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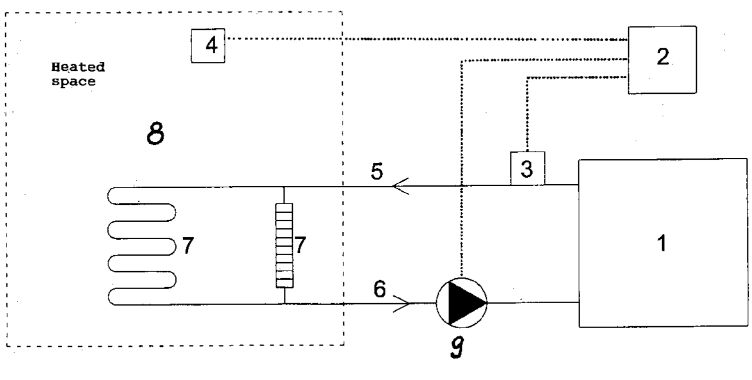

FIG.1

(57) Abstract: The heating cycle comprises a heat pump (1) with a regulation unit (2), a heating system (7) arranged in the heated space (8), at least one sensor (3) of the heat transfer fluid temperature retained in the line (5) conducting the heat transfer fluid from the heat pump (1) to the heating system (7) or in the line (6) conducting the heat transfer fluid from the heating system (7) to the heat pump (1), at least one sensor (4) of air temperature in the heated space (8) and a circulation pump (9). The subject matter of the method of regulation consists in that the limiting time period (t) for evaluation of heat consumption in the heated space (8) is set in a cyclic manner and the time of operation (s) of the circulation pump (9) is monitored in the limiting time period (t) and at the same time it is monitored whether the value of immediate temperature (T_o) achieving the required temperature T_p of the air in the heated space (8) was reached within the limiting time period (t). The regulation unit (2) controls the output of the heating cycle according to the result of comparison of $s \geq t$, $s < t$, $T_o < T_p$, $T_o \geq T_p$.

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Method of regulation of operation of a heat pump

Field of the invention

The invention relates to a method of regulaton of operation of a heat pump the purpose of which is to achieve the required temperature in a heated building with a minimum energy consumption.

Background and summary of the invention

The heat pumps of the type air to water, ground to water and water to water are designed to extract thermal energy from low potential refrigerated fluid, in general from air, water or a nonfreezing mixture and to transfer it to a high potential heat transfer fluid, in general to water in a heating system of buildings.

The deciding criterion to assess the efficiency of a heat pump is the heating factor. The heating factor is the ratio of the heat output transferred in the output of the heat pump to the heat transfer fluid to the energy input of the heat pump. This factor is decisive for the user since the higher heating factor, the lower energy input of the heat pump and due to it the lower operation costs.

The heating factor depends on the remainder of temperature of the low potential heat source, i.e. air, water or the nonfreezing mixture and of the temperature of the high potential heat transfer fluid, in general heating water. The temperature of the low potential heat source cannot, in general, be appropriately regulated because it is given by the environment the heat pump extracts energy from (the temperature of the air, water or nonfreezing mixture). However, the temperature of the heat transfer fluid can be influenced.

To achieve a high heating factor the heat transfer unit must be heated to the lowest possible temperature still capable of ensuring the required heat comfort in the heated space. This implies that the regulation of temperature of the heat transfer fluid to a constant temperature is very disadvantageous and is rarely used.

Mostly equithermal regulation is applied where to every outdoor temperature a different temperature of the heat transfer unit is assigned. The equithermal regulation results in decreasing (or increasing) of temperature of the heat transfer fluid according to the increase (or decrease) of the outdoor temperature regardless of the immediate real need of heat inside the heated building. This method of regulation requires that such temperature of the heat transfer fluid be set that corresponds to the worse possible conditions under the given outdoor temperature (e.g. the sun is not shining, a strong wind is blowing, all inside sources of heat are switched off etc.).

The applied methods of regulation result in failure to comply for the whole period of operation of the heat pump with the principle to regulate the temperature of the heat transfer fluid to the lowest possible temperature of the heat transfer unit to achieve the high heating factor. It is disadvantageous that in order to achieve a higher heating factor of a heat pump the setting of the appropriate equithermal curve must be carried out by a skilled person. The setting is never managed at the first time and has to be repeated to get the optimal performance and is therefore highly time demanding. In case the setting is carried out by a technician of an installation firm, it is also expensive. Due to the above mentioned reasons the required temperature is set unnecessarily high. Because the temperature of the heat transfer fluid is always higher than the lowest possible, the proper regulation of temperature in the heated space is carried out by switching on and off the water circulation pump of the heating circuit.

The published patent application JP 2009 287 895 teaches regulation of the output of the heating circuit by means of regulation of the speed of the circulation pump whereby only the temperature of the heat transfer fluid in the line conducting it to the heating system and in the reverse line conducting the heat transfer fluid back to the heat pump is compared.

Patent application DE 10 2007 025 121 teaches a similar method of regulation on the basis of comparing the remainder of temperatures of the heat transfer fluid. The subject matter of the invention is to improve the economics of operation of combined heating of warm water applying a heat pump and an independent floor heating.

European patent application EP 089 3657 teaches regulation of the heating system being controlled by data concerning the reached and required air humidity, these data being furnished by a humidity sensor installed in the heated space.

The heating circuit of the existing heat pumps consists of the heat pump proper with a regulation unit, of a line conducting the heat transfer medium to the heating system (radiators, floor heating etc.) in the heated space and back to the heat pump, of a circulation pump, of a sensor of temperature of the heat transfer unit arranged behind the output of the heat transfer fluid from the heat pump and of a sensor of the temperature of the air in the heated space.

It is the object of the invention to use the known connection of the heating circuit of a heat pump and to create a new method of regulation of its operation in view of achieving a decrease in consumption of energy and to optimize the heating factor of the heat pump compared to the known methods of regulation.

It is an object of the invention to design a method of regulation of operation of a heat pump that would allow a continuous setting of the lowest temperature possible of the heat transfer fluid according to the immediate situation and would thus allow for the increase of the heating factor of the heat pump the consequence of which would be the decrease of specific consumption of energy for heating.

The method of regulation of the present invention deals with regulation of the known heating cycle comprising a heat pump with a regulation unit, at least one heat transfer fluid temperature sensor retained in the line conducting the heat transfer fluid from the heat pump to the heating system or in the line conducting the heat transfer fluid from the heating system to the heat pump. The cycle further comprises a heating system arranged in the heated space, a circulation pump to conduct the heat transfer fluid and at least one sensor of air temperature in the heated space. The method of regulation according to the present invention corresponds to the existing methods of regulation in that the regulation unit compares the required temperature in the heated space with the immediate temperature of the air in the heated space regulating on the basis of this comparison the performance of the heating cycle by setting the heat pump.

The subject-matter of the method of regulation according to the present invention consists in that the limiting time period for evaluation of heat consumption in the heated space is set in a cyclic manner and the time of operation of the circulation pump is monitored in this limiting time period.

If the time of operation of the circulation pump is shorter than the set limiting time period, then this implies that the circulation pump was switched off for the whole limiting time period or for most of it. The regulation unit interprets that the given heating output of the heating system is unnecessarily high and that the heat transfer fluid temperature is higher than would be needed in the given moment. In consequence the regulation unit decreases the temperature of the heat transfer fluid in the output of the heat pump resulting in decrease of the heating output of the system.

If the time of operation of the circulation pump is the same as the set limiting time period, then this implies that the circulation pump was switched on for the whole time period and further method of regulation differs according to a parallel condition such as reaching or failure to reach the required temperature in the heated space. In case the required temperature of the air in the heated space has not been reached, the regulation unit increases the temperature of the heat transfer fluid in the output of the heat pump to increase the heating output of the system in the next limiting time period. In case the required temperature of the air in the heated space was achieved, the regulation unit maintains the temperature of the heat transfer fluid in the output of the heat pump in a constant value.

In another advantageous embodiment of the method according to the invention the process of regulation of temperature of the heat transfer fluid may be supplemented with a correction for compensation of fast changes in heat consumption in the heated space. Typically these are cases when the insolation of windows occurs and consequently part of heat losses of the building is covered by heat gains of windows during insolation or due to switching on electric appliances, e.g. electric range, oven, home bakery etc. Or a more intensive ventilation of the heated space occurs. This causes an almost immediate change in the need of heat for heating and the heating output of the heating system has to be quickly increased of decreased.

It is advantageous when this correction for compensation of fast changes in heat consumption in the heated space is carried out on the basis of evaluation of the remainder of temperatures T_p-T_o where T_p is the required temperature in the heated space and T_o is the immediate temperature in the heated space. The correction proper is carried out so that the required temperature of the heat transfer fluid in the output of the heat pump is adjusted by the n-multiple of this remainder [n. (T_p-T_o)].

The value of the multiple (n) lies in the range from 2 to 3 in heating systems made up by floor heating and in the range from 3 to 5 in heating systems made up by radiators.

The advantage of the method of regulation of operation of a heat pump according to the present invention consists in that the temperature of the heat transfer medium is continuously maintained on the lowest temperature possible corresponding to the immediate consumption of heat in the heated space thus optimizing the heating output of the heating system and the heating factor of the heat pump. This method of regulation creates energy saving in the range from 15 to 20% compared to the common methods of regulation and it can be applied practically in all heating cycles with heat pumps because it applies elements being part of existing heating cycles. To introduce the method of regulation according to the present invention only the control software of the regulation unit of the heat pump has to be adjusted. Another advantage consists in the simple regulation control for a user.

Brief description of the drawings

The invention will be described in detail by means of the drawing on which Fig. 1 shows a block scheme of the heating cycle of a heat pump.

Detailed description of the preferred embodiment

The below described and depicted particular examples of the invention embodiments are considered illustrative and they in no way limit the invention embodiment to the examples herein presented. Professionals in the technology sphere will find or will be able to find more or fewer equivalents to the specific embodiments of the invention herein described in their routine experimental work. These equivalents will also be included in the following claims.

A common heating cycle shown in Fig. 1 comprises a heat pump 1 with a regulation unit 2. In the output of the heat pump 1 there is a line 5 conducting the heat transfer fluid from the heat pump 1 to the heating system 7. The heating system 7 can be made up by a floor heating, radiators or by a combination thereof. The line 6 conducting the heat transfer fluid from the heating system 7 back to the heat pump 1 via a circulation pump 9 is in the output of the heating system 7. In general water is the heat transfer medium. The heating system 7 is situated in the heated space 8 mostly in the heated building, house, flat etc. There is a sensor 4 of air temperature in the heated space 8, the sensor 4 being interconnected with the regulation unit 2 of the heat pump 1. A sensor 3 of the heat transfer fluid temperature is retained in the line 5 conducting the heat transfer fluid from the heat pump 1 to the heating system 7. The sensor 3 is also interconnected with the regulation unit 2 of the heat pump 1. The sensor 3 of heat transfer fluid temperature can also be retained in the line 6 conducting the heat transfer fluid from the heating system 7 to the heat pump 1 or on the accumulation tank of the heat pump 1 and is also interconnected with the regulation unit 2 of the heat pump 1. The circulation pump 9 is also interconnected with the regulation unit 2.

In the first embodiment of the invention the regulation of operation of the heat pump 1 is carried out by regulating continuously the temperature of the heat transfer fluid in the output of the heat pump 1 or the temperature on the line 6 conducting the heat transfer fluid to the heat pump 1 meanwhile the regulation unit 2 evaluates the real immediate consumption of heat for heating the heated space 8 indirectly, on the basis of evaluation of the time of operation s of the circulation pump 9, which is a direct proportion parameter to the heat consumption in the heated space 8 (the greater is the heat consumption, the longer is the time of operation s of the circulation pump 9). To regulate, first a limiting time period t for evaluation of heat consumption is set and in this time limit t the time of operation s of the circulation pump 9 is monitored. In case the circulation pump 9 operates during the whole limiting time period t, i.e. $s=t$, and the temperature T_0 of the air in the heated space 8 is lower than the required temperature T_p, the immediate output of the heating system 7 is low, and the regulation unit 2 increases temperature of the heat transfer fluid in the output of the heat pump 1. In case the circulation pump 9 operates during the whole limiting time period t, i.e. $s=t$, and $T_p \geq T_0$, then the immediate heating output of the heating system 7 is correct and the regulation unit 2 does not change the temperature of the heat transfer fluid in the output of the heat pump 1. In case the circulation pump 9 is switched off for the whole time period t or for a significant part thereof, i.e. $s<t$, the heating output of the heating system 7 is unnecessarily high. The regulation unit 2 decreases the temperature of the heat transfer fluid in the output of the heat pump 1. This regulation process is automatically repeated in a continuous and cyclic manner.

To compensate fast changes in heat consumption the automatic regulation of temperature of heat transfer unit is supplemented with a correction for compensation of fast changes. This correction can be carried out by various methods, e.g. by a change of the required temperature of the heat transfer fluid in the output or input in the heat pump 1 by switching on or off another source for a fast change of temperature in the heated space 8.

In the above described embodiment the correction is carried out on the basis of evaluation of the remainder of temperatures (T_p-T_0) between the required temperature T_p in the heated space 8, while the immediate temperature T_0 is measured by means of a sensor 4 of air temperature in the heated space 8. The negative n-multiple of this remainder, i.e. the value n. (T_p-T_o) is added to the required temperature of the heat transfer fluid calculated by the regulation unit 2 according to the method described above. The value of n lies in the range from 2 to 3 in heating systems 7 made up by floor heating and in the range from 3 to 5 in heating systems 7 made up by radiators. These differences arise from different heating properties of heating systems 7.

For example, if the value of the required temperature in the heated space 8 is T_p = 23,0°C and the immediate temperature is T_0= 23,5°C, the correction in a heating system 7 with a floor heating is n. (T_p-T_o)=3.(23-23,5)=-1,5°C. If the regulation unit 2 calculated in a given moment that the required temperature of the heat transfer fluid calculated on the basis of time of operation of the circulation pump 9 is 40°C, a correction is carried out by -1,5°C and the temperature of the heat transfer fluid is set to 38,5°C.

If the value of the required temperature in the heated space 8 is T_p = 23,5°C and the immediate temperature is T_0= 23°C, the correction in a heating system 7 with a floor heating is n. (T_p-T_o)=3.(23,5-23)=1,5°C. If the regulation unit 2 calculated in a given moment that the required temperature of the heat transfer fluid calculated on the basis of time of operation of the circulation pump 9 is 40°C, a correction is carried out by +1,5°C and the temperature of the heat transfer fluid is set to 41,5°C.

Whether the correction (and its value) is to be used in the calculation and in the regulation depends mainly on the heated building. It is the size of heat sources in the interior, uniformity or nonuniformity of their operation, size of the windows and their situation in respect to the cardinal points, shading of the windows (e.g. by means of shutters). Further the accumulation of heat of the heated building is decisive. In buildings with a high heat accumulation this correction is not needed or is small, in light buildings with a low heat accumulation a greater correction is necessary.

Industrial applicability

The method of regulation of the heat pump can be applied in both, the existing and in heating cycles to be constructed, comprising a heat pump of air to water, ground to water and water to water type.

Overview of reference marks used in the drawings

1 heat pump

2 heat pump regulation unit

3 heat transfer fluid temperature sensor

4 sensor of air temperature in the heated space

5 line conducting the heat transfer fluid from the heat pump to the heating system

6 line conducting the heat transfer fluid from the heating system to the heat pump

7 heating system

8 heated space

9 circulation pump

t limiting time period

T_p required temperature value in the heated space

T_o immediate temperature value in the heated space

n multiple of the T_p-T_o remainder

s time of operation of the circulation pump

CLAIMS

1. Method of regulation of operation of a heat pump (1) in a heating cycle comprising a heat pump (1) with a regulation unit (2), a heating system (7) arranged in the heated space (8), at least one sensor (3) of the heat transfer fluid temperature retained in the line (5) conducting the heat transfer fluid from the heat pump (1) to the heating system (7) or in the line (6) conducting the heat transfer fluid from the heating system (7) to the heat pump (1), at least one sensor (4) of air temperature in the heated space (8) and a circulation pump (9), according to this method the regulation unit (2) compares the required temperature (T_p) in the heated space (8) with the immediate temperature (T_o) of the air in the heated space (8) regulating on the basis of this comparison the performance of the heating cycle **characterized in that** the limiting time period (t) for evaluation of heat consumption in the heated space (8) is set in a cyclic manner and the time of operation (s) of the circulation pump (9) is monitored in the limiting time period (t); in case $s<t$ the regulation unit (2) decreases temperature of the heat transfer fluid in the output of the heat pump (1); in case $s=t$ and the required temperature (T_p) of the air in the heated space (8) has not been reached, which implies $T_o<T_p$, the regulation unit (2) increases the temperature of the heat transfer fluid in the output of the heat pump (1); and in case $s=t$ and the required temperature (T_p) of the air in the heated space (8) was achieved, which implies $T_o \geq T_p$, the regulation unit (2) maintains the temperature of the heat transfer fluid in the output of the heat pump (1) in a constant value.

2. Method of regulation of operation of a heat pump according to claim 1 **characterized in that** the regulation of temperature of the heat transfer fluid in the output of the heat pump (1) is adjusted by the correction for compensation of fast changes in heat consumption in the heated space (8) while the remainder of temperatures (T_p-T_o) between the required temperature (T_p) in the heated space (8) and immediate temperature (T_o) in the heated space (8) is evaluated during the correction and the required temperature of

the heat transfer fluid in the output of the heat pump (1) is adjusted by the n-multiple of this remainder [n. (T_p-T_o)].

3. Method of regulation of operation of a heat pump according to claim 1 and 2 **characterized in that** the value of the multiple (n) lies in the range from 2 to 3 in heating systems (7) made up by floor heating and in the range from 3 to 5 in heating systems (7) made up by radiators.

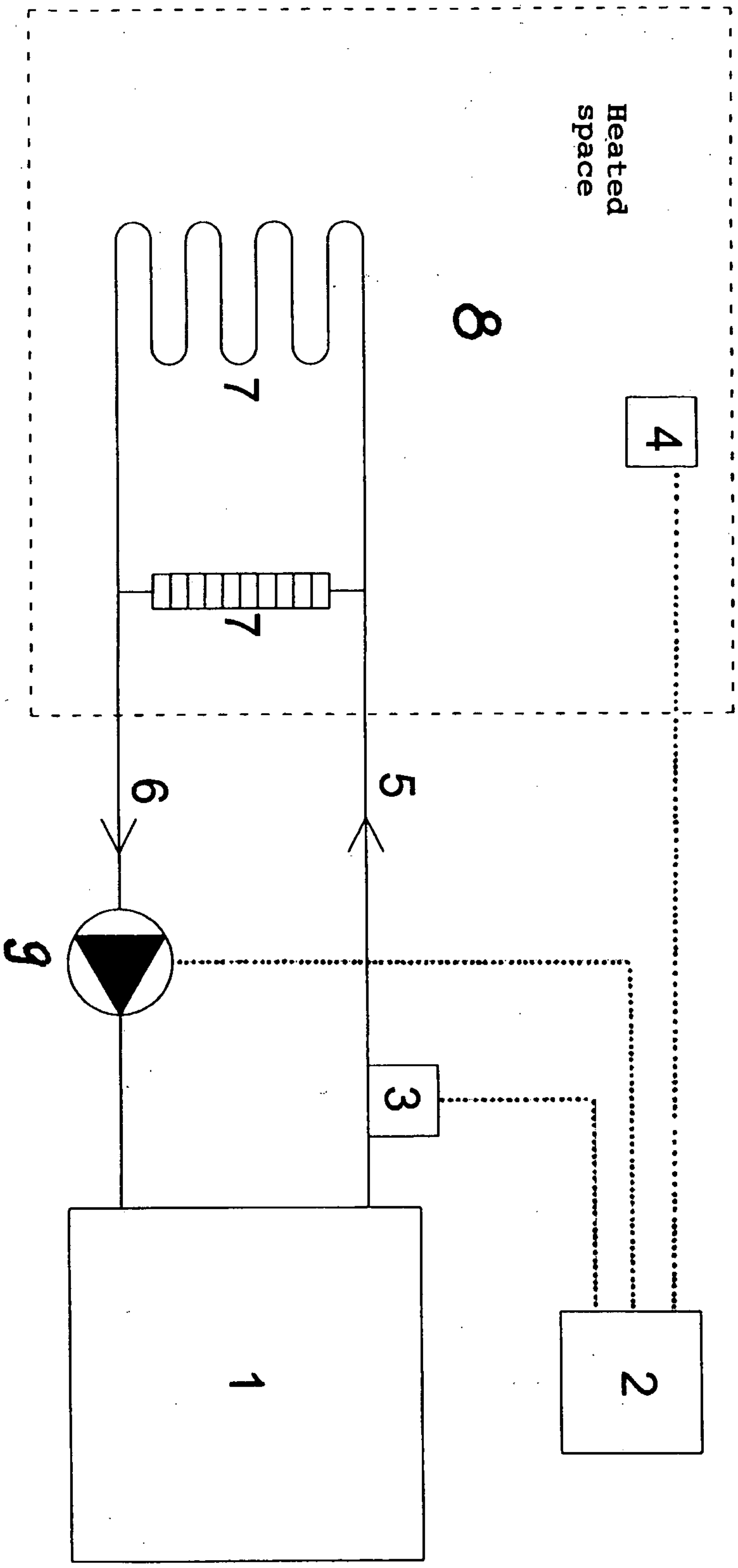

FIG.1