control device.

[0004]

The related air-cooled heat exchanger includes a heat exchanger body, a fan, and the like. The air-cooled heat exchanger is provided with a thermometer to measure the temperature of cold air, a thermometer to measure exhaust temperature, a power meter to measure the power consumption by the pump, a power meter to measure the power consumption by the fan, and a rotation rate control device to control the rotation of the fan.

[0005]

The control device calculates the amount of heat exchange using an air temperature difference that is a difference between the exhaust air temperature and the cold air temperature, and an air volume of the fan that is calculated from the rotation rate of the fan. A coefficient of performance (COP) is calculated from the amount of heat exchange, the power consumption by the pump, and the power consumption by the fan. The control device is configured to control the rotation rate of the fan so as to improve the coefficient of performance.

[0006]

It is said that the related air-conditioning system using outside air with the configuration makes it possible to operate at peak efficiency in any outside air condition and achieve a saving of energy.

[Citation List]

[Patent Literature]

[0007]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2012-193903

[Summary]

[Technical Problem]

Various embodiments provide a phase-change cooling apparatus and a method of controlling the phase-change cooling apparatus that solve the above-mentioned problem that a cooling system employing a phase-change cooling apparatus together with an air conditioner becomes complex and increases in cost if it is configured to maximize the efficiency of the entire cooling system.

[0012]

A phase-change cooling apparatus according to an exemplary aspect includes a heat receiving means for vaporizing refrigerant liquid stored and producing refrigerant vapor by receiving heat exhausted from a heating section having breathed in cold air; a heat radiation means for liquefying the refrigerant vapor and producing refrigerant liquid by radiating heat of the refrigerant vapor to cooling air by a fan; a vapor tube connecting the heat receiving means to the heat radiation means, the refrigerant vapor mainly flowing through the vapor tube; a liquid tube connecting the heat receiving means to the heat radiation means, the refrigerant liquid mainly flowing through the liquid tube; and a control means for controlling a rotation rate of the fan, wherein the control means controls the rotation rate of the fan so that a vapor temperature that is a temperature of the refrigerant vapor may approach an intake-air temperature that is a temperature of the cold air.

[0013]

A method of controlling a phase-change cooling apparatus according to an exemplary aspect on a phase-change cooling apparatus including a heat receiving means for vaporizing refrigerant liquid stored and producing refrigerant vapor by receiving heat exhausted from a heating section having breathed in cold air; a heat radiation means for liquefying the refrigerant vapor and

producing refrigerant liquid by radiating heat of the refrigerant vapor to cooling air by a fan; a vapor tube connecting the heat receiving means to the heat radiation means, the refrigerant vapor mainly flowing through the vapor tube; a liquid tube connecting the heat receiving means to the heat radiation means, the refrigerant liquid mainly flowing through the liquid tube, the method includes controlling a rotation rate of the fan so that a vapor temperature that is a temperature of the refrigerant vapor may approach an intake-air temperature that is a temperature of the cold air.

[0014]

According to the phase-change cooling apparatus and the method of controlling the phase-change cooling apparatus of various embodiments, it is possible in a cooling system employing a phase-change cooling apparatus together with an air conditioner to maximize the efficiency of the entire cooling system with a simple configuration and at low cost.

[Brief Description of the Drawings]

[0015]

[FIG. 1] FIG. 1 is a block diagram illustrating a configuration of a phase-change cooling apparatus according to a first example embodiment of the present invention.

[FIG. 2] FIG. 2 is a block diagram illustrating a configuration of a phase-change cooling system according to the first example embodiment of the present invention.

[FIG. 3] FIG. 3 is diagram to illustrate the heat exchanging performance of the phase-change cooling system according to the first example embodiment of the present invention.

[FIG. 4] FIG. 4 is a flowchart to explain an operation of a controller included in the phase-change cooling apparatus according to the first

example embodiment of the present invention.

[CLAIMS]

[Claim 1] A phase-change cooling apparatus, comprising:

a heat receiving means for vaporizing refrigerant liquid stored and producing refrigerant vapor by receiving heat exhausted from a heating section having breathed in cold air;

a heat radiation means for liquefying the refrigerant vapor and producing refrigerant liquid by radiating heat of the refrigerant vapor to cooling air by a fan;

a vapor tube connecting the heat receiving means to the heat radiation means, the refrigerant vapor mainly flowing through the vapor tube;

a liquid tube connecting the heat receiving means to the heat radiation means, the refrigerant liquid mainly flowing through the liquid tube; and

a control means for controlling a rotation rate of the fan,

wherein the control means controls the rotation rate of the fan so that a vapor temperature that is a temperature of the refrigerant vapor may approach an intake-air temperature that is a temperature of the cold air.

[Claim 2] The phase-change cooling apparatus according to claim 1,

wherein the control means controls the rotation rate of the fan so that the vapor temperature may approach the intake-air temperature at a range not in excess of the intake-air temperature.

[Claim 3] The phase-change cooling apparatus according to claim 1 or 2,

wherein the control means compares the vapor temperature with the intake-air temperature, and decreases the rotation rate of the fan if it is determined that the vapor temperature is not larger than the intake-air temperature.

[Claim 4] The phase-change cooling apparatus according to claim 1 or 2, wherein the control means compares the vapor temperature with the intake-air temperature, and increases the rotation rate of the fan if it is determined that the vapor temperature is larger than the intake-air temperature.

[Claim 5]

The phase-change cooling apparatus according to claim 4, wherein the control means controls the rotation rate of the fan so that a heat radiator temperature difference may become equal to a threshold temperature difference that is predetermined, where the heat radiator temperature difference is a difference between an inlet temperature that is a temperature of the cooling air flowing into the heat radiation means and an outlet temperature that is a temperature of the cooling air flowing away from the heat radiation means.

[Claim 6] The phase-change cooling apparatus according to claim 5, wherein the threshold temperature difference is the heat radiator temperature difference below which radiation performance of the heat radiation means becomes approximately constant.

[Claim 7] The phase-change cooling apparatus according to claim 1 or 2, wherein the control means

obtains an outside air temperature that is a temperature of outside air flowing into the heat radiation means,

controls the rotation rate of the fan in so that an outlet temperature that is a temperature of the cooling air flowing away from the heat radiation means may become constant, if the outside air temperature is not

larger than a threshold outside air temperature that is predetermined, and

controls the rotation rate of the fan so that a threshold temperature difference may become constant if the outside air temperature is larger than a threshold outside air temperature that is predetermined, where the threshold temperature difference is a heat radiator temperature difference below which radiation performance of the heat radiation means becomes approximately constant, and the heat radiator temperature difference is a difference between an inlet temperature that is a temperature of the cooling air flowing into the heat radiation means and the outlet temperature.

[Claim 8] The phase-change cooling apparatus according to any one of claims 1, 2, 3, 4, 5, 6, and 7,

wherein the vapor temperature is one of a value obtained by measuring a surface temperature of the vapor tube and a value obtained by measuring a temperature of exhaust air from the heat receiving means.

[Claim 9] A cooling system employing a phase-change cooling apparatus, comprising:

a phase-change cooling apparatus according to any one of claims 1, 2, 3, 4, 5, 6, 7, and 8; and

an air conditioning means,

wherein the heat receiving means takes in warm air exhausted from the heating section and cools the warm air, and exhausts an air blast reaching an outlet temperature, and

the air conditioning means takes in the air blast, produces the cold air at the intake-air temperature, and sends the cold air to the heating section.

[Claim 10] A method of controlling a phase-change cooling apparatus, on a

phase-change cooling apparatus including

a heat receiving means for vaporizing refrigerant liquid stored and producing refrigerant vapor by receiving heat exhausted from a heating section having breathed in cold air;

a heat radiation means for liquefying the refrigerant vapor and producing refrigerant liquid by radiating heat of the refrigerant vapor to cooling air by a fan;

a vapor tube connecting the heat receiving means to the heat radiation means, the refrigerant vapor mainly flowing through the vapor tube;

a liquid tube connecting the heat receiving means to the heat radiation means, the refrigerant liquid mainly flowing through the liquid tube,

the method comprising:

controlling a rotation rate of the fan so that a vapor temperature that is a temperature of the refrigerant vapor may approach an intake-air temperature that is a temperature of the cold air.