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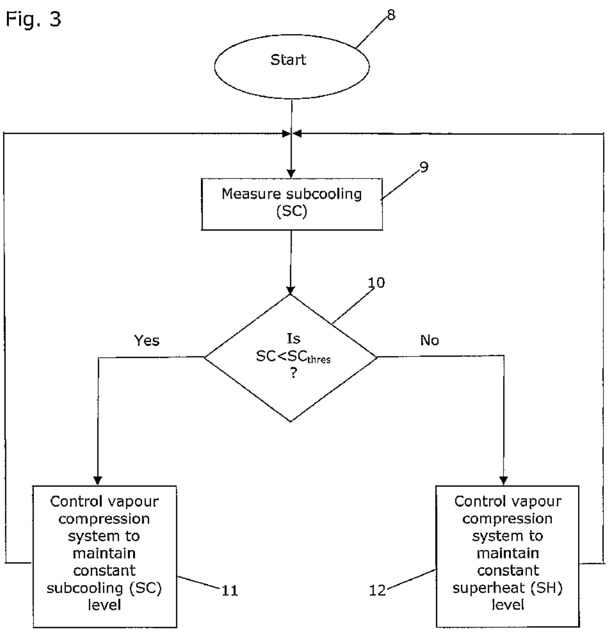
(54) **Title**: A METHOD OF CONTROLLING OPERATION OF A VAPOUR COMPRESSION SYSTEM

Fig. 3



(57) **Abstract**: A method for controlling operation of a vapour compression system (1) is disclosed. The vapour compression system (1) comprises a compressor (2), a condenser (3), an expansion device (4) and an evaporator (5) arranged in a refrigerant path. The method comprises the steps of obtaining values of an entity being indicative of a current distribution of liquid refrigerant of the vapour compression system (1) and comparing the obtained values to a predefined threshold value. In the case that the obtained values are below said threshold value, control parameter values being indicative of the amount of liquid refrigerant present in the condenser (3) are obtained, and operation of the vapour compression system (1) is controlled in accordance with the obtained control parameter values and in such a manner that the amount of liquid refrigerant in the condenser (3) is maintained at a substantially constant level. This prevents flash gas at the inlet of the expansion device of the vapour compression system (1).

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A METHOD OF CONTROLLING OPERATION OF A VAPOUR COMPRESSION SYSTEM

FIELD OF THE INVENTION

The present invention relates to a method of controlling operation of a vapour compressions system, such as a refrigeration system, an air condition system or a heat pump. The method of the present invention allows the vapour compression system to be controlled in such a manner that the refrigeration capacity of the vapour compression system is utilised to the greatest possible extent, and without risking the presence of flash gas at the inlet of the expansion device of the vapour compression system. The method of the invention is particularly suitable for controlling operation of vapour compression systems having components with microchannels.

BACKGROUND OF THE INVENTION

Vapour compression systems normally comprise a compressor or a compressor rack, one or more condensers, an expansion device, e.g. in the form of an expansion valve, and one or more evaporators. These components are arranged fluidly connected in a refrigerant path. Fluid medium, such as refrigerant, is compressed in the compressor. The compressed fluid is supplied to the condenser where it condenses, i.e. it leaves the condenser in a substantially liquid state. The fluid medium is expanded in the expansion device before it is fed to the evaporator, where the liquid part of the fluid medium is at least partly evaporated.

The vapour compression system is normally operated in such a manner that a desired temperature, a so-called set point temperature, is obtained in a volume being refrigerated or heated by the vapour compression system. This is normally obtained by monitoring the temperature of the volume, and operating the expansion device, e.g. by opening or closing an expansion valve, thereby allowing or preventing a supply of fluid medium to the evaporator, so as to maintain the temperature within a predefined temperature deadband. Furthermore, it is often attempted to operate the expansion device in such a manner that the capacity of the evaporator is utilised to the greatest possible extent. Ideally, fluid medium in a liquid phase should be present throughout the evaporator, but liquid should not be allowed to pass the evaporator. This can be obtained by using the superheat, i.e. the temperature difference between the dew point of the fluid medium and the temperature of the fluid medium leaving the evaporator, as a control parameter. The superheat should be low, but positive. When the superheat approaches zero, there is a risk that liquid medium is leaving the evaporator, and when the superheat is high, the evaporating capacity of the evaporator is not utilised to the full extent.

In vapour compression systems with ‘normal flow channels’, e.g. in the form of fin and tube heat exchangers, it is normally sufficient to control operation of the system in the manner described above. However, when the vapour compression system comprises flow channels with low internal volume, e.g. in the form of microchannels or plate heat exchangers, e.g. in the evaporator and/or in the condenser, the amount of fluid medium in these flow channels is considerably reduced. This introduces a risk that the fluid medium delivered from the condenser is purely or almost purely in a gaseous phase if the vapour compression system is operated in accordance with a minimum superheat strategy. Thereby there is a risk of introducing gaseous fluid medium in parts of the refrigerant path which should contain liquid fluid medium. This is known as ‘flash gas’. When flash gas is present at the entry to the expansion device, the flow capacity of the expansion device is considerably reduced, the pressure of the refrigerant oscillates, and the capacity of the vapour compression system is reduced. It is therefore desirable to avoid flash gas in the system.

On the other hand, if the vapour compression system is operated solely in order to ensure sufficient supply of liquid medium from the condenser, thereby avoiding flash gas, the amount of liquid medium in the condenser may become excessive, thereby reducing the amount of gaseous medium in the condenser. This reduces the part of the condenser where condensation takes place, i.e. the efficiency of the condenser is reduced. Thereby the overall efficiency of the vapour compression is also reduced.

DESCRIPTION OF THE INVENTION

It is, thus, an object of the invention to provide a method of operating a vapour compression system, the method allowing the vapour compression system to be controlled in an optimum manner while avoiding flash gas in the system.

It is a further object of the invention to provide a method of operating a vapour compression system, the method being suitable for operating a vapour compression system comprising flow channels with low internal volume.

It is an even further aspect of the invention to provide a method for operating a vapour compression system, where the method can be used for ensuring that a correct charge is applied to the vapour compression system.

According to a first aspect the invention provides a method for controlling operation of a vapour compression system, the vapour compression system comprising a compressor, a condenser, an expansion device and an evaporator arranged in a refrigerant path, the method comprising the steps of:

- obtaining values of an entity being indicative of a current distribution of liquid refrigerant of the vapour compression system,

- comparing the obtained values to a predefined threshold value,

- in the case that the obtained values are below said threshold value, obtaining control parameter values being indicative of the amount of liquid refrigerant present in the condenser, and controlling operation of the vapour compression system in accordance with the obtained control parameter values and in such a manner that the amount of liquid refrigerant in the condenser is maintained at a substantially constant level.

In the present context the term 'vapour compression system' should be interpreted to be a system in which fluid medium is alternatingly compressed and expanded. Such systems include, but are not limited to, refrigeration systems, air condition systems and heat pumps. The general operation of a vapour compression system has been described above.

The expansion device may advantageously be or comprise an expansion valve. Alternatively or additionally, the expansion device may be or comprise a fixed orifice, a capillary tube and/or any other suitable kind of expansion device.

The compressor may be a single compressor operating at a fixed speed or at variable speed. Alternatively, the compressor may be in the form of two or more compressors arranged fluidly in parallel, e.g. in a compressor rack.

The evaporator may be a single evaporator having a single evaporator coil, or having two or more evaporator coils arranged fluidly in parallel. Alternatively, the evaporator may be in the form of two or more evaporators arranged fluidly in parallel, and each comprising one or more evaporator coils.

The method of the invention comprises the step of obtaining values of an entity being indicative of a current distribution of liquid refrigerant of the evaporator system. In the present context the term 'current distribution of liquid refrigerant' should be interpreted to mean an immediately occurring distribution of liquid refrigerant along the refrigerant path and among the various components of the vapour compression system. Accordingly, the entity being obtained is an entity or a parameter which provides information about this distribution, and each obtained value represents the distribution of liquid refrigerant of the vapour compression system at the time where the value was obtained.

The values may be obtained by direct measurement. Alternatively, they may be obtained in a more indirect manner, e.g. by measuring values of another parameter or entity and obtain the desired values by means of calculations and/or look-up tables.

The method further comprises the step of comparing the obtained values to a predefined threshold value. The threshold value may advantageously be a value which defines a boundary between two regulating regimes. Accordingly, comparing the obtained values to the predefined threshold value gives an indication of which regulating strategy it would be most appropriate to use. The threshold value may advantageously correspond to a distribution of liquid refrigerant of the vapour compression system which defines a boundary between such two regulating regimes.

In the case that the comparing step reveals that the obtained values are below the threshold value, the method comprises the step of obtaining control parameter values being indicative of the amount of liquid refrigerant present in the condenser. The operation of the vapour compression system is then controlled in accordance with the obtained control parameter values and in such a manner that the amount of liquid refrigerant in the condenser is maintained at a substantially constant level. Thus, under these conditions, the vapour compression system is operated in such a manner that the amount of liquid refrigerant in the condenser is not allowed to change significantly. In particular, the amount of liquid refrigerant in the condenser is not allowed to drop to a level which is so low that there is a risk that the condenser 'runs dry'. Thereby flash gas in the vapour compression system is avoided when this control strategy is used. However, using this control strategy has the side effect that the potential capacity of the evaporator may not be utilised to the full extent, and that the overall efficiency of the vapour compression system is therefore reduced as compared to the situation where the vapour compression system is operated on the basis of a minimum superheat control strategy.

The control parameter values may be direct measurements of the amount of liquid present in the condenser. Alternatively, they may be values of another parameter which is merely a measure for or an indication of the amount of liquid refrigerant present in the condenser. This will be explained in further detail below.

Since the control strategy described above may potentially lead to the vapour compression system being operated in a less than optimal manner, it is an advantage that it is possible to use this control strategy only when the distribution of liquid refrigerant of the vapour compression system is such that the obtained values of the entity being indicative of this distribution falls below the threshold value.

When a vapour compression system is operated at a relatively high vapour compression capacity, the amount of liquid refrigerant present on the 'hot' side of the vapour compression circuit tends to be larger than is the case when the vapour compression system is operated at a relatively low vapour compression capacity. This is partly caused by the fact that liquid refrigerant takes up less space in the evaporator under these circumstances, thereby 'pushing' more liquid refrigerant towards the 'hot' side. Accordingly, when the vapour compression system is operated at a relatively high vapour compression capacity, the distribution of liquid refrigerant of the vapour compression system tends to be relatively uneven.

The step of obtaining control parameter values may comprise obtaining the subcooling of refrigerant entering the expansion device. The subcooling is the difference between the temperature of the refrigerant entering the expansion device, effectively the temperature of the refrigerant leaving the condenser, and the dewpoint of the refrigerant. If the subcooling is very small, the temperature of the refrigerant leaving the condenser is very close to the dewpoint, and this is an indication that the amount of liquid refrigerant in the condenser is very small. On the other hand, if the subcooling is somewhat larger, the temperature of the refrigerant leaving the condenser is well below the dewpoint of the refrigerant, and this is an indication that a relatively high amount of liquid refrigerant is present in the condenser, and that the condenser is therefore not operated in an optimal manner. The subcooling may, e.g., be obtained by measuring the temperature and the pressure of the refrigerant entering the expansion device. According to this embodiment, the operation of the vapour compression system is controlled on the basis of the subcooling of refrigerant leaving the condenser and entering the expansion device, when distribution of liquid refrigerant of the vapour compression system is such that the obtained values of the entity being indicative of the distribution is below the threshold value.

Alternatively or additionally, the expansion device may comprise an expansion valve, and the step of obtaining control parameter values may comprise obtaining values of an opening degree of the expansion valve. The opening degree of the expansion valve provides a measure for the present vapour compression capacity of the vapour compression system. Thereby the opening degree of the expansion valve provides an indirect measure for the amount of liquid refrigerant present in the condenser.

The compressor of the vapour compression system may be a variable capacity compressor, and the step of obtaining control parameter values may comprise measuring the capacity of the variable capacity compressor. The capacity of the compressor also provides a measure for the present vapour compression capacity of the vapour compression system, thereby providing an indirect measure for the amount of liquid refrigerant present in the condenser. The variable capacity compressor may, e.g., be in the form of a variable speed compressor, in which case the capacity may be measured by measuring the speed of the variable speed compressor. Alternatively, the variable capacity compressor may be in the form of a step compressor, in which case the capacity may be measured by determining how many steps are on and how many steps are off.

According to one embodiment, the substantially constant level of the amount of liquid refrigerant in the condenser may be sufficiently high to allow subcooled refrigerant to be present at an outlet of the condenser. Thereby it is ensured that the amount of liquid refrigerant in the condenser is not allowed to be reduced to a level where gaseous refrigerant is allowed to pass through the condenser, and thereby flash gas in the vapour compression system is efficiently prevented.

The method may further comprise the step of:

- in the case that the obtained values are above said threshold value, obtaining values of the superheat (SH) of the vapour compression system and controlling operation of the vapour compression system in such a manner that a minimal superheat (SH) is obtained.

According to this embodiment, the threshold value represents a boundary between operating conditions in which there is a risk that flash gas may occur in the vapour compression system, and operating conditions where this is not the case. When the obtained values are below the threshold value, it is an indication that the distribution of liquid refrigerant in the vapour compression system is uneven, and that the amount of liquid refrigerant in the condenser is so low that there is a risk of flash gas in the vapour compression system. In this case the vapour compression system is operated in order to maintain a substantially constant level of liquid refrigerant in the condenser as described above, i.e. the vapour compression system is operated in a manner which prevents flash gas from occurring. On the other hand, in the case that the obtained values are above the threshold value, it is an indication that the distribution of liquid refrigerant in the vapour compression system is acceptable, and that there is no immediate risk of flash gas in the vapour compression system. In this situation, the vapour compression system is therefore operated on the basis of the superheat of the vapour compression system, and in such a manner that a minimal superheat is obtained. Thus, the vapour compression system is, under these circumstances, operated in order to utilise the potential capacity of the vapour compression system to the greatest possible extent.

The method may further comprise the steps of:

- monitoring and/or storing results of the step of comparing the obtained values to a predefined threshold value, and

- using said monitored and/or stored results for diagnostic purposes of the vapour compression system.

The results of the step of comparing the obtained values to a predefined threshold value provides information regarding how often and for how long the vapour compression system is in the region where there is a risk of flash gas in the vapour compression system. If it turns out that the vapour compression system is relatively often, and/or for a major part of the total operating time of the vapour compression system, in such a region it may be an indication that the refrigerant charge of the vapour compression system is incorrect or inappropriate for the actual operating conditions. This may simply be because a wrong charge has initially been applied to the system. However, it may also be due to a leak, and it may therefore be an indication that replenishment is required. Similarly, if it turns out that the obtained values are above the threshold value for most of the time, then it may be an indication that the charge of refrigerant of the vapour compression system is too high, and that it should be lowered in order to allow the vapour compression system to be operated in an optimal manner.

Thus, the method may further comprise the step of determining whether or not the refrigerant charge of the vapour compression system is optimal for the actual operating conditions. In this case the method may even further comprise the step of adjusting the refrigerant charge of the vapour compression system in the case that it is determined that the current refrigerant charge is non-optimal. As described above, this may include reducing the charge as well as replenishing the charge.

The step of obtaining values of an entity may comprise obtaining values of an entity being indicative of a current vapour compression capacity of the vapour compression system. This may, e.g., include obtaining values of the opening degree of an expansion valve or values of the capacity of a variable capacity compressor. As described above, these entities provide measures for the present vapour compression capacity of the vapour compression system, thereby providing measures for the amount of liquid refrigerant in the condenser. Accordingly, these entities provide information regarding the distribution of liquid refrigerant in the vapour compression system.

Alternatively or additionally, the step of obtaining values of an entity may comprise obtaining values of an entity being indicative of the subcooling of refrigerant entering the expansion device. As described above, the subcooling of refrigerant entering the expansion device provides information regarding the state of the refrigerant leaving the condenser. If the subcooling approaches zero there is a risk of flash gas in the vapour compression system, and the system should therefore be operated in order to avoid this. In this case the threshold value may advantageously represent a subcooling level which the subcooling should not be allowed to fall below.

According to a second aspect the invention provides a method for verifying a charge of refrigerant in a vapour compression system, the vapour compression system comprising a compressor, a condenser, an expansion device and an evaporator arranged in a refrigerant path, the method comprising the steps of:

- determining an initial refrigerant charge in the refrigerant path of the vapour compression system,

- operating the vapour compression system to change the distribution of liquid refrigerant of the vapour compression system until a predefined distribution is reached,

- based on said operating step, determining whether or not the initial refrigerant charge is optimal for the given operating conditions, and

- adjusting the refrigerant charge in the case that it is determined that the initial refrigerant charge is not optimal for the given operating conditions.

The vapour compression system may, e.g., be a refrigeration system, an air condition system or a heat pump. The compressor may be a single compressor of fixed speed or variable speed, or it may be two or more compressors arranged in a compressor rack.

According to the method of the second aspect of the invention an initial refrigerant charge in the refrigerant path of the vapour compression system is initially determined. The initial refrigerant charge is the charge which is actually in the refrigerant path when the procedure is started. Then the vapour compression system is operated in such a manner that the distribution of liquid refrigerant of the vapour compression system is changed. The vapour compression system is operated in this manner until a predefined distribution is reached. The predefined distribution may advantageously be a distribution corresponding to the threshold value described above with reference to the first aspect of the invention, and it may advantageously define a boundary between two control strategy regimes. Thereby the vapour compression system is operated in such a manner that the distribution of liquid refrigerant of the vapour compression system is forced into a state where another control strategy must be used for controlling operation of the vapour compression system.

Based on this process it is determined whether or not the initial refrigerant charge is optimal for the given operating conditions. This may, e.g., include observing when or how fast the predetermined distribution of liquid refrigerant is reached. For instance, if the predetermined distribution is reached almost instantaneously, it may be an indication that a situation with insufficient liquid refrigerant in the condenser is likely to occur under normal operating conditions, and that the refrigerant charge of the vapour compression system is therefore too low. On the other hand, if it turns out to be difficult to operate the vapour compression system in such a manner that the predetermined distribution of liquid refrigerant is reached, then it may be an indication that the refrigerant charge of the vapour compression system is too high.

Finally, in the case that it is determined that the initial refrigerant charge is not optimal for the given operating conditions, the refrigerant charge is adjusted in order to obtain a refrigerant charge which is optimal, or at least more suitable, for the given operating conditions.

Thus, according to the method of the second aspect of the invention, the refrigerant charge is tested against the given operating conditions and possibly adjusted if it turns out that the original refrigerant charge is not optimal for the given operating conditions. Thereby the refrigerant charge of the vapour compression system can be optimised, and it can be ensured that the vapour compression system is operated in a manner which is as optimal as possible.

Ideally, the refrigerant charge applied to the vapour compression system should be such that the vapour compression system is operated optimally under operating conditions which are expected to occur during a major part of the operating time.

Furthermore, similar to the first aspect of the invention, the method of the second aspect of the invention uses the fact that the distribution of liquid refrigerant of the vapour compression system provides information about how efficiently the vapour compression system is operated, as well as information regarding the risk of flash gas in the vapour compression system.

The method may further comprise the step of recursively repeating the steps of determining the initial charge, operating the vapour compression system, determining whether the initial charge is optimal and adjusting the charge, thereby recursively optimising the refrigerant charge of the vapour compression system. According to this embodiment, the refrigerant charge is gradually and recursively adjusted until it is optimal for the given operating conditions. Furthermore, in the case that the operating conditions are changed over time, such changes can be taken into account, and the refrigerant charge can be adjusted in accordance with the changed operating conditions.

The step of operating the vapour compression system may comprise decreasing the subcooling of refrigerant entering the expansion device until a predefined subcooling level is reached. The predefined subcooling level may, e.g., be a level which is close to zero, indicating that there is a risk that gaseous refrigerant is passed through the condenser, i.e. that there is a risk of flash gas in the vapour compression system. As described above, the subcooling level provides information about the amount of liquid refrigerant present in the condenser, and thereby about the distribution of liquid refrigerant of the vapour compression system. Operating the vapour compression system in such a manner that the subcooling is changed therefore corresponds to operating the vapour compression system in such a manner that the distribution of liquid refrigerant of the vapour compression system is changed.

The step of operating the vapour compression system may comprise increasing or decreasing a secondary fluid flow across the evaporator. In the case that the secondary fluid flow is a flow of air, this may be obtained by increasing or decreasing the rotational speed of a fan arranged in the flow path of the secondary fluid flow, e.g. immediately adjacent to the evaporator. Such a fan may blow or push air across the evaporator. Increasing the secondary fluid flow across the evaporator causes the heat transfer of the evaporator to increase, thereby causing the evaporator to evaporate a larger amount of refrigerant, thereby changing the distribution of liquid refrigerant of the vapour compression system. Similarly, decreasing the secondary fluid flow across the evaporator causes the heat transfer of the evaporator to decrease, thereby causing the evaporator to evaporate a smaller amount of refrigerant, thereby changing the distribution of liquid refrigerant of the vapour compression system.

The compressor may be a variable capacity compressor, such as a variable speed compressor or a step compressor, e.g. in the form of two or more compressors arranged in a compressor rack. In this case the step of operating the vapour compression system may comprise increasing or decreasing the capacity of the variable capacity compressor. Increasing the compressor capacity causes more refrigerant to be supplied to the condenser, thereby increasing the subcooling. Similarly, decreasing the compressor capacity causes less refrigerant to be supplied to the condenser, thereby decreasing the subcooling.

The method may further comprise the step of applying the initial charge to the refrigerant path of the vapour compression system. According to this embodiment, the method may advantageously be performed by personnel who initially apply the refrigerant charge to the system, immediately after the refrigerant charge has been applied. Thereby it is ensued that a correct charge is applied. Alternatively or additionally, the method may be performed on vapour compression systems which are already operating, thereby investigating whether or not the refrigerant charge applied to such a system is correct or optimal.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in further detail with reference to the accompanying drawings in which

Fig. 1 is a schematic diagram of a vapour compression system with low refrigeration capacity,

Fig. 2 is a schematic diagram of a vapour compression system with high refrigeration capacity, and

Fig. 3 is a flow diagram illustrating a method according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram of a vapour compression system 1 comprising a compressor 2, a condenser 3, an expansion valve 4 and an evaporator 5 arranged fluidly connected in a refrigerant path. In Fig. 1 the vapour compression system 1 is in a state with relatively low vapour compression capacity. Thus, it can be seen that in the condenser 3 as well as in the evaporator 5 liquid refrigerant 6 as well a gaseous refrigerant 7 is present almost throughout the entire condenser 3/evaporator 5, and a balanced distribution of liquid refrigerant of the vapour compression system 1 is present. Thereby the heat exchanging capacity of the condenser 3 as well as the evaporator 5 is utilised to the greatest possible extent, and the vapour compression system 1 is operated in an optimal manner.

The amount of liquid refrigerant 6 in the condenser 3 further indicates that the subcooling of refrigerant entering the expansion valve 4 is low. Thus, if the distribution of liquid refrigerant of the vapour compression system 1 is changed in such a manner that less liquid refrigerant 6 is present in the condenser 3, then there is a risk of flash gas in the vapour compression system 1. Accordingly, the vapour compression system 1 of Fig. 1 should be operated in such a manner that the subcooling of the refrigerant entering the expansion valve 4 is maintained at a substantially constant level, thereby preventing flash gas in the vapour compression system 1.

Fig. 2 is a schematic view of the vapour compression system of Fig. 1. However, in Fig. 2 the vapour compression system 1 is in a state with relatively high vapour compression capacity. It is clear that the distribution of liquid refrigerant 6 of the vapour compression system 1 differs from the distribution shown in Fig. 1. Thus, in Fig. 2 a relatively large amount of liquid refrigerant 6 is present in the condenser 3, and a relatively large amount of gaseous refrigerant 7 is present in the evaporator 5. Accordingly, the potential heat exchanging capacity of the condenser 3 and of the evaporator 5 are not utilised to the full extent.

The large amount of liquid refrigerant 6 in the condenser 3 indicates that the subcooling of refrigerant entering the expansion valve 4 is relatively high, and that the risk of flash gas in the vapour compression system 1 is negligible. Accordingly, the vapour compression system 1 of Fig. 2 should be operated in such a manner that the vapour compression capacity of the vapour compression system 1 is utilised to the greatest possible extent. This can, e.g., be obtained by operating the vapour compression system 1 based on the superheat of the refrigerant leaving the evaporator 5.

Fig. 3 is a flow diagram illustrating a method for operating a vapour compression system in accordance with an embodiment of the invention. The vapour compression system may be the one shown in Figs. 1 and 2. The process is started at step 8. At step 9 the subcooling (SC) of refrigerant entering the expansion valve is measured. The measured subcooling value (SC) is then compared to a threshold value, SC_{thres}, at step 10. The threshold value may advantageously be a subcooling value which represents a level of liquid refrigerant in the condenser which prevents flash gas in the vapour compression system.

In the case that the measured subcooling value is below the threshold value, the process is moved to step 11, and the vapour compression system is operated on the basis of the subcooling of the refrigerant entering the expansion valve. More particularly, the vapour compression system is operated in such a manner that a substantially constant subcooling level is maintained, preferably a level which is at or near the threshold value. Thus, in this case the vapour compression system is operated in such a manner that it is ensured that there is no flash gas in the vapour compression system. However, this will most likely have the consequence that the superheat of the refrigerant leaving the evaporator is slightly higher than desired, and that the evaporator is therefore not operated in an optimal manner.

In the case that the comparison performed at step 10 reveals that the measured subcooling value is above the threshold value, the process is moved to step 12, and the vapour compression system is operated on the basis of the superheat of the refrigerant leaving the evaporator. When the measured subcooling value is above the threshold value, it can be assumed that the amount of liquid refrigerant in the condenser is sufficient to ensure that there is no flash gas in the vapour compression system, even if the distribution of liquid refrigerant of the vapour compression system is varied slightly. Accordingly, it is not necessary to control operation of the vapour compression system in a manner which specifically prevents flash gas in the vapour compression system, and another control strategy, taking other issues into consideration, may be used instead. In the embodiment illustrated in Fig. 3 a control strategy based on the superheat of the refrigerant leaving the evaporator is used. The vapour compression system may advantageously be controlled in such a manner that a low, but positive, superheat value is obtained, thereby ensuring that the potential capacity of the evaporator is utilised to the greatest possible extent.

From steps 11 and 12 the process is returned to step 9, i.e. the subcooling is measured and the measured value is once again compared to the threshold value, SC_{thres}, in order to determine which control strategy it is most appropriate to use.

Thus, controlling operation of the vapour compression system in accordance with the method illustrated in Fig. 3, it is ensured that the vapour compression system is operated in as optimal a manner as possible, while preventing flash gas in the vapour compression system.

CLAIMS

1. A method for controlling operation of a vapour compression system (1), the vapour compression system (1) comprising a compressor (2), a condenser (3), an expansion device (4) and an evaporator (5) arranged in a refrigerant path, the method comprising the steps of:

- obtaining values of an entity being indicative of a current distribution of liquid refrigerant of the vapour compression system (1),
- comparing the obtained values to a predefined threshold value,
- in the case that the obtained values are below said threshold value, obtaining control parameter values being indicative of the amount of liquid refrigerant present in the condenser (3), and controlling operation of the vapour compression system (1) in accordance with the obtained control parameter values and in such a manner that the amount of liquid refrigerant in the condenser (3) is maintained at a substantially constant level.

2. A method according to claim 1, wherein the step of obtaining control parameter values comprises obtaining the subcooling of refrigerant entering the expansion device (4).

3. A method according to claim 1 or 2, wherein the expansion device comprises an expansion valve (4), and wherein the step of obtaining control parameter values comprises obtaining values of an opening degree of the expansion valve (4).

4. A method according to any of the preceding claims, wherein the compressor (2) of the vapour compression system (1) is a variable capacity compressor, and wherein the step of obtaining control parameter values comprises measuring the capacity of the variable capacity compressor.

5. A method according to any of the preceding claims, wherein the substantially constant level of the amount of liquid refrigerant in the condenser (3) is sufficiently high to allow subcooled refrigerant to be present at an outlet of the condenser (3).

6. A method according to any of the preceding claims, further comprising the step of:

- in the case that the obtained values are above said threshold value, obtaining values of the superheat (SH) of the vapour compression system (1) and controlling operation of the vapour compression system (1) in such a manner that a minimal superheat (SH) is obtained.

7. A method according to any of the preceding claims, further comprising the steps of:

- monitoring and/or storing results of the step of comparing the obtained values to a predefined threshold value, and

- using said monitored and/or stored results for diagnostic purposes of the vapour compression system (1).

8. A method according to claim 7, further comprising the step of determining whether or not the refrigerant charge of the vapour compression system (1) is optimal for the actual operating conditions.

9. A method according to claim 8, further comprising the step of adjusting the refrigerant charge of the vapour compression system (1) in the case that it is determined that the current refrigerant charge is non-optimal.

10. A method according to any of the preceding claims, wherein the step of obtaining values of an entity comprises obtaining values of an entity being

indicative of a current vapour compression capacity of the vapour compression system (1).

11. A method according to any of the preceding claims, wherein the step of obtaining values of an entity comprises obtaining values of an entity being indicative of the subcooling of refrigerant entering the expansion device (4).

12. A method for verifying a charge of refrigerant in a vapour compression system (1), the vapour compression system (1) comprising a compressor (2), a condenser (3), an expansion device (4) and an evaporator (5) arranged in a refrigerant path, the method comprising the steps of:

- determining an initial refrigerant charge in the refrigerant path of the vapour compression system (1),

- operating the vapour compression system (1) to change the distribution of liquid refrigerant of the vapour compression system (1) until a predefined distribution is reached,

- based on said operating step, determining whether or not the initial refrigerant charge is optimal for the given operating conditions, and

- adjusting the refrigerant charge in the case that it is determined that the initial refrigerant charge is not optimal for the given operating conditions.

13. A method according to claim 12, further comprising the step of recursively repeating the steps of determining the initial charge, operating the vapour compression system (1), determining whether the initial charge is optimal and adjusting the charge, thereby recursively optimising the refrigerant charge of the vapour compression system (1).

14. A method according to claim 12 or 13, wherein the step of operating the vapour compression system (1) comprises decreasing the subcooling of

refrigerant entering the expansion device (4) until a predefined subcooling level is reached.

15. A method according to any of claims 12-14, wherein the step of operating the vapour compression system (1) comprises increasing or decreasing a secondary fluid flow across the evaporator (5).

16. A method according to any of claims 12-15, wherein the compressor (2) is a variable capacity compressor, and wherein the step of operating the vapour compression system (1) comprises increasing or decreasing the capacity of the variable capacity compressor.

17. A method according to any of claims 12-16, further comprising the step of applying the initial charge to the refrigerant path of the vapour compression system (1).

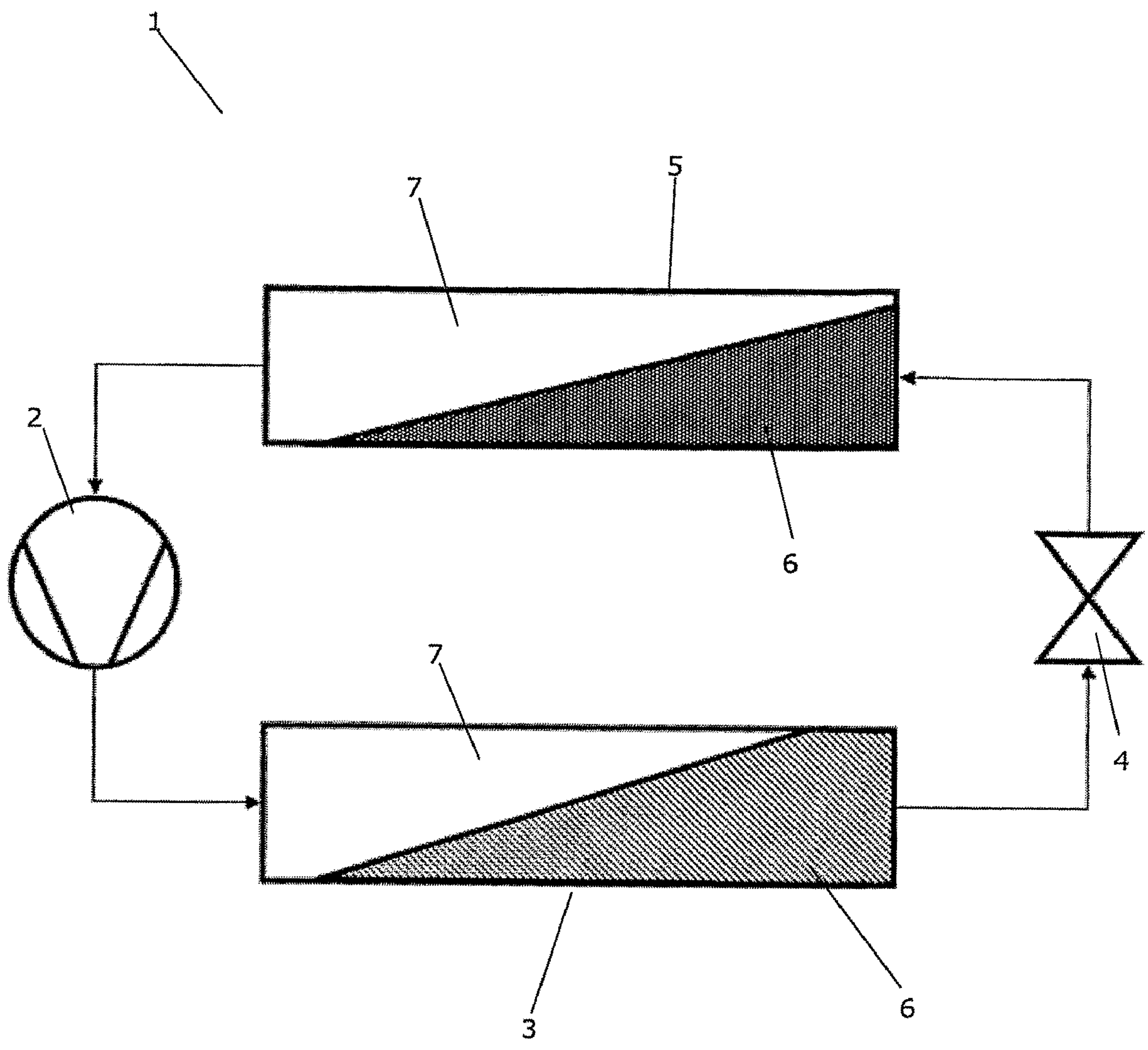

Fig. 1

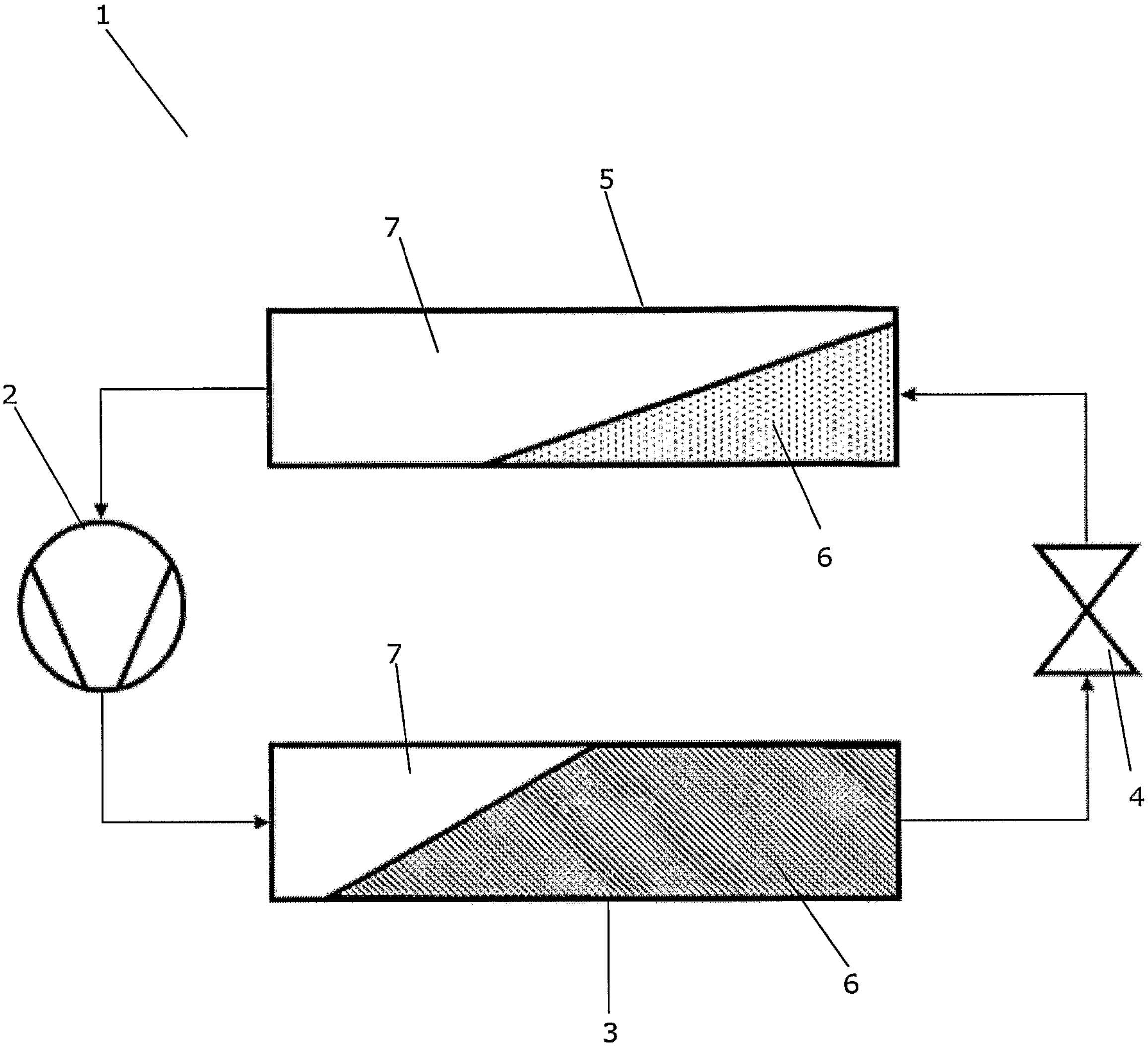

Fig. 2

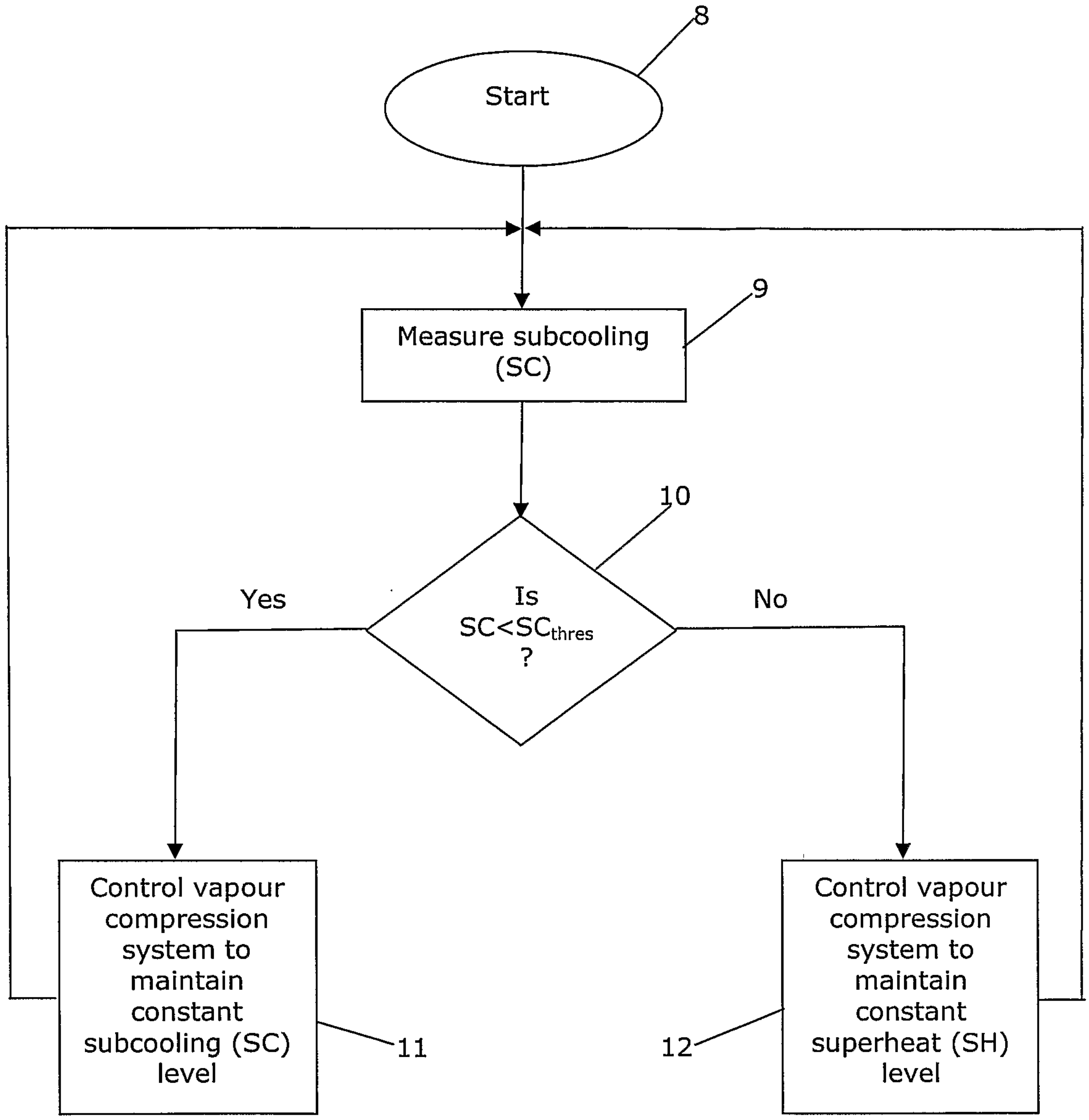
8
Start
9
Measure subcooling (SC)
10
Is SC<SCthres ?
Yes
No
Control vapour compression system to maintain constant subcooling (SC) level
11
12
Control vapour compression system to maintain constant superheat (SH) level

Fig. 3