Title: A METHOD TO IMPROVE THE HEAT PUMP PROCESS

Abstract: The invention relates to the improvement of such an absorption heat pump process, in which thermal effect is generated by means of a heat pump (5, 8, 9, 10) operating according to the absorption principle. In order to improve the controllability of the process, and to make the location of the components easier, the pressure difference and/or the volume flow between the components (5, 8, 9, 10) are changed and/or controlled by means of a specific device or devices (36, 27, 31).
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
A method to improve the heat pump process.

This invention relates to a method to improve such absorption heat pump process in which thermal effect is generated by means of a heat pump operating in absorption principle, and in which is utilised a refrigerant evaporating and condensing on different temperature levels, usually water.

Absorption equipment have for a long time been used to transfer thermal energy from one energy level to an other level, in other words to produce heating or cooling effect on a serviceable level from a source which is not on serviceable level. The operation of an absorption equipment is based on the fact that certain absorption substances are able to absorb certain other substances at a temperature which is higher than the boiling point of the substance in the prevailing pressure. In other words the substances can bind as liquid an other substance which is in gaseous state at a temperature which is higher than the boiling point of the substance in question. Such substances which form so-called absorption pair can be separated from each other again by means of rising the temperature, in other words by boiling. The most common absorption pairs are lithiumbromide/water and ammonia/water. Such equipment is described for instance in publications FI 963470, NO 158007, SU 879202, GB 2132327A and DE 3202863A1. The processes for producing heating and cooling effect are slightly different, but the same basic elements are included. For the sake of simplicity only producing of cooling effect is discussed in the following, but the basic idea of the invention can be applied also for producing heating effect.

The absorption process for producing the cooling power operates as follows. The absorption substance, e.g. lithium bromide and the refrigerant, e.g.water, are separated from each others in so-called generator by heating the weak absorption liquid pumped to the generator with heat conveyed from an external source in a vacuum, the level of
which is related to the boiling temperature, which is usually higher than 80 deg.C. The refrigerant is evaporated resulting in increased concentration of the absorption substance. The concentrated liquid is conveyed into the absorber, and the water vapour into the condenser. In the condenser the steam is cooled by means of a coolant as water. The water is conveyed to an expansion valve in which the pressure is lowered, and the water is evaporated again in a heat exchanger into which the liquid to be cooled is conveyed. The evaporation binds heat and the liquid is cooled. The steam generated in the so-called evaporator flows to the absorber in which the strong absorption liquid conveyed from the generator absorbs the steam and the concentration of the solution is lowered. When the water vapour is condensed, heat is released, and the heat is bound with the cooling water pumped from an external source. The weakened solution is pumped to the generator to be concentrated again.

For different reasons, primarily in order to improve the efficiency factor, the process may consist of even other components, e.g. heat exchangers, ejectors etc.; the generator may have two stages etc. However, the description before includes the most essential components from the point of view of the process.

The most common application of the absorption principle is perhaps the gas-driven refrigerator in which the external heat source is a gas burner. However, the absorption process is not widely applied. A remarkable reason is the low efficiency factor compared with competing heat pump process operated with mechanical compressors. Typical efficiency factor of absorption process is 0,75, and of compressor operated heat pumps 3,5. Though the absorption process utilises heat instead of electricity used by mechanical compressors, the operation costs are clearly higher in case of present price relation of heat and electricity if full price of heat is paid. The absorption process cannot be defended with environmental reasons: the counterbalance of the refrigerants
used by compressors is the greater energy consumption of the absorption process and the disadvantages related to it.

Due to lower efficiency factor the need of external cooling energy is also greater. All heat fed to the heat pump process in the boiler and evaporator must be conveyed away in order to keep the process in operation. In absorption cooling the necessary effect is 2.4 times the produced cooling effect, in compressor cooling 1.3 times the produced cooling effect. The investment and operation costs of cooling towers or other equipment producing external cooling effect are in other words almost double compared with compressor cooling.

The manufacturers have tried to improve the efficiency factor in many ways, e.g. by means of 2-stage generator, by using the steam produced in the generator to pull the steam with an ejector to bypass the absorber and the generator. In this way the efficiency factor has been improved to 1.3. The investment costs of the cooling tower and other equipment has been lowered and its size and need for space has been reduced but respectively the investment costs and the size of the absorption unit are greater. The energy consumption and consequently the operation costs are reduced to some extent, and therefore the competitiveness of the absorption cooling compared with the compressor cooling has been slightly improved.

The third weakness of the existing technology is the great size of the absorption units compared with the compressor units. There are many reasons. Perhaps the most important is that the absorption process can operate only in vacuum, the evaporator and absorber in almost absolute vacuum in order to achieve the temperature level needed for cooling. In compressor cooling process there is a remarkable positive pressure. Due to the big size it is difficult to place the absorption cooling units, and the space cost is remarkably higher than that of compressor units. Especially the height of the unit is a problem, and the units greater than 1MW cannot be located in spaces of
conventional height.

The absorption equipment is used mainly in case waste heat is available free of cost or at very low price. There are applications both for cooling and heating, in other words for rising the temperature of waste heat to an applicable level. Thanks to the free or cheap driving energy the operation costs are low and compensate the higher space and investment costs.

The absorption heat pump is especially competitive in case water from a river, lake etc is available for cooling the condenser and absorber, and a cooling tower is not needed. E.g. in the process industry the situation is often that both cheap waste heat and water is available, because the factory uses lot of water in its production process, and the factory is located according to this fact.

In this case new problems are collided. At first the temperature of the water taken from a river, lake etc varies strongly depending on the season during the cooling period e.g. in the range +5...+25 deg. C. In many cases the short term variation is remarkable if the water cannot be taken from deep water and/or the water system is small. The main reason is variation of the strength and direction of the wind. This problem can be solved by controlling the volume flow and the temperature of the cooling water by means of so-called shunt circuit. Of course, the costs are increased, and it makes the control of the absorption process which as such is difficult to control, more complicated and more inclined to malfunctions.

Still more difficult problem is that also the temperature of the waste heat used as driving energy in the generator varies in many cases strongly, and these variations may be, depending on the production process, quite quick in relation to the speed on which the absorption process can be controlled. The situation is made further more difficult by the fact that the temperature changes are often connected with strong changes of the pressure in the waste heat network. This is in most cases caused by the variation of the
consumption of heat in the production process.

Moreover, in the use of the waste heat there is the problem that its temperature level related to the desired temperature of the cooling water is often quite low. The temperature of waste heat is often 70...90 deg. C and the required temperature of the cooling liquid 4...10 deg. C. To make the water in the generator to vaporise, the pressure in it and the condenser must be low resulting in a small pressure difference between the condenser and the evaporator. This generates problems in the function of the expansion valve. This is illustrated by figure 1 which is measured when the pressure in the condenser is 40 mbar and in the evaporator 10 mbar, and when the flows and the temperatures in the generator, condenser and evaporator are constant. In the figure can be clearly noticed the so-called hunting-phenomenon which has been generated in uniform conditions.

Of course it is clear that variations of the liquid flows and/or temperatures to the generator and condenser make problems remarkably more difficult. In addition, the whole complex of problems includes the fact, that the cooling effect produced by the absorption process must be controlled within wide ranges according to e.g. the cooling needs of a process or a building. In figure 2 is presented the variation of cooling load in a conventional industrial building during one day and night. As can be noticed in the figure the effect must be regulated in the range 0...100 % during some hours.

Altogether, the influence of three external factors which vary independently must be eliminated. In addition, the absorption process itself sets many boundary conditions to the control. The most important condition perhaps is to fall below the crystallisation boundary which may be caused by too high temperature in the generator, too low temperature in the evaporator, too low temperature of the cooling water to the absorber etc. It must be pointed out that all individual factors may well stay inside the allowable boundaries. The crystallisation may be caused by the influence of many factors to same
direction. Another example of the limitations is the delay in following the controls caused by the inertia of the masses, resulting in unstable control, so-called hunting.

In practice it has been found out that the absorption heat pump process cannot be economically controlled so that it could follow the variation of cooling load e.g. in a building caused by the variations of the outdoor temperature, of internal thermal load of a building, of the solar radiation, of the wind etc. So the cooling applications are commonly equipped with thermal storages actually in order to eliminate the influence of the variations of the load. Of course, this results in great additional costs. Often the target of such storages is to shave peak loadings and to save in investment costs, as is presented e.g. in publications FI 954949 and FI 954950. Often a great(est) part of the storage capacity is consumed in the regulation.

With the method and the equipment according to this invention the controllability of the absorption process can be remarkably improved resulting in remarkable broadening of the control range of the absorption process, and in improving the ability to adapt to the variations of cooling load. The influence of the temperature changes of the liquid used to cool the absorber and the condenser is essentially reduced, as well as the influence of the temperature and pressure variations of the substance transferring heat to the boiler. In addition, by means of the method according to this invention many problems related to the great size and locating of the absorption heat pump can be solved essentially easier than by means of the known equipment. Moreover, in the specific applications are achieved other benefits which are discussed in detail later in connection of the applications.

The simple basic idea of the invention is to arrange between the condenser and evaporator of the absorption unit a device intended to control the pressure. Such device can make an one-time correction of the pressure difference which generally is too small, or operate in two or several stages, but the greatest benefits are achieved if
such a device can control the pressure difference between the condenser and the evaporator. Quite many factors, e.g. the flow between the condenser and the evaporator, in other words the effect of the absorption unit can be controlled by means of the pressure difference.

5 Even better results are achieved if also the flow path from the boiler to the absorber is equipped with a device intended to control the pressure and/or flow. In that case the whole absorption process can be controlled, and it is able to adapt better to the pressure/temperature variations of the external fluid flows. The control range of the effect taken from the process can be remarkably widened compared with the known technology, and the efficiency factor is essentially improved resulting in decreased heat consumption, reduced need of the condensing effect, and reduced fluid flows which cuts down the electricity consumption.

Furthermore it is very important that the location of the boiler and the condenser of the absorption process can be selected quite freely in relation to the evaporator and absorber both in the horizontal and vertical direction, and it is not necessary to locate the components close to each others. The evaporator and the absorber can be located e.g. in one room space and the generator and the condenser in another even above them which is quite impossible for the equipment according to the prior art. This lessens essentially the problems related to the great size of the absorption equipment and makes it possible to apply the absorption process in close spaces, e.g. in ships.

The method according to the invention makes it also possible to use more effective methods to wet the heat transfer surfaces because the available pressure is not more a limiting factor. This improves the heat transfer coefficients which makes the devices smaller and reduces the costs, improves the efficiency factor resulting in the benefits described before etc.

Furthermore by different application forms of the invention are achieved some other
benefits which are described in connection with the applications later. The invention is described in greater detail in the following by means of the examples to apply the invention and the known technology presented in the attached drawings, while fig. 1 shows the variation of the pressure in the condenser while all factors influencing the absorption unit are constant,

fig. 2 shows the variation of the cooling load in a building during a day and night,

fig. 3 shows a conventional 2-chamber lithiumbromide/water absorption device used for cooling,

fig. 4 shows an embodiment according to the invention in which a pump is used to control the pressure.

fig. 5 shows an embodiment according to the invention in which the gravity and a control valve is used to control the pressure,

fig. 6 shows an embodiment in which the equipment is divided into two parts which are not located in the same space, and

fig. 7 shows an embodiment in which the effect of the device is controlled by regulating the flow between the condenser and the evaporator.

Figures 1 and 2 are considered before.

In figure 3 is presented an example of the known solutions. The operation of a solution according to figure 3 is in principle as follows: From the supply pipe 1 of a district heating network is taken hot water to the generator 5 of the absorption device, and the water is returned trough pipe 4 to the return pipe 3 of the district heating network.

Because of controllability the generator 5 is usually equipped with a circulation pump 6 and a control valve 7. The refrigerant is separated in the generator 5 from absorption liquid by evaporating with hot district heating water. The refrigerant is transferred to the condenser 8 in which it is cooled so that it is condensed. From the condenser 8 the refrigerant is transferred to the evaporator 9, and the pressure is by the same lowered
by means of an expansion valve 17 so that the refrigerant is evaporated and its
temperature lowered, and it cools the cooling water of the cooling system of a building.
From the evaporator the refrigerant is transferred to the absorber 10 into which is
transferred also absorption liquid from the generator 5 through a heat exchanger 11.

5 The refrigerant is absorbed by the absorption liquid whereupon reaction heat is
released. The solution formed by the absorption liquid and water is preheated in a heat
exchanger 11 and pumped by means of a pump 12 in higher pressure to the generator
5. External heat is transferred to the generator 5 and evaporator 9 of the absorption
device, and it must be carried out in order to make the device to operate continuously.

10 In cooling is used usually water which is transferred as heated from the absorber 10
through a pipe 13 to a cooling tower 14 in which it is cooled by evaporating. Of course
e.g. sea water heat exchanger or any other as such known device can be used. From
the cooling tower 14 water is pumped through a pipe 15 to the condenser 8 of the
absorption device, and from it some much heated to the absorber 10 through a pipe 16

15 and from it back to the cooling tower 14. The cooling water of a building cooled in the
evaporator is transferred through a pipe 33 to the cooling network of the building, from
which it is returned as heated through a pipe 32 to the evaporator.

In a building there are usually several devices that use cooling water, but for the sake
of clarity, only one air-conditioning unit is shown in figure 1. The cooling water flows

20 through a control valve 18 to a heat exchanger 23, by which the cooling effect is
transferred to the heat transfer circuit of the air-conditioning unit, from which it is
returned by a pump 20 either through the control valve 18 back to the heat exchanger
23 or to the evaporator 9. The heat exchanger 23 is not necessarily needed: the cooling
water can be supplied also directly to the circulation water pipe 21 or even directly to a

25 cooling coil 19 in case there is not a recovery coil 22 and respectively a circulation
water circuit in the air-conditioning unit.
The solution before has the drawbacks presented before in the general part describing the prior art.

Figure 4 shows a first preferred embodiment of the invention. In figure 4 the reference numbers are the same as in figure 3 for respective components.

Figure 4 includes all the components and functions which were discussed before in connection with figure 3. In addition, between the condenser 8 and the evaporator 9 before the expansion valve 17 in flow direction there is a device for controlling the flow and the pressure, in figure 4 a pump 26, by which the pressure of the refrigerant flowing from the condenser is raised.

The expansion valve 17 is now operated by a higher pressure difference, e.g. instead of 30 mbar mentioned before by a pressure difference of 150 mbar. This leads to many benefits. At first a great part of the limitations concerning the valve type are eliminated which makes it possible to use valves which are more precise in operation and/or less expensive. Secondly the relative influence of friction, hysteresis and other mechanical disturbances on the control function is reduced in this case to one fifth. In practice this means, that e.g. the hunting shown in figure 1 and caused mainly by mechanical disturbances is reduced respectively, in other words the hunting phenomena is reduced as insignificant.

Furthermore the pump itself has an influence which lessen the influence of external disturbances, if the pump is selected correctly. If the pump is selected so that its operational point is on the steep part of the characteristic, in other words when the volume flow is reduced the pressure rises strongly, the pump 26 absorbs disturbances effectively. If e.g. the temperature of the heating fluid to the generator 5 rises, the generator 5 evaporates more refrigerant from the solution, and the concentration of the return solution to the absorber 10 is increased. If the pump 26 does not exist, the refrigerant flows trough the expansion valve when a given pressure difference prevails.
The solution to the absorber is more concentrated than usually, its absorbency increased, and it is able to absorb the increased amount of water vapour. Therefore the effect of the machine is increased.

If there is in a system a pump which is selected correctly the pressure generated by it decreases when the flow increases. The pressure in the generator 5 and condenser 8 must rise that greater flow would pass the valve 17. At higher pressure the generator 5 is not more able to vaporise the refrigerant as effectively as at lower pressure, and the solution is not concentrated as much. This results also in decreased absorbency of the absorber. In other words the effect of the machine rises much less than in case the pump does not exist.

The description of the absorption process above is remarkably simplified in order to get the understanding of the basic idea easier. In fact the influence of the changes on the operation of the condenser 8 and of the absorber 10 should be taken into account. The influence is partly contradictory, partly similar to what is discussed above. However, the influence is much weaker. The basic phenomena is as described above.

Respectively, when the temperature of the heating fluid to the generator 5 is lowered, the effect of the generator 5 turns to decrease resulting in decreased concentration of the solution to the absorber 10, and to decreased effect of the whole machine, in other words the volume flow trough the pump 26 turns to decrease. In that case the pump 26 draws greater vacuum in the generator 5 and condenser 8. Thus the generator is able to vaporises more effectively, and the effect is respectively decreased much less than by solutions without the pump.

Similar consideration can be made of the influence of temperature change of the cooling water to the absorber 10. The pump 26 operates in a similar way and reduces essentially the influence of temperature changes on the effect of the machine. As a matter of fact, the pressure in the generator and in the condenser gets “by itself” settled
on a level required by varying temperatures.

A consequence of this is one of the central benefits of the invention. When the pump 26 actually decreases the concentration variations caused by the temperature changes, it by the same decreases essentially the crystallisation risk of the solution, which was considered before. In theory it is possible to totally eliminate the crystallisation risk by dimensioning the pump properly.

The pump 26 is not necessarily needed for controlling the pressure difference. Figure 5 shows an embodiment in which the gravity is utilised, actually by increasing the hydrostatic pressure to a given level. The generator 5 and the condenser 8 are located above the level 28, and the absorber 10 and the evaporator 9 below the level 28 on a totally different floor. The pressure difference over the expansion valve can then be instead of the before mentioned 40 mbar e.g. 400 mbar (corresponds vertical distance of 4 m), whereupon the expansion valve 27 may have a large control range. The control can be made on base of any process factor or a combination of the factors. The control becomes essentially easier when it is found out that the height of the liquid level in the pipe 29 need not to be constant.

The room height is not a limiting factor to apply the absorption process in the embodiment shown in figure 5. The location becomes further essentially easier, when it is found out, that the generator 5 and the absorber 10, and respectively the condenser 8 and the evaporator 9 need not to be directly one upon another, but the mutual location can be selected freely, in other words the pipes connecting the components can have even long horizontal parts.

The embodiment shown in figure 5 has the drawback that the equipment cannot be assembled in the factory. The solution and cooling pipes must be connected on the site, as well as components must be filled with the solution and vacuum tested etc. This rises the costs, is a cause of quality problems etc.
This difficulty is eliminated when it is found out that when both the pipe between the condenser 8 and the evaporator 9, and respectively the pipe between the generator 5 and the absorber 10 are equipped with a pump, the location of the components 5 and 8 in relation to components 9 and 10 can be chosen totally freely. The components 9 and 10 can be located even above the components 5 and 8, which is quite impossible by the equipment of prior art.

Figure 6A shows such embodiment viewed from side, and figure 6B viewed from above. The figure shows for the sake of clarity only the mere absorption device without the cooling tower and other accessories, and for the same reason the pipes combining the components are shown schematically. The figure shows an equipment which is installed in the shape of an angle, in which the generator 5 and the condenser 8 are below the evaporator 9 and the absorber 10, but the components can be located completely freely e.g. parallel side by side or one after another, mutual location in vertical direction has no limitations etc. Of course it is clear, that usually it makes sense to locate the components of the equipment 5, 8, 9, 10 as close to each others as possible, but they can be located practically speaking at any distance from each others.

The embodiment shown in figures 6A and 6B has also another very remarkable benefit compared with the technical level of prior art. Because all liquid transfer circuits are equipped with a pump, the flows, pressure differences, temperatures, concentrations of the liquids etc can be controlled in range of certain limitations by means of as such known control devices and methods. Measuring devices and control valves can be located in the flow circuits, different shunt connections can be utilised, the pumps can be equipped with speed control etc. It is possible e.g. to construct protection systems against the crystallisation of the liquid, to improve the efficiency coefficient especially on partial loads etc. However, the most important thing is that the controllability of the whole absorption process can be improved, and the control range can be widened. In
that case it is possible to e.g. reduce the size of the storage tanks or/and a greater part of their capacity can be used instead of control for shaving of the peak loads.

Furthermore the use of the pumps results in the benefit that spreading of the fluids on the mass- and heat transfer surfaces of the components 5, 8, 9, 10 can be improved, and quite often the heat exchangers and respectively the size of the whole equipment can be reduced. Figure 6A shows simple drain boxes 36 and 37 for distributing the liquid/steam to the heat exchangers 34 and 35. When the pressure loss does not set limitations the boxes can be substituted by effective spray nozzles when the liquid circuits are equipped with the pumps 26 and 30, as well as in the evaporator 5 thanks to the pump 12.

Figure 7 shows as an example of the options for control, the control of the liquid flow between the condenser 8 and the evaporator 9. In the pipe between the condenser 8 and the evaporator 9 is located a flow meter. Its reading is regulated to wanted value by means of the controllable expansion valve 27. The position message is received from a control panel not shown in the figure, e.g. on base of the reading of a flow meter measuring the effect needed by consumers, on base of the position of the valve 7 etc. The flow meter 31 can of course control e.g. the speed of the pump 26, whereupon the expansion valve need not to be controllable. Furthermore there can be a feedback to the valve 7 e.g. to prevent hunting; in addition to the valve 27 to control e.g. the liquid pump 12 and/or the pump 14 of cooling tower or a control valve located in the pipe 15.

Figure 7 is only an example of the numerous embodiments, which are provided by the control of the pressures and/or the flows and so indirectly also the control of the temperatures in different parts of the absorption process. E.g. the crystallisation risk of the absorption liquid mentioned before can be decreased essentially by increasing the circulation of the solution between the generator 5 and the absorber 10. If a constant
heating power is fed to the process from a heat source, and a constant cooling power from the cooling tower, the concentrations of the strong and weak solution approach each others. In other words the strong solution to the absorber is diluted, whereupon risk to crystallise is decreased. The theoretical limit is to increase the solution flow to infinity, whereupon the concentrations of the strong and weak solutions are equal, because the small amount of water evaporating in the generator 5 and absorbing in the absorber 10 cannot change the concentration of the infinite flow. Of course in practice it is not possible to go so far, but the risk of crystallisation can be essentially reduced and so eliminate perhaps the most important limiting factor for the control of the absorption process.

The above embodiments are only examples how to beneficially apply the invention. All the embodiments implemented by combining the above applications, as well as all the solutions for controlling, for pipe connections, and for locating the components that are known per se, fall in the scope of the invention, as well as the substitution of the components presented above with other components known per se, as well as combining the components in different ways into entire equipment. E.g. in figures 6A and 6B the heat exchangers 34 and 35 of the absorber and the evaporator are located one after another in a round, cylindrical housing. Of course it is obvious that the components can be located e.g. side by side in an oval housing, or each in its own housing. Respectively the heat exchangers 34 and 35 are shown as plate heat exchangers. The components can of course be of any heat exchanger type known per se.
Claims

1. A method to produce thermal effect by means of the absorption process (5, 8, 9, 10) characterised in that the pressure and/or the solution flow between the condenser (8) and the evaporator (9) of the absorption process (5, 8, 9, 10) are changed before the pressure of the refrigerant is lowered or coincide with it.

2. A method according to claim 1, characterised in that the pressure and/or the volume flow of the solution flow from the generator (5) to the absorber (10) is changed by means of a device (30) intended to change a pressure and/or a volume flow.

3. A method according to claim 1 or 2, characterised in that the pressure differences and/or fluid flows are changed on base of the variations in the volumes and/or temperatures and/or pressures of the fluid flows transferring thermal energy to or from the absorber (10) and/or the generator (5) and/or the condenser (8) and/or the evaporator (9) of the absorption process (5, 8, 9, 10).

4. A method according to claim 1 or 2, characterised in that one or several size(s) of the volume flows and/or of pressure differences between the components of the absorption process (5, 8, 9, 10) are changed on base of the thermal effect wanted to be generated.

5. A method according to claim 1 or 2, characterised in that one or several size(s) of the volume flows and/or pressure differences between the components of the absorption process (5, 8, 9, 10) are changed on base of the mutual location.

6. A method according to anyone of claims 1-5 or to the combination of the claims, characterised in that the changes are made in dependence to each others

7. A method according to anyone of claims 1-6 or to the combination of the claims,
characterised in that the size of one or several fluid flows and/or pressures and/or temperatures of the fluid flows transferring thermal energy to or from the components (5, 8, 9, 10) of the absorption process are changed on base of a change or changes made in the size of volume flows and/or pressure differences between the components (5, 8, 9, 10) of the absorption process.

8. A method according to anyone of claims 1-7 or to the combination of the claims, characterised in that the changes in the size of volume flows and/or pressure differences and/or temperatures are made in order to keep the temperature of the absorber over the crystallisation limit and/or to keep the concentration of the liquid over the crystallisation limit in the pressure in question.

9. A method according to anyone of the claims 1-8 or to the combination of the claims, characterised in that the evaporator (9) and/or the absorber (10) of the absorption process are located essentially separated from the generator (5) and/or the condenser (8).

10. A method according to claim 9, characterised in that the evaporator (9) and/or the absorber (10) of the absorption process are in the vertical direction essentially on the same level as the generator (5) and/or the condenser (8), or above them or it.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F25B 15/06, F25B 49/04 // F25B 30/04
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)

IPC7: F25B

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

SE, DK, FI, NO classes as above

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>X</td>
<td>DE 19538348 C2 (ABSOTECH ENERGIESPARSYSTEM GMBH &amp; CO. KG), 6 November 1997 (06.11.97), column 6, line 61 - column 10, line 29, figures 1,2</td>
<td>1-10</td>
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<td>X</td>
<td>DE 3201349 A1 (STIEBEL ELTRON GMBH &amp; CO KG), 28 July 1983 (28.07.83), page 6 - page 10, figure 1</td>
<td>1-10</td>
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<tr>
<td>X</td>
<td>US 5423189 A (D.V. NICOL ET AL), 13 June 1995 (13.06.95), column 1, line 12 - line 51; column 3, line 6 - column 5, line 37, figure 1</td>
<td>1-8</td>
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Further documents are listed in the continuation of Box C.

Date of the actual completion of the international search: 25 Sept. 2000

Date of mailing of the international search report: 03-10-2000

Name and mailing address of the ISA/
Swedish Patent Office
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Form PCT/ISA/210 (second sheet) (July 1992)
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<td>X</td>
<td>US 3895499 A (N.E. HOPKINS), 22 July 1975 (22.07.75), column 3, line 19 - column 14, line 46, figures 1, 2</td>
<td>1-8</td>
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<tr>
<td>A</td>
<td>US 5477696 A (S. TAKAHATA ET AL), 26 December 1995 (26.12.95), the whole document</td>
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 00/00427

Box I  Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.☐ Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2.☐ Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.☐ Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a): 

Box II  Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The invention according to claim 1 - 8 has been found not fulfilling the requirements of novelty. The independent claims 9 - 10 will therefore include inventions which "à posteriori" do not have a common technical feature over the prior art and do therefore lack unity. The inventions are as follows:

.../...

1.☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2.☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3.☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4.☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest  ☐ The additional search fees were accompanied by the applicant’s protest.
☐ No protest accompanied the payment of additional search fees.
The invention according to claim 1 - 8 a method to produce thermal effect by means of the absorption process where pressure or flow are changed.

The invention according to claim 9 - 10 location of evaporator and/or absorber or generator and/or condenser.

There is no technical relationship between the features of these inventions. See PCT Rule 13.2
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