Title: VARIABLE FAN SPEED CONTROL IN HVAC SYSTEMS AND METHODS

Abstract: Generally, a variable fan speed control in an HVAC system is described. Such methods and systems to control fan speed can in turn improve efficiency of the HVAC system by minimizing power consumption, for example of the compressor. The control scheme is based on various operating conditions of compressor load and ambient air temperature, which are used to determine an optimum fan speed.
VARIABLE FAN SPEED CONTROL IN HVAC SYSTEMS AND METHODS

Field
The disclosure herein relates to heating, ventilation, and air-conditioning ("HVAC") systems and methods, and more particularly to a variable fan speed control used in such HVAC systems and methods. Generally, systems and methods are described that are directed to controlling fan speed to thereby control power consumption, for example by the HVAC compressor(s) and fan(s). The control is based on various operating conditions of compressor load and ambient air temperature.

Background
In HVAC units and systems, condenser fans are used such as in water chillers to reject heat from refrigerant flowing through the system. Heat can be rejected from the refrigerant, for example to some other fluid such as air or water, or to ambient. Control of the condenser fans can be operated to minimize head pressure on the compressor(s), such as by maximizing the number of fans running in units/systems that use fixed speed fans. Such control can maximize chiller efficiency, such as at full load.

Summary
At many operating conditions, a chiller may not be operating at full load. For chillers that have variable speed fan(s) and/or fans with a multiple number of fan stages or discrete steps, and that have variable speed compressor(s), a method to determine the optimum fan speed based on chiller operating condition is needed and improvements may be made to fan control in HVAC units or systems. Generally, systems and methods of variable fan speed control are described.

Power optimization such as in a chiller can be achieved, by the methods/systems herein, at various unloaded conditions, i.e. conditions not at full load or at partial load. The systems and methods herein have been founded on an observation, for example that lowering fan speed under certain conditions, can save power relative to a cost associated with a corresponding increase in
head pressure on the compressor.

Generally, the control can be functionally based on an algorithm implemented into software and control program and which is suitable for use to control the fan(s) of a unit, such as a cooling unit or a heat pump used in a cooling mode. For example, such a unit can be an air cooled water chiller with one or more variable speed compressors and one or more variable speed fans, such as may be used in HVAC systems, can employ the control methods and systems described herein.

The control is based on various operating conditions of compressor load and ambient air temperature.

In one embodiment, a method of controlling condenser fan speed in an HVAC system includes detecting, with a sensor, ambient air temperature and then obtaining a present load on a variable speed compressor. With a controller, a target differential pressure between a condenser and an evaporator can be determined, which can be based on the ambient air temperature detected and the present load on the variable speed compressor obtained. With the controller, a condenser fan speed can be outputted to obtain fan capacity and that is suitable to achieve the target differential pressure determined, and such that the power of the HVAC system is managed through a relative power consumed by the variable compressor and the fans. One or more variable speed fan(s) and/or fan(s) with a multiple number of fan stages or discrete steps can be controlled based on the output of condenser fan capacity, e.g. based on fan speed.

In one embodiment, an HVAC system can include a unit, such as an air cooled water chiller. The system includes one or more variable speed fan(s) and/or fans with a multiple number of fan stages or discrete steps, a variable speed compressor, a condenser, an evaporator, a device to detect ambient air temperature, and a device to obtain present load on the variable speed compressor. The system includes a controller to determine a target differential pressure between the condenser and the evaporator based on the ambient air temperature detected and the present load on the variable speed compressor obtained. The controller also can determine an output of condenser fan speed to achieve a fan capacity suitable to achieve the target differential pressure determined. The controller can operate the one or more fans based on the output of
condenser speed to achieve fan capacity, and such that the power of the HVAC system is managed through a relative power consumed by the variable compressor and the fans.

It will be appreciated that the use of target differential pressure is just one example of a control parameter obtained from compressor load, and is not meant to be limiting. It will be appreciated that the input(s) of compressor load, such as for example the compressor speed, and the input of ambient temperature could be used to output fan speed directly.

Other features and aspects of the systems, methods, and control concepts will become apparent by consideration of the following detailed description and accompanying drawings.

**Brief Description of the Drawings**

Reference is now made to the drawings in which like reference numbers represent corresponding parts throughout.

Fig. 1 is a schematic view of an HVAC system that can employ a variable fan speed control.

Fig. 2 is a scheme of a system of variable fan speed control.

Fig. 3 is a flow chart of a method on a variable fan speed control.

Fig. 4 shows an exemplary fan control regime using differential pressure setpoint based on compressor speed and ambient temperature.

**Detailed Description**

Improvements may be made to fan control in HVAC units and/or systems. Generally, methods and systems are described to control fan speed of an HVAC unit and/or systems that has variable speed and/or fans with a multiple number of fan stages or discrete steps and variable speed compressor(s). The variable fan speed control is based on compressor load, e.g.

As to the basic design of an HVAC system, Fig. 1 shows a schematic view of a chiller unit in an HVAC system to control, e.g. variable speed fan(s). Fig. 1 shows one embodiment of an air cooled chiller that has a compressor 1, an evaporator 3, a condenser 4 with air coil 5 and
fans 8, and a control unit 2 and panel 7. It will be appreciated that the compressor 1 is a variable
speed compressor and the fans 8 may be variable speed and/or fans with a multiple number of
fan stages or discrete steps. The condenser 4 and its air coil 5 in the embodiment shown are one
example of an air cooled condenser, however it will be appreciated that the specific condenser
4/coil 5 combination shown is merely exemplary. The chiller can be considered a single unit
within the HVAC system and be supported by a frame 6 for example. It will be appreciated that
the specific configuration shown in Fig. 1 is merely exemplary, as other chiller designs, layouts,
and specific configurations may be employed. For example, the chiller of Fig. 1 is a known
chiller with "W" shaped coils, however, it will be appreciated that other coil types may be used,
such as for example multiple "V" shaped coils or more than one circuit employing multiple
compressors, evaporators, condensers. Generally, the methods and systems to control fan speed
may be employed in any type of air cooled chiller unit with variable speed and/or with fan(s) that
have a multiple number of fan stages or discrete steps and variable speed compressor(s).

Fig. 2 is a scheme of variable fan speed control 200 that can include devices to detect,
obtain, or otherwise determine the inputs needed for a controller to determine the appropriate
output to control fan speed. In one embodiment, a device 202 is used to detect an ambient air
temperature. The device 202 may be any suitable sensor that can measure the ambient air
temperature, for example external or outdoor temperature, and communicate the ambient
temperature measurement to controller 206. It will be appreciated that the device 202 may be a
sensor mounted near the airside coils (e.g. 5 in Fig. 1). A device 204 is used to obtain the present
load on the compressor of the circuit. It will be appreciated that the device 204 can be any
suitable detector, sensor, meter that can determine the present load on the compressor, of which
some examples are provided below. In some embodiments, the present load is based on a
compressor's running speed, which in some examples may be expressed as a percentage of rated
speed for a particular compressor frame size, e.g. relative to the compressor full speed
configured limit. The device 204 is to communicate for example, the percentage of rated speed
of the compressor to the controller 206. The devices 202, 204 can periodically update the
measurements taken as needed and/or desired, such as automatically, during/after an operation
change or changing conditions of the unit, and/or manually. It will be appreciated that the controller 206 can use the most recent sensor data available unless otherwise specified.

The controller 206 can be implemented into for example control unit 2 and panel 7 e.g. in Fig. 1. It will be appreciated that it is known that the control unit 2, such as shown in the air-cooled chiller of Fig. 1, generally can include a processor (not shown), a memory (not shown), and optionally a clock (not shown) and an input/output (I/O) interface (not shown), and the control unit 2 can be configured to receive data as input from various components within an HVAC system, such as the components shown in Fig. 1 and Fig. 2, and can also send command signals as output to various components within the system.

The controller 206 uses the ambient temperature detected and the compressor load obtained to determine a target differential pressure ΔPdiff between the evaporator and condenser (e.g. evaporator 3 and condenser 4 of Fig. 1). The target differential pressure can be a function of ambient temperature and compressor load, which may be employed in an algorithm implemented in a control program to vary the fan speed as needed and/or desired for the appropriate fan capacity, e.g. by control of variable speed fan(s) 208.

It will be appreciated that the target differential pressure can be added to the suction pressure from the compressor to get a target discharge pressure of the compressor. As the fans may change speed to reach a target discharge pressure of the compressor, the unit capacity, e.g. of the chiller, can also change causing a new compressor speed. The new compressor speed can then in turn change the output target differential pressure across the compressor. The chilled water temperature control then drives the chiller to the appropriate chiller capacity.

The fan control can determine the optimum fan speed to minimize total power consumption at that unit capacity, such as by using the compressor load and the ambient temperature to obtain the output target differential pressure. The output target differential pressure in turn can be used to determine the appropriate fan capacity, e.g. based on the resulting fan speed that can minimize total power consumption at that unit capacity, for example the relative power consumed by the compressor and by the fans.

It will be appreciated that compressor speed in rpm can be commanded by the controller,
e.g. 206, in response to, for example, the chiller water temperature control loop of a water chiller, and can and/or would be known by the controller. In the methods and systems described herein, differential pressure can be the controller output parameter, and compressor load (e.g. speed in rpm or relative value of rpm) can be the input parameter used to obtain the output parameter.

It will be appreciated that the use of target differential pressure is just one example of a control parameter obtained from compressor load, and is not meant to be limiting. It will be appreciated that the input(s) of compressor load, such as for example the compressor speed, and the input of ambient temperature could be used to output fan speed directly, rather than using them to first obtain the target differential pressure.

For example, in other situations where target differential pressure is not used as the control parameter, it would be appreciated that a typical speed sensor may be employed to obtain the compressor load, e.g. compressor speed, and that a look-up table may be employed, which has correlated compressor speed and ambient temperature. It also will be appreciated that, depending on the method of unloading of the compressor, mechanical unloader position sensor(s) may be considered to obtain the compressor load, e.g. compressor speed. In other embodiments, compressor load, e.g. compressor speed, could also be estimated indirectly such as for example by a change in evaporator water temperature obtained by the controller through use of for example temperature sensor(s).

In some embodiments, the controller 206 may employ a high pressure avoidance control to control fan capacity in multi-stages such as for example, when the condensing temperature approaches the condenser pressure limit, fan capacity can be added in discrete fixed speed fan stages in systems using variable speed fan(s) and/or fan(s) with a multiple number of fan stages or discrete steps.

Fig. 3 is a flow chart of one embodiment of a method 300 of variable fan speed control.

The method 300 of controlling variable speed condenser fans in an HVAC system includes detecting, with a sensor, ambient air temperature 302 and then obtaining a present load on a variable speed compressor 304. With a controller, a target differential pressure between a condenser and an evaporator can be determined 306, which can be based on the ambient air
temperature detected and the present load on the variable speed compressor obtained. With the controller, a condenser fan speed suitable to achieve a fan capacity can be outputted 308 and that is suitable to achieve the target differential pressure determined. One or more variable speed fans can be controlled 310 based on the output of condenser fan speed to achieve the fan capacity. It will be appreciated that the fans may be fans with a multiple number of fan stages or discrete steps, or a combination of variable speed fan(s) and fan(s) with a multiple number of fan stages or discrete steps.

Using a system with such a control, method, the differential pressure target can be varied based on a function of ambient temperature and compressor speed to optimize the fan speed, which can save power to the system, relative to potential costs due to increases in compressor head pressure. Historically, the differential pressure target was set at a fixed psi for a given, or clamped, ambient temperature such that the differential pressure target would not change despite the ambient temperature being lower than the given ambient temperature. At part load and full load operation conditions, the control can optimize the fan speed to obtain efficiencies in the circuit to allow trade-offs between condenser fan power (which can increase to keep system differential pressure relatively low) and compressor power (which can increase when system differential pressure increases).

Fig. 4 shows an exemplary fan control regime using differential pressure setpoint based on compressor speed and ambient temperature. As shown, the delta pressure setpoint can increase as a function of ambient temperature, as well as for different speeds, see graph lines e.g. for Speeds 1 to 4. In some examples, the delta pressure setpoint can be as low as about 35 psid, pounds per square inch differential, and can be as high as about 190 psid. It will be appreciated that the delta pressure setpoint can vary depending upon in general the unit operating/load conditions, and can vary depending on the oil flow needs through the unit/system. Part load efficiency of the circuit can be optimized, where the delta pressure can be set for various operating conditions of changing ambient temperature and compressor speed.
With regard to the following aspects, it will be appreciated that any of aspects 1 to 6 may be combined with any of aspects 7 to 21, any of aspects 7 to 14 may be combined with any of aspects 15 to 21, and any of aspects 15 to 17 may be combined with any of aspects 18 to 21.

Aspect 1. A method of controlling condenser fans in an HVAC system, comprising:
- detecting, with a device to detect ambient air temperature, ambient air temperature;
- obtaining, with a device to obtain compressor present load, a present load on a variable load compressor;
- determining, with a controller, a desired condenser fan capacity suitable to control one or more condenser fans based on the ambient air temperature detected and the present load on the variable load compressor obtained;
- outputting, with the controller, the desired condenser fan capacity suitable to control the one or more condenser fans; and
- controlling the one or more fans based on the output of the desired condenser fan capacity, such that the power of the HVAC system is managed through power consumed by the variable load compressor and the one or more condenser fans.

Aspect 2. The method of aspect 1, wherein the step of obtaining the present load comprises obtaining the present load on a variable speed compressor.

Aspect 3. The method of aspect 1 or 2, wherein the step of obtaining the present load comprises obtaining the present load through the device to obtain compressor present load which includes a speed sensor.

Aspect 4. The method of any of aspects 1 to 3, wherein the step of obtaining the present load comprises obtaining the present load through the device to obtain compressor present load which includes a mechanical unloader position sensor.
Aspect 5. The method of any of aspects 1 to 4, wherein the step of obtaining the present load comprises obtaining the present load by estimating a change in evaporator water temperature obtained through the device to obtain compressor present load which includes a temperature sensor.

Aspect 6. The method of any of aspects 1 to 5, wherein the step of determining a desired condenser fan capacity comprises determining the speed of the one or more condenser fans, and the step of outputting the desired condenser fan capacity comprises outputting the speed of the one or more condenser fans.

Aspect 7. An HVAC system, comprising:
- a variable load compressor;
- an evaporator fluidly connected to the variable load compressor;
- a condenser fluidly connected to the variable load compressor;
- the condenser including one or more condenser fans;
- a device to detect ambient air temperature;
- a device to obtain present load on the variable load compressor; and
- a controller operatively connected to the device to detect ambient air temperature, to the device to obtain present load on the variable load compressor, and to the condenser including the one or more condenser fans;

the controller configured to determine a desired condenser fan capacity suitable to control the one or more condenser fans based on the ambient air temperature detected and the present load on the variable load compressor obtained;

the controller configured to operate the one or more condenser fans based on the desired condenser fan capacity, such that the power of the HVAC system is managed through power consumed by the variable load compressor and the one or more condenser fans.

Aspect 8. The system of aspect 7, wherein the variable load compressor is a variable
speed compressor.

Aspect 9. The system of aspect 7 or 8, wherein the device to obtain compressor present load includes a speed sensor.

Aspect 10. The system of any of aspects 7 to 9, wherein the device to obtain compressor present load includes a mechanical unloader position sensor.

Aspect 11. The system of any of aspects 7 to 10, wherein the device to obtain compressor present load includes one or more temperature sensors configured to obtain the present load by estimating a change in evaporator water temperature.

Aspect 12. The system of any of aspects 7 to 11, wherein the controller, in determining the desired condenser fan capacity, is configured to determine the speed of the one or more condenser fans, and is configured to output the speed of one or more condenser fans to operate the one or more condenser fans based on the desired condenser fan capacity.

Aspect 13. The system of any of aspects 7 to 12, wherein the controller includes a high pressure avoidance control to the one or more fans under a condition when the condensing temperature approaches the condenser pressure limit.

Aspect 14. The system of any of aspects 7 to 13, wherein the system is an air cooled water chiller with one or more variable speed compressors and one or more variable speed fans.

Aspect 15. A method of controlling condenser fans in an HVAC system, comprising: detecting, with a device to detect ambient air temperature, ambient air temperature; obtaining, with a device to obtain compressor present load, a present load on a variable speed compressor;
determining, with a controller, a target differential pressure between a condenser and an evaporator based on the ambient air temperature detected and the present load on the variable speed compressor obtained;

outputting, with the controller, a condenser fan speed suitable to achieve the target differential pressure determined; and

controlling one or more fans based on the output of condenser fan speed to obtain a fan capacity suitable to control one or more condenser fans, such that the power of the HVAC system is managed through a power consumed by the variable speed compressor and the fans.

Aspect 16. The method of aspect 15, wherein the step of obtaining the present load comprises obtaining the present load through the device to obtain compressor present load which includes a mechanical unloader position sensor.

Aspect 17. The method of aspect 15 or 16, wherein the step of obtaining the present load comprises obtaining the present load by estimating a change in evaporator water temperature obtained through the device to obtain compressor present load which includes a temperature sensor.

Aspect 18. An HVAC system, comprising:

a variable speed compressor;
an evaporator fluidly connected to the variable speed compressor;
a condenser fluidly connected to the variable speed compressor;
the condenser including one or more condenser fans;
a device to detect ambient air temperature;
a device to obtain present load on the variable speed compressor; and

a controller operatively connected to the device to detect ambient air temperature, to the device to obtain present load on the variable speed compressor, and to the condenser including the one or more condenser fans;
the controller configured to determine a target differential pressure between the condenser and the evaporator based on the ambient air temperature detected and the present load on the variable speed compressor obtained,

the controller configured to determine an output of condenser fan capacity suitable to achieve the target differential pressure determined, and

the controller configured to operate the one or more condenser fans based on the output of condenser fan capacity, such that the power of the HVAC system is managed through power consumed by the variable speed compressor and the one or more condenser fans.

Aspect 19. The system of aspect 18, wherein the device to obtain compressor present load includes a mechanical unloader position sensor.

Aspect 20. The system of aspect 18 or 19, wherein the device to obtain compressor present load includes one or more temperature sensors configured to obtain the present load by estimating a change in evaporator water temperature.

Aspect 21. The system of any of aspects 18 to 20, wherein the controller, in determining the desired condenser fan capacity, is configured to determine the speed of the one or more condenser fans, and is configured to output the speed of one or more condenser fans to operate the one or more condenser fans based on the desired condenser fan capacity.

With regard to the foregoing description, it is to be understood that changes may be made in detail, without departing from the scope of the present invention. It is intended that the specification and depicted embodiments are to be considered exemplary only, with a true scope and spirit of the invention being indicated by the broad meaning of the claims.
Claims

1. A method of controlling condenser fans in a HVAC system, comprising:
detecting, with a device to detect ambient air temperature, ambient air temperature;
obtaining, with a device to obtain compressor present load, a present load on a variable load compressor;
determining, with a controller, a desired condenser fan capacity suitable to control one or more condenser fans based on the ambient air temperature detected and the present load on the variable load compressor obtained;
outputting, with the controller, the desired condenser fan capacity suitable to control the one or more condenser fans; and
controlling the one or more fans based on the output of the desired condenser fan capacity, such that the power of the HVAC system is managed through power consumed by the variable load compressor and the one or more condenser fans.

2. The method of claim 1, wherein the step of obtaining the present load comprises obtaining the present load on a variable speed compressor.

3. The method of claim 1, wherein the step of obtaining the present load comprises obtaining the present load through the device to obtain compressor present load which includes a speed sensor.

4. The method of claim 1, wherein the step of obtaining the present load comprises obtaining the present load through the device to obtain compressor present load which includes a mechanical unloader position sensor.

5. The method of claim 1, wherein the step of obtaining the present load comprises obtaining the present load by estimating a change in evaporator water temperature obtained through the device to obtain compressor present load which includes a temperature sensor.
6. The method of claim 1, wherein the step of determining a desired condenser fan capacity comprises determining the speed of the one or more condenser fans, and the step of outputting the desired condenser fan capacity comprises outputting the speed of the one or more condenser fans.

7. An HVAC system, comprising:
   a variable load compressor;
   an evaporator fluidly connected to the variable load compressor;
   a condenser fluidly connected to the variable load compressor;
   the condenser including one or more condenser fans;
   a device to detect ambient air temperature;
   a device to obtain present load on the variable load compressor; and
   a controller operatively connected to the device to detect ambient air temperature, to the device to obtain present load on the variable load compressor, and to the condenser including the one or more condenser fans;
   the controller configured to determine a desired condenser fan capacity suitable to control the one or more condenser fans based on the ambient air temperature detected and the present load on the variable load compressor obtained;
   the controller configured to operate the one or more condenser fans based on the desired condenser fan capacity, such that the power of the HVAC system is managed through power consumed by the variable load compressor and the one or more condenser fans.

8. The system of claim 7, wherein the variable load compressor is a variable speed compressor.

9. The system of claim 7, wherein the device to obtain compressor present load includes a speed sensor.
10. The system of claim 7, wherein the device to obtain compressor present load includes a mechanical unloader position sensor.

11. The system of claim 7, wherein the device to obtain compressor present load includes one or more temperature sensors configured to obtain the present load by estimating a change in evaporator water temperature.

12. The system of claim 7, wherein the controller, in determining the desired condenser fan capacity, is configured to determine the speed of the one or more condenser fans, and is configured to output the speed of one or more condenser fans to operate the one or more condenser fans based on the desired condenser fan capacity.

13. The system of claim 7, wherein the controller includes a high pressure avoidance control to the one or more fans under a condition when the condensing temperature approaches the condenser pressure limit.

14. The system of claim 7, wherein the system is an air cooled water chiller with one or more variable speed compressors and one or more variable speed fans.

15. A method of controlling condenser fans in an HVAC system, comprising:
   detecting, with a device to detect ambient air temperature, ambient air temperature;
   obtaining, with a device to obtain compressor present load, a present load on a variable speed compressor;
   determining, with a controller, a target differential pressure between a condenser and an evaporator based on the ambient air temperature detected and the present load on the variable speed compressor obtained;
   outputting, with the controller, a condenser fan speed suitable to achieve the target
differential pressure determined; and
controlling one or more fans based on the output of condenser fan speed to obtain a fan capacity suitable to control one or more condenser fans, such that the power of the HVAC system is managed through a power consumed by the variable speed compressor and the fans.

16. The method of claim 15, wherein the step of obtaining the present load comprises obtaining the present load through the device to obtain compressor present load which includes a mechanical unloader position sensor.

17. The method of claim 15, wherein the step of obtaining the present load comprises obtaining the present load by estimating a change in evaporator water temperature obtained through the device to obtain compressor present load which includes a temperature sensor.

18. An HVAC system, comprising:

a variable speed compressor;
an evaporator fluidly connected to the variable speed compressor;
a condenser fluidly connected to the variable speed compressor;
the condenser including one or more condenser fans;
a device to detect ambient air temperature;
a device to obtain present load on the variable speed compressor; and
a controller operatively connected to the device to detect ambient air temperature, to the device to obtain present load on the variable speed compressor, and to the condenser including the one or more condenser fans;
the controller configured to determine a target differential pressure between the condenser and the evaporator based on the ambient air temperature detected and the present load on the variable speed compressor obtained,
the controller configured to determine an output of condenser fan capacity suitable to achieve the target differential pressure determined, and
the controller configured to operate the one or more condenser fans based on the output of condenser fan capacity, such that the power of the HVAC system is managed through power consumed by the variable speed compressor and the one or more condenser fans.

19. The system of claim 18, wherein the device to obtain compressor present load includes a mechanical unloader position sensor.

20. The system of claim 18, wherein the device to obtain compressor present load includes one or more temperature sensors configured to obtain the present load by estimating a change in evaporator water temperature.

21. The system of claim 18, wherein the controller, in determining the desired condenser fan capacity, is configured to determine the speed of the one or more condenser fans, and is configured to output the speed of one or more condenser fans to operate the one or more condenser fans based on the desired condenser fan capacity.
Fig. 2

202 Device to detect ambient temperature

200

206 Controller

ΔP_{diff} Fan capacity

208 Variable speed fan(s)

204 Device to obtain compressor present load
Detecting, with a sensor, ambient air temperature

Obtaining a present load on a variable speed compressor

Determining a target differential pressure between a condenser and an evaporator based on the ambient air temperature detected and the present load on the variable speed compressor obtained

Outputting a condenser fan capacity suitable to achieve the target differential pressure determined

Controlling one or more variable speed fans based on the output of condenser fan capacity
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

F24F 11/02(2006.01)i, F04D 27/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

F24F 11/02; F25B 39/04; F24F 11/00; F25B 1/00; F04D 27/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: condenser, temperature, compressor, load, fan, and control

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>X</td>
<td>JP 10-185284 A (DAIKIN INDUSTRIES, LTD.) 14 July 1998 See paragraphs [0065], [0066], [0072H0074], claim 1, 2, and figures 1, 2.</td>
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<td>A</td>
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Further documents are listed in the continuation of Box C.

See patent family annex.

<T> later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

<X> document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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<&> document member of the same patent family

Date of the actual completion of the international search

22 January 2014 (22.01.2014)

Date of mailing of the international search report

22 January 2014 (22.01.2014)

Name and mailing address of the ISA/KR

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Form PCT/ISA/2410 (second sheet) (July 2009)
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