The second bi-stable electro-valve 7 is placed on the FC loop to allow switching ON and OFF of the sub-cooling loop. Operation of the loop is decided according to the amount of cooling capacity accumulated in PCM or RC evaporator request for defrost operation. Higher sub-cooling during FC operation results in higher cooling capacity delivered to FC evaporator 10 with the assumption of unchanged refrigerant mass-flow. This gain in cooling capacity is shown in Figure 3.

[0008] According to the embodiment shown in figure 2, the sub-cooling loop may contain a dedicated capillary tube 11 or any kind of expansion device placed after the PCM reservoir to properly match refrigerant mass-flow rate at high sub-cooling. One of the main advantages of the present invention derives from the PCM contact with the evaporator 6 of the refrigeration compartment RC. This contact improves the global heat transfer coefficient of such evaporator and therefore it allows operation of the RC refrigeration loop at increased evaporator temperatures and increased compressor COP (coefficient of performance). During the RC loop operation, cooling capacity is accumulated in the PCM and continuously released to the refrigeration compartment RC by means of natural convection or a variable speed air fan at a relatively small rate.

[0009] In case the PCM in the refrigeration compartment contains a sufficient amount of accumulated cooling capacity, it can be used during the operation of the freezer evaporator 10 to additionally sub-cool liquid by switching ON the sub-cooling loop. Sub-cooling loop can also contain expansion valve (not shown) to partially expand the liquid refrigerant before entering sub-cooling heat exchanger. Increased cooling capacity is delivered to the refrigeration compartment FC, which decreases FC loop time and energy consumption.

[0010] Sub-cooling loop acts also as a quick defrost of

the evaporator 6 in cases when set phase change temperature is significantly below 0°C and there is a risk of frost accumulation.

Claims

1. Refrigeration appliance having a refrigerating circuit with a compressor (1), a condenser (2) and two evaporators (6, 10) placed in different compartments (RC, FC) of the appliance, valve means (3) being provided for alternatively directing refrigerant flow towards one of the evaporators, **characterized in that** one evaporator (6) is in heat exchange relationship with a phase change material (8).

2. Refrigeration appliance according to claim 1, wherein it comprises second valve means (7) adapted to divert refrigerant flow towards an auxiliary circuit in heat exchange relationship with said phase change material (8) in order to sub-cool refrigerant.

3. Refrigeration appliance according to claim 2, wherein said auxiliary circuit, downstream the phase change material (8), comprises an expansion device (11) upstream the evaporator (10).

4. Refrigeration appliance according to any of the preceding claims, wherein the evaporator (6) in heat exchange relationship with the phase change material is the evaporator placed in the refrigeration compartment (RC).

5. Refrigeration appliance according to claim 1, wherein valve means (3) is a three-way electro valve.

6. Refrigeration appliance according to claim 2, wherein the second valve means (7) is a three-way electro valve.

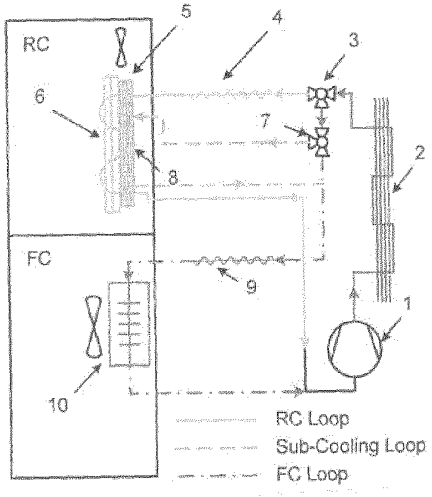

Fig. 1

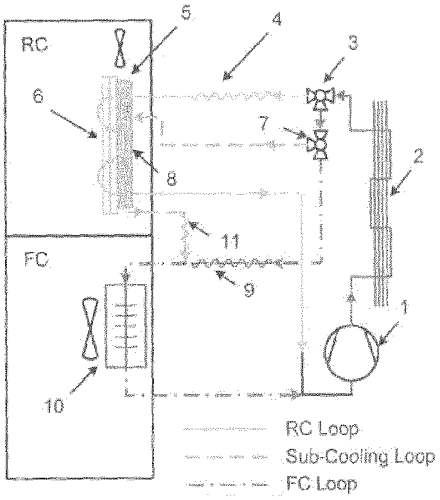

Fig. 2

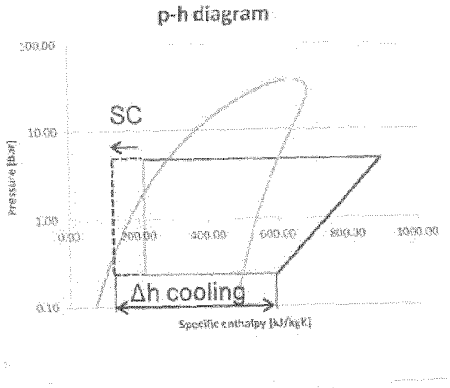

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 12 18 2353

DOCUMENTS CONSIDERED TO BE RELEVANT

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TECHNICAL FIELDS SEARCHED (IPC)

F25D
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 December 2012	Lucic, Anita

CATEGORY OF CITED DOCUMENTS

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