



EUROPEAN PATENT APPLICATION

(43) Date of publication:
15.11.2023 Bulletin 2023/46

(51) International Patent Classification (IPC):
F25D 17/06 ^(2006.01) **F25B 49/02** ^(2006.01)
F25D 29/00 ^(2006.01)

(21) Application number: **23165439.3**

(52) Cooperative Patent Classification (CPC):
F25D 17/06; F25B 49/02; F25D 29/00;
F25B 2600/0251; F25B 2600/112; F25B 2700/2104;
F25B 2700/2117; F25D 2700/10; F25D 2700/12

(22) Date of filing: **30.03.2023**

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(72) Inventors:
• **OZKAN, Ozgur**
34445 Istanbul (TR)
• **KILICARSLAN, Sanem**
34445 Istanbul (TR)
• **PEKER, Gokmen**
34445 Istanbul (TR)
• **OZTURK, Erkan**
34445 Istanbul (TR)
• **GERIS, Gokberk**
34445 Istanbul (TR)

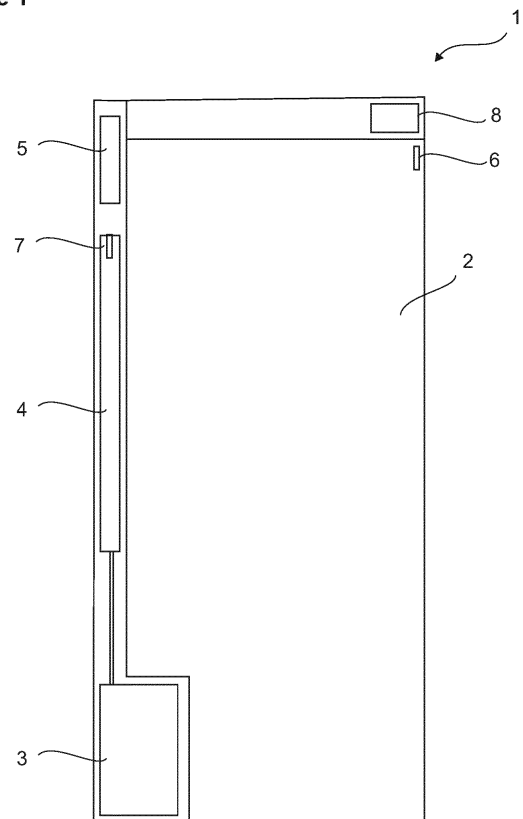
(30) Priority: **11.05.2022 TR 202207636**

(71) Applicant: **Arçelik Anonim Sirketi**
34445 Istanbul (TR)

(54) **A COOLING DEVICE AND CONTROL METHODS THEREOF**

(57) The present invention relates to a cooling device (1) comprising at least one compartment (2) wherein the items to be cooled and/or frozen are loaded; a compressor (3) which provides the performance of the cooling cycle; at least one evaporator (4) which is disposed on the rear wall of the compartment (2) and which provides the cooling of the compartment (2); at least one fan (5) which provides the transfer of the air cooled down by the evaporator (4) into the compartment (2); at least one first temperature sensor (6) which detects the temperature in the compartment (2); at least one second temperature sensor (7) which is disposed on the evaporator (4) and which detects the temperature of the evaporator (4); and a control unit (8) which enables the compressor (3) to be operated depending on the information from the second temperature sensor (7) and enables the fan (5) to be operated depending on the information from the first temperature sensor (6).

Figure 1



Description

[0001] The present invention relates to a cooling device wherein the compressor is efficiently and effectively operated and the temperature of the compartment interior is kept at the desired level, and relates to a control method thereof.

[0002] In conventional cooling devices, the compartment temperature control is based on the principle of starting and stopping the compressor such that the temperatures of the fresh food compartment or freezer compartment remain between the cut-in / cut-out limits. Accordingly, in the cooling device control method, the operating status and speed of the compressor are determined by taking the values set as a reference and determining whether the temperature in the compartment reaches the predetermined set value or not. In the cooling device control method, the values detected by the temperature sensors which detect the temperature in the fresh food compartment or freezer compartment are taken into account. When the air temperature in the compartment reaches the point called cut-in, the compressor is started, and upon reaching the point called cut-out, that is, upon cooling down to the desired level, the compressor is stopped. Thus, the average temperature in the compartment oscillates between the cut-in and cut-out set values.

[0003] In said state of the art embodiments, the operation of the compressor and the air temperatures in the compartment are directly connected to each other. Moreover, the evaporator temperature sensor is used only for controlling the defrost process. The evaporator temperature information is not taken directly as an input to the control method of the fresh food or freezer compartment temperature. Even though the evaporator temperature is low enough, it causes the compressor to work unnecessarily because it takes time for the temperature in the compartment to decrease.

[0004] In the state of the art, the compressor does not directly affect the temperature in the compartment. The component which is mainly affected by the compressor is the evaporator. When the compressor starts, the refrigerant fluid reaches the evaporator, thus reducing the temperature of the evaporator. By means of the fan, the air cooling down around the evaporator is transferred into the compartment.

[0005] In the state of the art United States Patent Application No. US2020080769, a control method is disclosed, wherein the temperature information is collected from the temperature sensors disposed in the compartment so as to determine the capacity of the compartment.

[0006] In the state of the art United States Patent Application No. US2020064042, a control method is disclosed, wherein the cooling device is controlled according to the amount of load in the compartment.

[0007] In the state of the art European Patent Application No. EP3090223, a cooling device control method is disclosed, wherein the fan is controlled according to the

temperature of the evaporator and in the compartment and the compressor is controlled according to the temperature in the compartment.

[0008] In the state of the art European Patent Application No. EP3090222, a cooling device control method is disclosed, wherein the fan is controlled according to the temperature in the compartment.

[0009] The aim of the present invention is the realization of a cooling device wherein the compressor is efficiently and effectively operated and the temperature of the compartment interior is kept at the desired level, and relates to a control method thereof.

[0010] The cooling device realized in order to attain the aim of the present invention, explicated in the first claim and the respective claims thereof, comprises at least one compartment wherein the items to be cooled and/or frozen are loaded; a compressor which provides the performance of the cooling cycle; at least one evaporator which is disposed on the rear wall of the compartment and which provides the cooling of the compartment; at least one fan which provides the transfer of the air cooled down by the evaporator into the compartment; at least one first temperature sensor which detects the temperature in the compartment; at least one second temperature sensor which is disposed on the evaporator and which detects the temperature of the evaporator; and a control unit which enables the compressor to be operated depending on the information from the second temperature sensor and enables the fan to be operated depending on the information from the first temperature sensor. Thus, the compartment is cooled down to the predetermined set value, and thus energy savings are provided.

[0011] By detecting and controlling the temperature of the evaporator with the second temperature sensor, the evaporator is cooled down as much as required and the compressor is operated effectively and efficiently.

[0012] In the embodiment of the present invention, the set value of the evaporator determined by the manufacturer and the instantaneous temperature of the evaporator are determined by the second temperature sensor and transmitted to the control unit, and thus the compressor operating frequency is calculated by the control unit.

[0013] In an embodiment of the present invention, a range is defined by the manufacturer for the operating time and speed of the fan. If the speed of the fan stays above said range for the defined time, the set value of the evaporator is decreased, and if below, the same is increased. Thus, the fan speed is enabled to be determined according to the cooling requirement in the compartment. If the fan speed exceeds the range determined by the manufacturer, it is detected that the cooling requirement in the compartment has increased, and the set value of the evaporator is changed to a lower temperature and the compressor is activated. On the contrary, if the fan speed is below the specified range, it is detected that the cooling requirement of the compartment has decreased, and the evaporator set value is changed to a higher temperature and the compressor is deactivated.

vated.

[0014] The amount and time of increase/decrease of the evaporator set value can be changed according to the place of use of the cooling device where the algorithm is used and the features desired such as rapid cooling, etc.

[0015] The rule of changing the set value of the evaporator downwards is as follows: the higher the temperature in the compartment, which is instantly measured by the first temperature sensor, is above the set value, the lower the upper limit of the fan's operating range is changed. Thus, the cooling demand of the fan in the compartment is processed faster thanks to the change in the evaporator set value. As the temperature moves away from the temperature value in the compartment in the positive direction, the high speed rotation of the fan causes the evaporator set value to move downwards faster.

[0016] Similarly, the rule for changing the evaporator set value upwards is as follows: the lower the temperature in the compartment, which is instantly measured with the first temperature sensor, is below the set value, the higher the lower limit of the fan goes up. Thus, the possibility of the evaporator set value to change upwards increases when the fan is at the slow side and the demand for cooling the compartment is low. In the system which moves away from the set value in the negative direction and cools down, the slow rotation of the fan causes the evaporator set to move upwards faster.

[0017] In case the cooling balance changes, such as the automatic determination of the evaporator set value according to the cooling requirement, the changing temperature of the environment, the hot load loading, etc., the compressor is enabled to be operated in the most appropriate manner without making any change in the algorithms in the control unit.

[0018] In the embodiment of the present invention, the PID method is used for the control method. The AI-based actor-critic method is used to calculate the P, I and D coefficients. This control method comprises an input where the temperature measurement value is entered and an output which generates the control output.

[0019] By means of the present invention, instead of controlling the compressor by only monitoring the temperature in the compartment, the compressor is controlled by monitoring the evaporator temperature, and the fan is controlled by monitoring the temperature in the compartment such that the cooling device is controlled more effectively and efficiently. Moreover, the fan speed is adjusted according to the values detected by the first temperature sensor, that is, according to the air temperature in the compartment. Furthermore, energy savings are provided by controlling the compressor and the fan in this manner.

[0020] A cooling device and the control method thereof realized in order to attain the aim of the present invention are illustrated in the attached figure, where:

Figure 1 - is the schematic view of the cooling system of a cooling device.

[0021] The elements illustrated in the figures are numbered as follows:

1. Cooling device
2. Compartment
3. Compressor
4. Evaporator
5. Fan
6. First temperature sensor
7. Second temperature sensor
8. Control unit

[0022] The cooling device (1) comprises at least one compartment (2) wherein the items to be cooled and/or frozen are loaded; a compressor (3) which provides the performance of the cooling cycle; at least one evaporator (4) which is disposed on the rear wall of the compartment (2) and which provides the cooling of the compartment (2); at least one fan (5) which provides the transfer of the air cooled down by the evaporator (4) into the compartment (2); at least one first temperature sensor (6) which detects the temperature in the compartment (2); at least one second temperature sensor (7) which is disposed on the evaporator (4) and which detects the temperature of the evaporator (4); and a control unit (8) which enables the compressor (3) to be operated depending on the information from the second temperature sensor (7) and enables the fan (5) to be operated depending on the information from the first temperature sensor (6). Thus, the second temperature sensor (7) actively participates in the cooling of the compartment (2), enabling the compartment (2) to cool down to the predetermined set value, and saving energy (Figure 1).

[0023] By detecting and controlling the temperature of the evaporator (4) with the second temperature sensor (7), the evaporator (4) is cooled down as much as required and the compressor (3) is operated effectively and efficiently.

[0024] In the embodiment of the present invention, the instantaneous temperature of the evaporator (4) is detected by the second temperature sensor (7) and evaluated in the control unit (8) together with the set value of the evaporator (4) determined by the manufacturer, and the compressor (3) operating frequency is calculated by the control unit (8).

[0025] In an embodiment of the present invention, a range is defined by the manufacturer for the operating time and speed of the fan (5). If the speed of the fan (5) stays above said range for the defined time, the set value of the evaporator (4) is decreased, and if below, the same is increased. Thus, the fan (5) speed is enabled to be

determined according to the cooling requirement in the compartment (2). If the fan (5) speed exceeds the range determined by the manufacturer, it is detected that the cooling requirement in the compartment (2) has increased, and the set value of the evaporator (4) is changed to a lower temperature and the compressor (3) is activated. On the contrary, if the fan (5) speed is below the specified range, it is detected that the cooling requirement of the compartment (2) has decreased, and the evaporator (4) set value is changed to a higher temperature and the compressor (3) is deactivated.

[0026] The amount and time of increase/decrease of the evaporator (4) set value can be changed according to the place of use of the cooling device (1) where the algorithm is used and the features desired such as rapid cooling, etc.

[0027] The higher the temperature value in the compartment (2) instantly measured by the first temperature sensor (6) is above the set value, the lower the upper limit of the fan (5) operating range is lowered. Thus, the set value of the evaporator (4) is changed downwards, and the cooling demand of the fan (5) of the compartment (2) is processed faster thanks to the change in the set value of the evaporator (4). As the temperature moves away from the temperature value in the compartment (2) in the positive direction, the high speed rotation of the fan (5) causes the evaporator (4) set value to move downwards faster.

[0028] However, the lower the temperature in the compartment (2), which is momentarily measured by the first temperature sensor (6), is below the set value, the higher the lower limit of the fan (5) goes up. Thus, the set value of the evaporator (4) is changed upwards, and the possibility of the evaporator (4) set value to change upwards increases when the fan (5) is at the slow side and the demand for cooling the compartment (2) is low. In the system which moves away from the set value in the negative direction and cools down, the slow rotation of the fan (5) causes the evaporator (4) set to move upwards faster.

[0029] In case the cooling balance changes, such as the automatic determination of the evaporator (4) set value according to the cooling requirement, the changing temperature of the environment, the hot load loading, etc., the compressor (3) is enabled to be operated in the most appropriate manner without making any change in the algorithms in the control unit (8).

[0030] In the embodiment of the present invention, the PID method is used for the control method. The AI-based actor-critic method is used to calculate the P, I and D coefficients. This control method comprises an input where the temperature measurement value is entered and an output which generates the control output.

[0031] By means of the present invention, instead of controlling the compressor (3) by only monitoring the temperature in the compartment (2), the compressor (3) is controlled by monitoring the evaporator (4) temperature, and the fan (5) is controlled by monitoring the tem-

perature in the compartment (2) such that the cooling device (1) is controlled more effectively and efficiently. Moreover, the fan (5) speed is adjusted according to the values detected by the first temperature sensor (6), that is, according to the air temperature in the compartment (2). Furthermore, energy savings are provided by controlling the compressor (3) and the fan (5) in this manner.

10 Claims

1. A cooling device (1) **comprising** at least one compartment (2) wherein the items to be cooled and/or frozen are loaded; a compressor (3) which provides the performance of the cooling cycle; at least one evaporator (4) which is disposed on the rear wall of the compartment (2) and which provides the cooling of the compartment (2); at least one fan (5) which provides the transfer of the air cooled down by the evaporator (4) into the compartment (2); at least one first temperature sensor (6) which detects the temperature in the compartment (2); and at least one second temperature sensor (7) which is disposed on the evaporator (4) and which detects the temperature of the evaporator (4); **characterized by** a control unit (8) which enables the compressor (3) to be operated depending on the information from the second temperature sensor (7) and enables the fan (5) to be operated depending on the information from the first temperature sensor (6).
2. A cooling device (1) as in Claim 1, **characterized by** the control unit (8) which, when the instantaneous temperature of the evaporator (4) is detected by the second temperature sensor (7), evaluates the same together with the set value of the evaporator (4) determined by the manufacturer, and which calculates the compressor (3) operating frequency.
3. A cooling device (1) as in Claim 1, **characterized by** where a range is defined by the manufacturer for the operating time and speed of the fan (5), and if the speed of the fan (5) stays above this range for the defined period, the set value of the evaporator (4) is reduced and if below, the same is increased (8).
4. A cooling device (1) as in any one of the above claims, wherein if the fan (5) speed exceeds the range determined by the manufacturer, it is decided that the cooling requirement in the compartment (2) has increased, and the evaporator (4) set value is changed to a lower temperature and the compressor (3) is activated.
5. A cooling device (1) as in any one of Claims 1 to 3, wherein if the fan (5) speed is below the range determined, it is decided that the cooling requirement in the compartment (2) has decreased, and the evap-

orator (4) set value is changed to a higher temperature and the compressor (3) is deactivated.

6. A control method for a cooling device (1) as in any one of the above claims, wherein the higher the temperature value in the compartment (2) instantly measured by the first temperature sensor (6) is above the set value, the lower the upper limit of the fan (5) operating range is lowered. 5 10
7. A control method for a cooling device (1) as in any one of the above claims, wherein the lower the temperature in the compartment (2), which is momentarily measured by the first temperature sensor (6), is below the set value, the higher the lower limit of the fan (5) goes up. 15

20

25

30

35

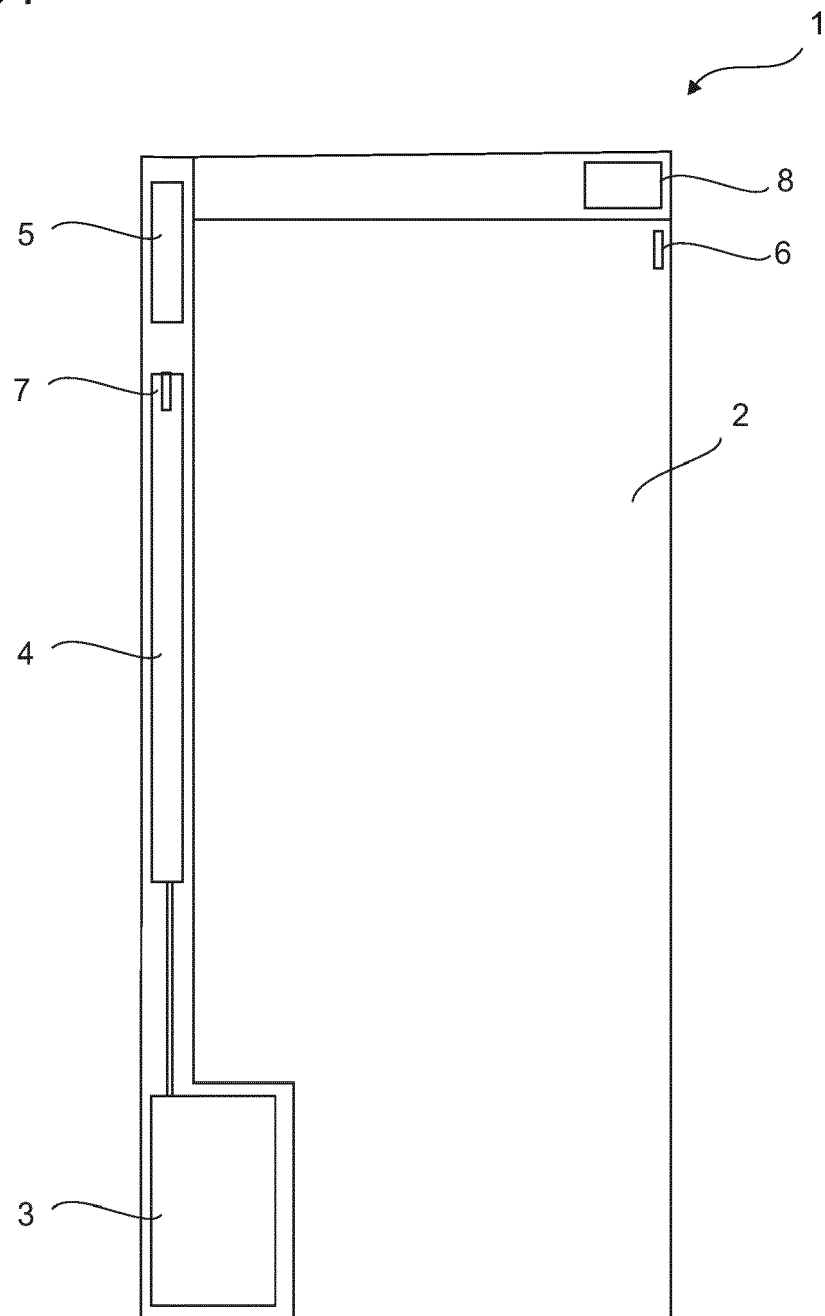
40

45

50

55

Figure 1





EUROPEAN SEARCH REPORT

Application Number

EP 23 16 5439

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 10 35 671 B (GEN MOTORS CORP) 7 August 1958 (1958-08-07)	1	INV. F25D17/06
A	* figures 1-3 * * paragraphs [[0014]], [[0015]] * -----	3-5	F25B49/02 F25D29/00
X	US 2 937 511 A (MANN LEONARD J) 24 May 1960 (1960-05-24)	1	
A	* figures 1,2 * -----	3-5	
X	US 2012/060526 A1 (MAY JASON ANDREW [US] ET AL) 15 March 2012 (2012-03-15)	1,2	
Y	* figures 1,3 *	6,7	
A	* paragraphs [0035], [0036] * -----	3-5	
Y	US 2022/113078 A1 (AHN BUHWAN [KR] ET AL) 14 April 2022 (2022-04-14)	6,7	
	* figure 15 * -----		

TECHNICAL FIELDS
SEARCHED (IPC)F25D
F25B

The present search report has been drawn up for all claims

1

EPO FORM 1503 03.82 (P04C01)

Place of search

The Hague

Date of completion of the search

13 September 2023

Examiner

Dezso, Gabor

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 23 16 5439

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

13-09-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 1035671 B	07-08-1958	NONE	
US 2937511 A	24-05-1960	NONE	
US 2012060526 A1	15-03-2012	CA 2759558 A1 US 2012060526 A1	01-06-2012 15-03-2012
US 2022113078 A1	14-04-2022	KR 20220048316 A US 2022113078 A1	19-04-2022 14-04-2022

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 2020080769 A [0005]
- US 2020064042 A [0006]
- EP 3090223 A [0007]
- EP 3090222 A [0008]