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(54) **REFRIGERATING MACHINE COMPRISING DIFFERENT SORPTION MATERIALS**

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(57) **ABSTRACT**

The invention relates to the use of an adsorbent instead of a condenser in a heat pump/refrigerating machine as well as the use of said adsorbant during the reduction of the vapor pressure in a heat pump/refrigerating machine in order to improve the desorption capacity. The invention further relates to a refrigeration method in which preferably two different adsorbants are used in two stages.

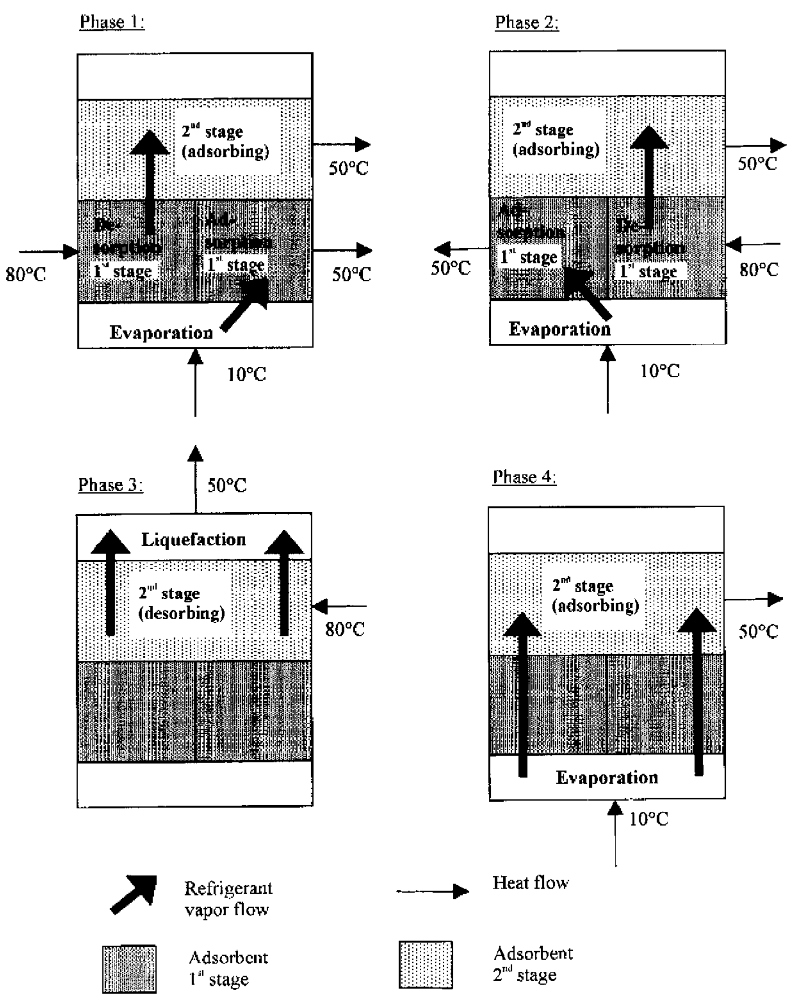
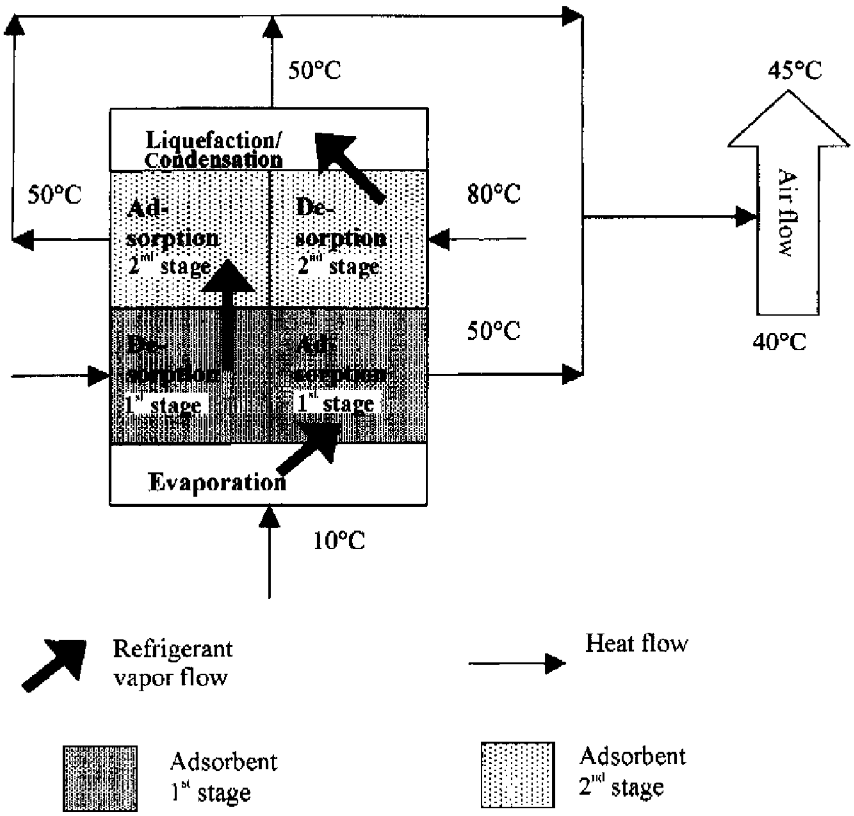


Fig.1:



50°C
45°C
Liquefaction/ Condensation
50°C
Ad-sorption 2nd stage
De-sorption 2nd stage
80°C
Air flow
50°C
40°C
De-sorption 1st stage
Ad-sorption 1st stage
Evaporation
10°C
Refrigerant vapor flow
Heat flow
Adsorbent 1st stage
Adsorbent 2nd stage

Fig.2:

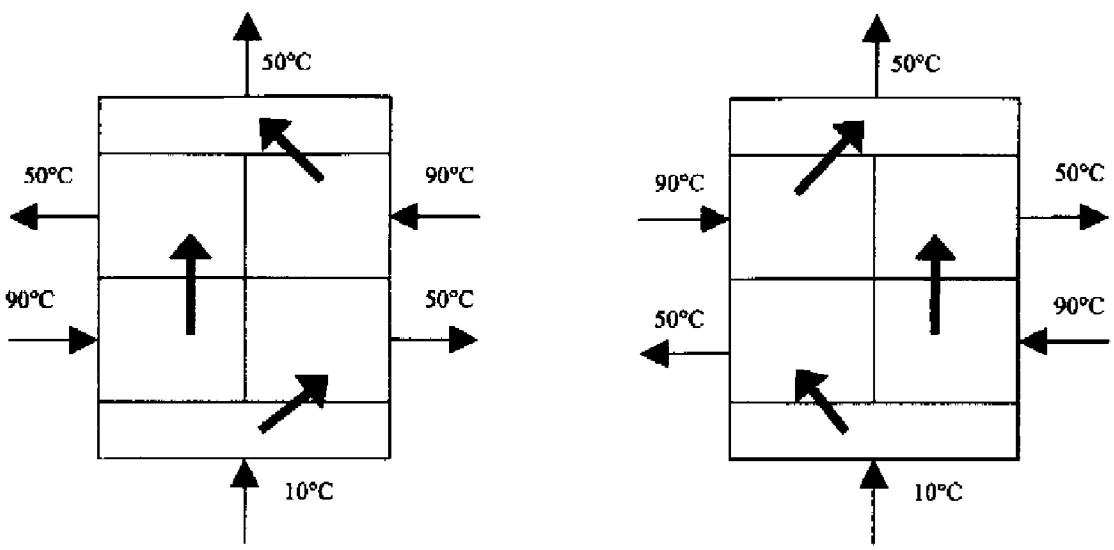
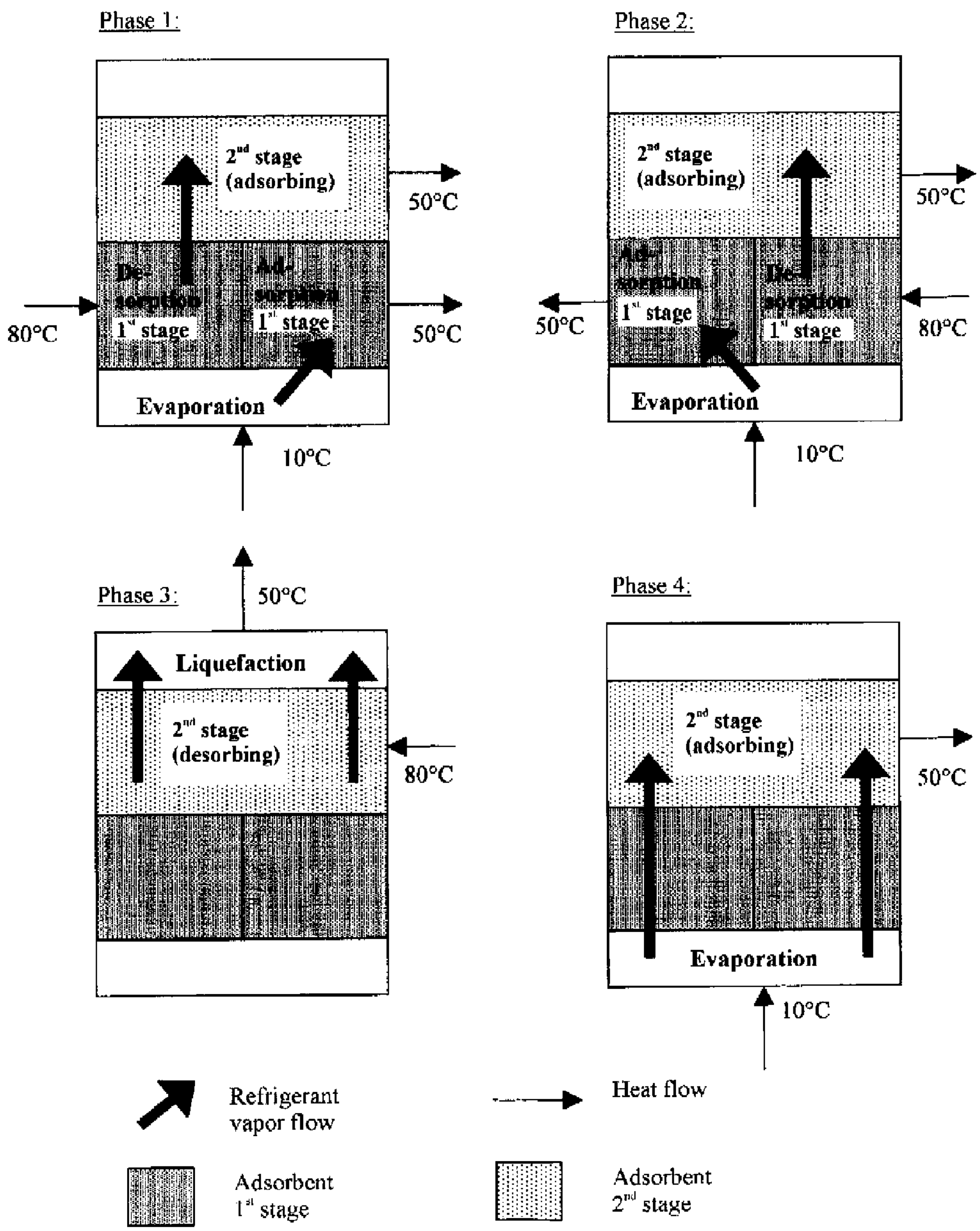


Fig. 3:


Phase 1:
2nd stage (adsorbing)
De-sorption 1st stage
Ad-sorption 1st stage
Evaporation
80°C
50°C
50°C
10°C
Phase 2:
2nd stage (adsorbing)
Ad-sorption 1st stage
De-sorption 1st stage
Evaporation
50°C
50°C
80°C
10°C
Phase 3:
50°C
Liquefaction
2nd stage (desorbing)
80°C
Phase 4:
2nd stage (adsorbing)
Evaporation
50°C
10°C
Refrigerant vapor flow
Heat flow
Adsorbent 1st stage
Adsorbent 2nd stage

REFRIGERATING MACHINE COMPRISING DIFFERENT SORPTION MATERIALS

[0001] The invention relates to the use of an adsorbent instead of a liquefier in an adsorption heat pump as well as the use of an adsorbent during pressure reduction, especially during intermediate pressure reduction, in an adsorption heat pump in order to improve the desorption capacity. The invention further relates to a refrigeration method using two adsorption stages.

[0002] As is well-known to a person of average skill in the art, refrigerating machines implement thermodynamic cycles wherein e.g. heat is absorbed below ambient temperature and rejected at elevated temperature. These cycles in refrigerating machines are essentially identical to the cycles in heat pumps. For this reason, refrigerating machines can also be interpreted as heat pumps. Well-known refrigerating machines are, for example, absorption refrigerators, diffusion-absorption refrigerating machines, adsorption refrigerators or solid sorption heat pumps as well as compression refrigerators. The structure of these machines is well-known to those skilled in the related field of the art. As applies to all refrigerating machines, their performance and efficiency are strongly dependent on the temperatures of the surrounding heat sinks and heat sources. The driving heat for desorption and the absorbed heat at low temperature levels in refrigeration represent heat sources for adsorption refrigerating machines. Both of these heat flows must return back from the machines in order to keep the adsorption processes going. As a rule, this is accomplished by recooling the heats of condensation and adsorption into the environment Hence, there are preferably three temperature levels that are crucially important in adsorption heat pumps: a) the temperature level of the heat source driving the desorption process, e.g. 80° C.; b) the temperature level of the actual refrigeration or of the heat to be absorbed by the adsorption heat pump, e.g. 10° C., at which temperature level evaporation of the refrigerant takes place; c) the temperature level of recooling or heat release into the environment, e.g. 40° C. It is this temperature level where the heats of condensation and adsorption generated in the adsorption heat pump are dissipated into the environment and thus withdrawn from the adsorption heat pump.

[0003] The desorption/liquefaction temperature difference driving the process is referred to as driving temperature and the temperature difference in adsorption/evaporation as temperature lift by those skilled in the art. According to the well-known laws of thermodynamics, the function of thermal sorption machines is improved when the "drive" at a given "lift" is increased, i.e., the better the adsorption material is dried or desorbed, the better it is able to imbibe the evaporating refrigerant and, as a consequence, furnish the desired refrigeration. Thus, at otherwise identical conditions, a heat pump at a recooling temperature of 50° C. will invariably be inferior in performance compared to a recooling temperature of 30° C. because the lift is 20 K higher and the drive therefore is smaller by 20K as well.

[0004] A typical single-stage adsorption refrigerating machine, such as marketed by the Japanese company Mayekawa, essentially consists of an evaporator, a liquefier and an adsorber/desorber pair which alternately adsorbs and desorbs. In adsorption refrigerating machines the refrigerant to be used is adsorbed into previously desorbed (dried) adsorption material, i.e., the better the previous desorption, the more efficient the actual adsorption and refrigeration. As described above, the heats of adsorption and condensation obtained in the process require recooling. In a typical single-stage adsorption refrigerating machine the achievable recooling temperature therefore has an immediate effect on the drive/lift ratio and a significant influence on the performance of the apparatus. Thus, particularly in the event of dry recoolers where the recooling temperature is invariably above the ambient air temperature, limiting process boundary conditions for the performance of adsorption refrigerating machines are being encountered, especially on warm and hot days. For this reason, there are e.g. no commercial adsorption refrigerating machines which could be subjected to dry recooling at ambient temperatures above 40° C. and require driving or desorption temperatures of less than 100° C. Ultimately, however, it is precisely warm and hot days which represent the essential conditions of use for refrigerating machines, especially where air conditioning duties are concerned.

[0005] From the facts described above it follows that adsorption refrigerating machines up to now have normally been operated using wet recoolers (wet cooling tower). However, in the low-capacity range, in the private sector, i.e. non-industrial sector, and in mobile uses, the approach of using wet recooling instead of dry recooling, utilizing the evaporation of water in ambient air (e.g. power plant cooling tower), is barely achievable in technical, economic and political terms (water consumption, maintenance intensity of wet recoolers, additional water pipes, risk of legionella formation, resulting in regional prohibition of such installations).

[0006] For many uses, the well-known adsorption refrigerating machines therefore do not have the required performance, especially in those cases where elevated or relatively unfavorable recooling temperatures are encountered.

[0007] The prior art has attempted to overcome the lack of performance through complex constructional arrangements which, however, require immense efforts during production, initial start-up and use of refrigerating machines/heat pumps.

[0008] For example, the patent of the Denso company, EP 0 795 725 A2, shows that skillful interconnection of the heat carrier circuits can achieve an improvement of the adsorption of a first stage by using lower heat carrier temperatures compared to customary adsorption installations. In the Denso invention this is accomplished by connecting a second evaporator of a second stage upstream of the adsorber of the first stage in the recooling circulation. That is, the heat carrier fluid is cooled down by the second evaporator prior to entering the adsorber and is therefore capable of providing improved refrigeration to the adsorber, thereby improving the adsorption.

[0009] This approach requires a plurality of evaporators. In addition, the plurality of evaporators in EP 0 795 725 necessitate even distribution of the recirculated condensate from the condenser among the number of evaporators, which represents a difficulty or at least requires a separate device.

[0010] Furthermore, a large number of components, such as adsorbers, evaporators and recoolers, are connected in series in EP 0 795 725; that is, the heat carrier fluid flows successively through several components. This implies high pressure loss of the heat carrier fluid, necessitating larger pumps and increased power consumption for these pumps.

[0011] As another matter of fact, a variety of adsorbents have such properties that desorption, i.e. stripping the refrigerant from the adsorbent, requires high temperatures or low pressures. With these adsorbents, sufficient desorption of the adsorbents is difficult during the course of the process under usual temperature boundary conditions.

[0012] The teaching of EP 0 795 does not overcome this problem either because adsorption rather than desorption is supported therein.

[0013] If there is the option of using higher driving temperatures (e.g. >100° C.), multi-stage adsorption heat pumps can also be implemented, with the aim of recovering heat between the stages so that e.g. an increase in efficiency can be obtained. However, such an increase invariably requires such high driving temperatures that the outgoing heat or temperature level of the outgoing heat of the first stage is sufficient to drive a second stage. This multi-stage structure is implemented by interconnection of the heat carrier media (e.g. water or brine) rather than interconnection on the refrigerant side.

[0014] The object of the invention was therefore to provide simple and efficient means and methods which do not have the drawbacks of the prior art. More specifically, the essential point was to find a way that would allow operation of an adsorption refrigerator even with dry recooling and high ambient air temperatures where conventional apparatus either do not function at all or only to a very limited extent.

[0015] Surprisingly, the drawbacks of the prior art can be overcome when using an adsorbent instead of a liquefier in a heat pump/refrigerating machine, especially when the adsorbent is used in a solid sorption heat pump for pressure reduction and particularly for intermediate pressure reduction in the solid sorption heat pump. According to the invention, this does not imply that a component is to be replaced with an adsorbent, but rather it means that in this case adsorption of the refrigerant in an adsorbent proceeds at a position where a liquefaction normally takes place. Either process—liquefaction as well as adsorption of the refrigerant—results in a pressure reduction during desorption of the refrigerant. However, adsorption results in lower pressures than liquefaction at equal temperatures. In the absence of a second stage the desorption pressure (p_{des1}) of the first stage would correspond to the liquefaction pressure ($p_{liquf.}$). If the refrigerant released as a result of desorption is not immediately liquefied but adsorbed in a second stage in accordance with the invention, the desorption pressure of the first stage (p_{des1}) corresponds to the adsorption pressure of the second stage (p_{ads2}). Owing to the relative vapor pressure reduction during adsorption, the pressure p_{ads2} is invariably below $p_{liquf.}$ (at otherwise equal temperatures). Therefore, the following applies:

$$p_{des1}=p_{ads2}<p_{liquf.} \qquad \text{a.}$$

[0016] The following applies during desorption of the second stage:

$$p_{des2}=p_{liquf.} \qquad \text{a.}$$

[0017] The intermediate pressure p_{ads2} is therefore between the desorption of the first stage and the liquefaction.

[0018] As this pressure is lower than the pressure during immediate liquefaction, the capacity of desorption of the first stage is increased in accordance with the invention.

[0019] In another aspect the invention relates to the use of said adsorbent, wherein the intermediate pressure reduction is effected via at least two stages, with an adsorbent desorbing in the first stage, which previously has undergone adsorption in this stage, and the gaseous refrigerant formed in this way, especially water or water vapor, being passed onto another adsorbent for adsorption in a second stage.

[0020] In the meaning of the invention, the gaseous refrigerant being formed has previously been adsorbed and is released in gaseous state from the adsorbent during desorption.

[0021] Accordingly, a preferred aspect of the invention is expanding a single-stage adsorption refrigerating machine by an additional adsorption/desorber unit which preferably has a different adsorption material. Adsorbents are e.g. zeolites or silica gels. According to the invention, the first stage may include zeolite as adsorption material and the 2^{nd} or any additional stage may include silica gel. A reversed arrangement is of course also possible. Likewise, the use of different types or classes of zeolites in the respective stages is conceivable. In this way, a two-stage adsorption refrigerating machine is obtained, the materials in a preferred embodiment being selected such that a) the adsorbent of the first stage is suitable for the process temperatures, especially the temperatures of evaporation and adsorption, and b) the adsorption material of the second stage is suitable for the process temperatures, especially the temperatures of desorption and condensation.

[0022] According to the invention, different properties of adsorbents can be combined in this way so that desorption of the material in a first stage, which in the prior art can only be achieved by using a higher driving temperature, is achieved via adsorption in the second stage. The otherwise usual liquefaction in the first stage does not take place. The desorber of the first stage dries the adsorber of the second stage. Hence, instead of refrigerant liquefaction as known in the prior art, adsorption with intermediate pressure reduction takes place.

[0023] The pressure in such an adsorption corresponds to the pressure of a normal condensation/liquefaction at reduced recooling temperature. In other words, operation of the adsorption refrigerating machine is also possible at a significantly lower driving temperature where prior art adsorption refrigerating machines are no longer functional. By virtue of the teaching according to the present application, especially the preferred variants specified below, a variety of advantages are achieved:

[0024] According to the above, one specific advantage is that operation of the adsorption refrigerating machines may proceed at otherwise impossible operating temperatures. That is, for example, refrigeration with dry recooling is possible throughout the year and even in summer. By virtue of the teaching according to the invention, it is possible to utilize highly adsorbable materials such as zeolites which normally require very high driving temperatures for desorption. In a particularly advantageous manner, the second stage—depending on the design of the invention—can also be used as a storage means.

[0025] In a preferred embodiment of the invention an adsorbent is used during vapor pressure reduction in a heat pump/refrigerating machine to improve the capacity of desorption, especially of the first stage.

[0026] The invention also relates to a method for refrigeration in a refrigerating apparatus/heat pump, wherein an adsorbent is used instead of a liquefier. For example, said liquefier can be a condenser well-known in cryogenics.

[0027] One stage in the meaning of the invention implies that a (n+1) stage adsorbs from the (n) stage (e.g. the second stage from the first). As far as the refrigerant is concerned, different stages are preferably arranged in series in the course of the process. In principle, a stage is constituted of a single unit. Irrespective of which stage, these units can be implemented in various ways, i.e. in the form of one or more components or adsorbers/desorbers:

[0028] One adsorber/desorber: If only one adsorber/desorber is used it cannot adsorb and refrigerate during the desorption phase because desorption is just proceeding. Refrigeration does not start until desorption is completed and adsorption begins. Such an approach would be suitable in the heating system technology, e.g. in operation as a heater-supporting heat pump.

[0029] Two or more adsorbers/desorbers (in a single stage): during desorption of an adsorber/desorber, another one of the same stage can adsorb at the same time. Thus, refrigeration can be made quasi continuous and recovery of heat between components can be utilized as is the case in adsorption heat pumps.

[0030] In preferred embodiments of the invention the way in which the individual stages are implemented is insignificant because implementation in one aspect of the invention is essentially directed to the desorption of the first stage. Advantageously, it is therefore not a crucial point whether desorption from the first stage is quasi continuous (two components) or only completion of adsorption of the first stage is concerned (single component). It will be appreciated that other implementations of the teaching according to the invention are also possible.

[0031] In a prior art adsorption machine the gaseous refrigerant of the desorber is received by a liquefier and liquefied.

[0032] In contrast, the present invention uses an adsorbent to receive the gaseous refrigerant which is released in a desorber. The present invention encompasses adsorption machines which include a liquefier in addition to the adsorbent in order to liquefy the refrigerant of an additional desorption stage as well as machines operating completely without a liquefier.

[0033] In a preferred embodiment of the invention, at least one further liquefier, preferably a condenser, is additionally used apart from the adsorbent instead of liquefier. In a particularly preferred fashion the additional liquefier is used for desorption of another stage, especially the second or last stage. It may be preferred to implement the method according to the invention in such a way that the refrigerating apparatus has at least two adsorption and desorption units. As is well-known to those skilled in the art, adsorption cannot proceed continuously because the material, in accordance with its properties, must be regarded as saturated in cryogenic terms at some point in time. Around that point in time it would be possible to switch to desorption, whereafter the material is ready to adsorb again. Accordingly, another preferred embodiment of the invention relates to a refrigerating apparatus having at least two adsorption and desorption units.

[0034] Advantageously, preferred embodiments of the invention make it possible to use only one evaporator, whereas the EP 0 795 725 requires a plurality of evaporators. One drawback of the plurality of evaporators is that the recirculation of the condensate from the condenser must be evenly distributed among the number of evaporators, thereby requiring at least one separate device. Advantageously, this is not required according to the present invention. For this reason, the teaching according to the invention can be implemented with a simpler, smaller and less expensive device compared to the teachings of the prior art, especially because only one evaporator is included in a preferred variant. Another advantage of preferred variants in accordance with the teaching of the invention results from the fact that desorption, i.e. stripping the adsorbed material, in particular the refrigerant, from the adsorbent requires high temperatures or low pressures; with such adsorbents it is difficult under normal temperature boundary conditions to obtain sufficient desorption of the adsorbent in the course of the process. According to the invention, desorption of the adsorbent, unlike the teachings of the prior art, is supported, especially by adsorption of the adsorbed material from the desorber into an adsorber of the second stage. Thus, according to the invention, it is also possible to use adsorbents which cannot be sufficiently desorbed under normal temperature boundary conditions.

[0035] The term "refrigerant" is preferably used synonymously with the term "adsorbed material" and comprises any agent that adds to or is adsorbed by the adsorbent in an adsorption machine; it is therefore not limited to agents used in refrigeration.

[0036] Accordingly, a person of average skill in the art is able to implement the teaching of the invention because the disclosure of the invention preferably makes clear that the refrigerating apparatus in an advantageous embodiment of the invention at least two adsorption and desorption units; the terms adsorption and desorption units and first or second stage are known to a skilled person in the context with the overall disclosure of the invention and general standard knowledge. Also, a person of average knowledge in the art is able to implement the first or second stage in constructional terms in the meaning of the invention. A person of skill in the art is familiar with the fact that the term "second stage" in the prior art represents a repetition of the first stage at a different temperature level. In the meaning of the invention the second stage results from an interconnection of two different adsorbers, and the second stage is preferably implemented at the same temperature level. To date, there has been no description in the prior art concerning two-stage adsorption apparatus wherein the two stages are operated at the same temperatures. Consequently, the second stage in the meaning of the invention is rather regarded as an additional stage or extended stage by a person of average knowledge in the art.

[0037] In a particularly preferred embodiment of the invention it is envisaged that the refrigerating apparatus additionally has a storage unit. It is advantageous when particularly the solid sorption heat pumps additionally have a storage unit in such a form that the latter can be shut off from the rest of the solid sorption heat pump by one or more vapor barriers or a vapor valve.

[0038] In a particularly preferred embodiment of the invention it is envisaged that the refrigerating apparatus—as set forth above—additionally has a storage unit, advantageously in such a form that the desorbed material in this stage, independently of the operation of the other stage, is not automatically readsorbed but adsorption of this stage may proceed at a later point in time so that desorption (loading) and adsorption (discharging=evaporation) do not immediately follow each other in time and in particular the state of desorption is not or only slightly changed during the temporary storage.

[0039] Advantageously, at least two different adsorbents can be used when implementing the teaching according to the invention. In a preferred fashion the adsorbents can be selected from the group comprising zeolite, silica gel, bentonite, active charcoal, aluminum oxide gel, cellulose and/or starch.

[0040] In a preferred embodiment of the invention, water vapor or a methanol-water mixture or methanol is used as refrigerant; of course, any other refrigerant known to those skilled in the art can be used.

[0041] By virtue of the constructional design, the refrigerant, especially water/water vapor, is conducted in the refrigerating apparatus preferably in such a way that the gaseous refrigerant generated from desorption of the first stage, especially water vapor, is passed into the adsorber of the second stage. The methods of constructional designing are well-known to a person of average skill in the art. In a particularly preferred fashion, zeolite is used as adsorbent in the first stage and silica gel in the second stage. Of course, it may also be preferred to use silica gel in the first stage and zeolite in the second stage.

[0042] In principle, however, it is also possible to use the same adsorbent in both stages.

[0043] In another preferred embodiment of the invention, desorption of the adsorbent in the first stage is achieved by adsorption in the second stage.

[0044] In another embodiment of the invention it may be particularly preferred that the refrigerating apparatus comprises a vapor distributing system in addition to the two adsorption/desorption units, with all stages being interconnectable in such a way that the flow of water vapor can be conducted to all stages.

[0045] In a particularly preferred fashion, an adsorption stage is connected between desorption and liquefaction, i.e. condensation in a preferred manner.

[0046] In another aspect the invention also relates to the use of the inventive method in intermediate pressure reduction, and in another preferred embodiment it also relates to the use of the inventive method for the desorption of a refrigerant in an adsorber. According to the invention, intermediate pressure reduction implies that desorption of a first stage takes place at lower pressure, resulting in improved adsorptive capacity of this stage because drying of this stage can be improved at lower pressure. In relation to a liquefaction pressure of an additional stage wherein the desorbed refrigerant is liquefied, this pressure is lower than the liquefaction pressure. On the other hand, this pressure also is invariably above the adsorption pressure of the first stage. Hence, it is between these different pressures which, according to the invention, appear during operation of a two- or multi-stage adsorption heat pump.

[0047] In preferred embodiments of the invention the inventive method can be used to perform a two-stage adsorption in a heat pump/refrigerating machine with the advantages mentioned above.

[0048] In another preferred embodiment of this method, reduction of the desorption pressure of the first stage and decoupling of this pressure from the condensation/desorption pressure of the second stage are obtained. Decoupling in the meaning of the invention implies that, as a rule, the desorption pressure of the first stage is invariably depending on or dominated by the liquefaction pressure. According to the invention, an adsorption can be connected upstream of the liquefaction with advantage so that the liquefaction pressure no longer has an immediate effect on the desorption pressure of the first stage.

[0049] In another preferred embodiment of the invention the method results in at least two different relative vapor pressure reductions in an adsorption refrigerating machine. Accordingly, the invention also relates to the use of an adsorbent as a vapor sink for a desorption process in a solid sorption heat pump for pressure reduction, especially pressure reduction of desorption of a first stage. Vapor sink in the meaning of the invention implies that the vapor no longer flows about the chambers of the respective component but is converted or changed into liquid or adsorbed material (adsorbed phase) via phase transition.

[0050] Advantageously, the second stage is not always used for pressure reduction of the first stage desorption, but instead is deactivated or operated in analogy to the first stage so as to increase the performance of the solid sorption heat pump or operate the second stage only optionally, with “analogy” in the meaning of the invention implying that adsorption proceeds directly from the evaporator so that no adsorption takes place from a desorption stage.

[0051] Therefore, the invention in another aspect also relates to an apparatus wherein a vapor distributing system is provided which facilitates all flow paths between the adsorbers and desorbers, particularly also direct flow from the evaporator to the second stage and all further stages and from the first stage and all further stages to the condenser. By virtue of the disclosure of the teaching according to the invention, a person skilled in the art will recognize which constructional designs of heat pumps/refrigerating machines could be used to accomplish and implement the inventive uses and methods and will know how to implement the teaching according to the invention in an apparatus. Specific embodiments of the invention require a refrigerant-side interconnection in such a form that the refrigerant is conducted not only from the evaporator in the first stage, from there into the second stage or in series through all further stages, and finally into a liquefier. In storage operation, for example, direct evaporation from the evaporator into a second or further stage but not into the first stage can be advantageous if this stage has been loaded as storage means in accordance with the invention. Advantageously, however, all the other refrigerant-side vapor flows may be required so that, in accordance with the invention, a suitable vapor guide system is required to facilitate this. The apparatus for implementing the use and the methods according to the invention are included in the teaching according to the invention.

[0052] Without intending to be limiting, preferred embodiments of the invention will be described and explained in more detail below with reference to examples, drawings and flow diagrams.

[0053] FIG. 1 shows a possible two-stage adsorption heat pump with refrigerant vapor flow and heat flow as well as the connection to a dry recooler and the temperatures resulting therefrom. In the example the apparatus is run with 80° C., i.e. the desorber of the first stage and the desorber of the second stage are desorbed with this temperature level. Desorption of the second stage takes place at a liquefaction pressure which corresponds to the liquefaction temperature or recooling temperature which, in particular, depends on the air temperature and is typically above this temperature (here: T_{air}=40° C. and $T_{liquefaction}$=50° C.). In contrast, desorption of the first stage takes place at the adsorption pressure of the second stage. This pressure not only depends on the recooling temperature but in particular on the relative vapor pressure reduction at this temperature as a result of the adsorption process.

[0054] FIG. 2 shows two possible operation phases of a two-stage adsorption heat pump according to the invention. For example, the typical alternating operation in both stages is seen in that the vapor from the evaporator is alternately adsorbed by the first stage and the vapor of the second stage which is to be liquefied flows alternately from the second stage to the liquefier.

[0055] FIG. **3** shows a possible embodiment according to the invention with a second stage which is designed as a component having a multiple of the capacity of the first stage and therefore can be operated as a storage means. Owing to the different capacities, the first stage will exhibit a more rapid alternating operation than the second. Also, owing to the design of the second stage as a single component, desorption of the second stage will only take place if there is no simultaneous desorption of the first stage. Specifically, four operation phases are illustrated:

[0056] No liquefaction, 2^{nd} stage adsorbs from the 1^{st} stage.

[0057] In analogy to phase 1, but exchanged operation in stage 1.

[0058] Repetition of phases 1 and 2 until the adsorptive capacity of the 2^{nd} stage is exhausted.

[0059] 2^{nd} stage is desorbed, no refrigeration. After completing desorption and maintaining this state e.g. by means of vapor valves, cold is stored by sorption.

[0060] Storage discharge: refrigeration without supply of driving heat by direct evaporation into the 2^{nd} stage.

1. Use of an adsorbent instead of a liquefier in a heat pump/refrigerating machine, especially a solid sorption heat pump, for pressure reduction in at least one desorption process, particularly intermediate pressure reduction in a solid sorption heat pump.

2. Use of the adsorbent according to claim **1**,
characterized in that
intermediate pressure reduction is effected via at least two stages, wherein in the first stage a refrigerant is desorbed, which previously has undergone adsorption in this stage, and the gaseous refrigerant formed in this way, especially water/water vapor, being passed into a second stage for adsorption on another adsorbent.

3. Use of an adsorbent, in particular according to claim **1**, in vapor pressure reduction in a heat pump/refrigerating machine to improve the capacity of desorption of the first stage.

4. A method for refrigeration in a refrigerating apparatus/heat pump, especially a solid sorption heat pump,
characterized in that
an adsorbent is used instead of a liquefier.

5. The method according to claim **4**,
characterized in that
apart from the adsorbent as liquefier, at least one further liquefier is used in addition.

6. The method according to claim **4**,
characterized in that
the refrigerating apparatus has at least two adsorption and desorption units.

7. The method according to claim **6**,
characterized in that
the solid sorption heat pump additionally has a storage unit in such a form that the latter can be shut off from the rest of the solid sorption heat pump by one or more vapor barriers or a vapor valve.

8. The method according to claim **4**,
characterized in that
at least two different adsorbents are used.

9. The method according to claim **8**,
characterized in that
desorption of the adsorbent in the first stage is achieved by adsorption in the second stage.

10. The method according to claim **4**,
characterized in that
an adsorption stage is connected between desorption and liquefaction.

11. The method according to claim **4**, which method results in a reduction of the desorption pressure of the first stage and a decoupling of this pressure from the condensation/desorption pressure of the second stage.

12. The method according to claim **11**, which method results in at least two different relative vapor pressure reductions in an adsorption refrigerating machine.

13. The method according to claim **11**,
characterized in that
the same adsorbent is used in both stages.

14. Use of the method according to claim **4** in intermediate pressure reduction.

15. Use of an adsorbent, in particular according to claim **1**, as a vapor sink for a desorption process in a solid sorption heat pump for pressure reduction, especially for pressure reduction of desorption of a first stage.

* * * * *