SYSTEM PERFORMANCE CORRECTION BY MODIFYING REFRIGERANT COMPOSITION IN A REFRIGERANT SYSTEM

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ABSTRACT

An adequate operation and performance of a refrigerant system includes the steps of adding a refrigerant that is different from the original refrigerant, into the refrigerant system should any operational problems be observed during operation of the refrigerant system. As an example, should the refrigerant system be cycling frequently, a lower pressure refrigerant may be added or replace, partially or fully, the refrigerant the system being initially charged with. By making this change, the present invention can, for example, lower the provided system capacity, and hence reduce the amount of cycling. Additionally, conditioned space comfort and system reliability would be improved. Further, changes over time, such as the degradation of the heat exchanger performance, and their negative effect on system operation can be alleviated by such a refrigerant substitution.
OPERATE WITH EXISTING REFRIGERANT

DOES PORTION OF EXISTING REFRIGERANT NEED TO BE REMOVED?

NO

YES

REMOVE PORTION OF EXISTING REFRIGERANT

NO

NO

ADEQUATE OPERATION TEST OK?

YES

CONTINUE OPERATION WITH EXISTING REFRIGERANT

ADD NEW REFRIGERANT OR REFRIGERANT MIXTURE?

NO

YES

ADD NEW REFRIGERANT OR REFRIGERANT MIXTURE

FIG. 1

FIG. 2
SYSTEM PERFORMANCE CORRECTION BY MODIFYING REFRIGERANT COMPOSITION IN A REFRIGERANT SYSTEM

BACKGROUND OF THE INVENTION

[0001] This invention relates to correcting system performance of a refrigerant system by modifying the refrigerant composition in the refrigerant system.

[0002] Refrigerant systems are employed to change the temperature and/or humidity of a secondary fluid. One common example is an air conditioning or heat pump system, which is utilized to condition air to be delivered into an indoor environment. Another example is a chiller system delivering chilled water or glycol solution for cooling purposes.

[0003] As known, a typical vapor compression refrigerant system includes a compressor for compressing a refrigerant, a condenser downstream of the compressor, an expansion device downstream of the condenser, and an evaporator downstream of the expansion device. Refrigerant circulates between these four basic components, and a number of other optional components and sub-circuits.

[0004] One control feature that is often incorporated into a refrigerant system is the ability to, or temporarily turn off the compressor. This control feature is normally included into at least one of the refrigerant circuits of the refrigerant system, should a refrigerant system be delivering more capacity than is necessary. Such cycling is inefficient, presents a discomfort to occupants of the conditioned space, and can also cause reliability issues such as oil pump-out from the compressor oil sump. Therefore it would be desirable to reduce the amount of cycling. Further, cycling can result in temperature and humidity variations in the conditioned space that are dependent upon the frequency of cycling and duration of an off-cycle. This problem is further aggravated by a frequent requirement of continuous indoor fan operation such that, during the compressor off-cycle, moisture is accumulated on the evaporator external surfaces and is re-evaporated into the airstream supplied to the conditioned space. It is often the case that once a refrigerant system is installed at a specific location, it is later determined that the system is over-specified and excess capacity has been provided. Such systems will cycle frequently, which, as explained above, is undesirable.

[0005] Further, as the unit ages, its performance may begin to deteriorate. Examples of conditions that can lead to the reduced performance would include (but are not limited to) damaged, corroded or clogged condenser, and/or evaporator, external or internal surfaces. Again, this can cause the unit to “trip” or cycle, and can otherwise degrade performance.

[0006] Traditionally, once a system is in the field, the only change to the refrigerant cycle would be the addition or removal of a refrigerant charge using the same refrigerant. However, this provides only a limited change or benefit to the unit operational characteristics (normally, the allowed refrigerant charge amount would not affect the unit capacity by more than 5% by slightly varying the amount of subcooling leaving the condenser coil). In addition, changes in the refrigerant charge level can result in component malfunction problems or operation outside of functional specification.

SUMMARY OF THE INVENTION

[0007] In a disclosed embodiment of this invention, it is proposed to partially or fully charge a refrigerant system with a distinct new refrigerant should any of the above, or similar problems be detected, while the old refrigerant is either fully removed or partially removed/added into the system. The distinct new refrigerant should have different characteristics that in particular would result in the identified problems being addressed.

[0008] As one example, should excess unit delivered capacity be identified, a partial or complete changeover could occur from a typically higher pressure refrigerant to a lower pressure refrigerant (a high pressure refrigerant is broadly defined as a refrigerant that has a higher pressure than a low pressure refrigerant for the same saturation temperature). This typically would then result in lower unit capacity, and would reduce the amount of cycling.

[0009] In such circumstances, the agency qualification (such as UL, CSA, etc.) for the system would typically be automatically granted, and need not be redone. This should be true since the refrigerant system, and its compressor, will be operating at a lower pressure and lower current, should a higher pressure refrigerant be replaced with a lower pressure refrigerant. Thus, unit cycling losses can be substantially reduced, system reliability enhanced and comfort in the conditioned space significantly improved. By reducing cycling, the present invention will address all these concerns. The refrigerant addition can also be made on an iterative basis, where the unit performance is checked after a new refrigerant has been added to the system and a portion of the old refrigerant is removed (if necessary). If the system performance still remains unsatisfactory, then an additional amount of the new refrigerant is added to the system. As the new refrigerant is added, it may also be desirable to remove, add or maintain the same level of the old refrigerant in the system.

[0010] For instance, under some circumstances, it would be also beneficial to add a small amount of another substance that is compatible with the existing refrigerant to make the refrigerant less flammable. This situation may arise, for example, when refrigerant in some of the systems is a mixture of several pure refrigerant components. As a system refrigerant leak develops, some of the refrigerant components in the mixture can leak more than the others. Thus over time, it might be possible for the remaining mixture to have a different composition than the original mixture. Therefore in case of leakage, it may become necessary to replenish the system with a specific refrigerant component of the mixture to achieve the same refrigerant mixture composition as before the leakage has occurred. This becomes especially important, if the leakage of a particular refrigerant fraction caused the refrigerant mixture to become more flammable.

[0011] It is also possible that under some circumstances and for some installations, that the existing refrigerant mixture needs to be made less flammable. In this case, the refrigerant mixture can be made less flammable by adding another substance (refrigerant or compound) that is different than the original refrigerant mixture.

[0012] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 is a schematic view of a refrigerant system.

[0014] FIG. 2 is a flow chart of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] As shown in FIG. 1, a refrigerant system 20 includes a compressor 22 compressing a refrigerant and delivering it
downstream to a condenser 24. Refrigerant passes from the condenser 24 to an expansion device 26, and then to an evaporator 28. As is known, the condenser in a conventional air conditioning system is typically located outdoors, and delivers heat to the ambient environment. The evaporator is typically positioned indoors, and conditions air to be delivered into a building. As also known, refrigerant circuity between the four basic components, 22, 24, 26 and 28 interconnected in a closed-loop arrangement. Many other subsystems and components are often included in refrigerant systems. However, for purposes of explaining this invention, all that is necessary is to understand the basic refrigerant system schematic and operation.

When it has been determined that the refrigerant system 20 is operating less than optimally, a decision can be made to partially or fully change the refrigerant. In a disclosed embodiment of this invention, it is proposed to partially or fully charge a refrigerant system with a new distinct refrigerant or substance, and either partially or fully remove the old refrigerant should any of the abovementioned problems be determined. The distinct refrigerant or substance should have different thermo-physical properties and characteristics that in particular would result in the identified problems being addressed. In most cases, changing to a lower pressure refrigerant is desirable.

As one major example, should reduced capacity be desired, a partial or full changeover could occur typically from a higher pressure refrigerant to a lower pressure refrigerant. This would then result in lower capacity, and would reduce the amount of cycling.

As one example, by changing from R410A refrigerant to R407C refrigerant, it would be possible to reduce unit capacity up to 30%. Smaller unit capacity reduction would be expected if the R410A refrigerant were only partially replaced by the R407C refrigerant. Unit cycling losses can be substantially reduced, system reliability enhanced and comfort in the conditioned space significantly improved.

In some cases, when the adjustments to the refrigerant mixture are made, the unit efficiency may increase because the heat exchanger coils would effectively become “oversized” when a change to a lower pressure refrigerant is made. This would be due to a difference in thermo-physical properties of the various refrigerants. The oversizing effect can be especially important if the coils are substantially damaged, “aged” or clogged, as mentioned above. In this case, by using a lower pressure refrigerant, the compressor loading and compressor discharge pressure can typically be reduced. Further, unit cycling on a high-pressure switch can be avoided if the clogged condenser coil was the cause of this problem.

For example, the refrigerant additions can be made to/from the R410A refrigerant from/to any of the R407C, R22, R134a, or R404A refrigerants. Also, the additions can be done to/from the R404A refrigerant from/to any of the R407C, R22, or R134a refrigerants. Also, the R407C refrigerant can be replaced partially or completely by the R22, or R134a refrigerants. Lastly, the additions can be performed to/from the R22 from/to R134a refrigerant. Of course, these examples don’t cover a wide spectrum of available refrigerants and substances, and other combinations are possible. As an example, other pure refrigerants that would fail within the scope of this invention may include (but are not limited to): R-11, R-113, R-115, R-116, R-12, R-123, R-124, R-125, R-13, R-142b, R-143a, R-152a, R-227ea, R-23, R-236fa, R-245ca, R-245fa, R-32, R-41, Propane, Butane, Isobutane, ammonia, propylene, and carbon dioxide. Also, examples of the suitable refrigerant mixtures are listed below: R-401a, R-401b, R-401c, R-402a, R-402b, R-407a, R-407b, R-407d, R-408a, R-409a, R-409b, R-410b, R-500, R-501, R-507a, R-32/R-125, R-22/isobutane/R-142b, and ammonia/butane.

It should be noted that for most refrigerants, the removal or addition would be relatively straightforward, since the system components, such as the compressors, heat exchangers and even expansion devices may handle the refrigerant additions without any modification. For most systems, it will often not even be necessary to use different compressor oil, since the same oil is compatible with many refrigerants.

It also has to be noted that although a single-circuit refrigerant system configuration was described, multi-circuit arrangements are also feasible.

Although a preferred embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.

1. A method of operational maintenance for a refrigerant system comprising the steps of:
   (1) providing a refrigerant system having a compressor for compressing a first refrigerant, delivering that refrigerant to a first heat exchanger, then to an expansion device, and then to a second heat exchanger, the refrigerant returning from the second heat exchanger to the compressor;
   (2) operating the refrigerant system and monitoring the operation of the refrigerant system;
   (3) adding a distinct substance into the refrigerant should the monitoring of step (2) indicate that a distinct substance can assist in elimination of operational concerns.

2. The method as set forth in claim 1, wherein the said distinct substance has a different composition than said first refrigerant.
3. (canceled)

4. The method as set forth in claim 3, wherein said second refrigerant is a pure refrigerant.
5. (canceled)

6. The method as set forth in claim 3, wherein the second refrigerant is operable at a lower pressure than the first refrigerant.
7-10. (canceled)
11. The method as set forth in claim 1, wherein a portion of said first refrigerant is removed or added to the system.
12. The method as set forth in claim 1, wherein a portion of said first refrigerant is not removed and not added to the system.
13. The method as set forth in claim 1, wherein the said distinct substance replaces a portion of the first refrigerant.
14. The method as set forth in claim 1, wherein one of the concerns monitored in step (2) would be a high amount of cycling of the refrigerant system between on and off states.
15. The method as set forth in claim 1, wherein one of the concerns monitored in step (2) would be a flammability of said first refrigerant.
16. The method as set forth in claim 1, wherein one of the concerns monitored in step (2) would be whether at least one of the refrigerant system heat exchangers has degraded in any manner.
17-18. (canceled)
19. The method as set forth in claim 1, wherein one of the concerns monitored in step (2) would be whether performance of said compressor has degraded in any manner.

20. A refrigerant system comprising:
   a compressor for compressing refrigerant, delivering the first refrigerant to a first heat exchanger, then to an expansion device, then to a second heat exchanger, with the refrigerant returning from the second heat exchanger to the compressor, and the refrigerant system being initially charged with a first refrigerant; and
   a second refrigerant added to the system, said second refrigerant being operable at a lower pressure than the first refrigerant the system being initially charged with.

21. The refrigerant system as set forth in claim 20, wherein the first refrigerant is R410A and the second refrigerant is any one of R407C, R22, R134a, and R404A.

22. The refrigerant system as set forth in claim 20, wherein the first refrigerant is R404A and the second refrigerant is any one of R407C, R22, and R134a.

23. The refrigerant system as set forth in claim 20, wherein the first refrigerant is R407C and the second refrigerant is any one of R22 and R134a.

24. The refrigerant system as set forth in claim 20, wherein the first refrigerant is R22 and the second refrigerant is R134a.

25. The refrigerant system as set forth in claim 20, wherein said second refrigerant is a pure refrigerant.

26. The refrigerant system as set forth in claim 20, wherein said second refrigerant is a refrigerant mixture.

27. The refrigerant system as set forth in claim 20, wherein said first refrigerant is a refrigerant mixture.

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