CLAIMS

What is claimed is:

1. A method of raising the maximum feasible condenser operating temperature in a high temperature heat pump apparatus comprising charging the high temperature heat pump with a working fluid comprising Z-1,1,1,4,4,4-hexafluoro-2-butene, wherein the maximum feasible condenser operating temperature is raised to a temperature greater than about 120°C.

2. A composition comprising: (a) Z-1,1,1,4,4,4-hexafluoro-2-butene; (b) 2-chloropropane; and (c) at least one lubricant suitable for use at a temperature of at least about 150°C; wherein the 2-chloropropane is present in an amount effective to form an azeotrope or azeotrope-like combination with the Z-1,1,1,4,4,4-hexafluoro-2-butene.

CLAIMS

What is claimed is:

1. A method for producing heating in a high temperature heat pump comprising condensing a vapor working fluid comprising Z-1,1,1,4,4,4-hexafluoro-2-butene, in a condenser, thereby producing a liquid working fluid; wherein said high temperature heat pump operates at condenser temperatures of at least about 100°C.

2. The method of claim 1 further comprising passing a heat transfer medium through the condenser, whereby said condensation of working fluid heats the heat transfer medium, and passing the heated heat transfer medium from the condenser to a body to be heated.

3. The method of claim 2, further comprising compressing the working fluid vapor in a dynamic or a positive displacement compressor.

4. The method of claim 1, further comprising passing a fluid to be heated through said condenser, thus heating the fluid.

5. The method of claim 1 wherein heat is exchanged between at least two heating stages, comprising:

   absorbing heat in a working fluid in a heating stage operated at a selected condenser temperature and transferring this heat to the working fluid of another heating stage operated at a higher condenser temperature; wherein the working fluid of the heating stage operated at the higher condenser temperature comprises Z-1,1,1,4,4,4-hexafluoro-2-butene.

6. A method of raising the maximum feasible condenser operating temperature in a high temperature heat pump apparatus comprising charging the high temperature heat pump with a working fluid comprising Z-1,1,1,4,4,4-hexafluoro-2-butene.

7. The method of claim 6 wherein the maximum feasible condenser operating temperature is raised to a temperature greater than about 120°C.

8. A composition comprising: (a) Z-1,1,1,4,4,4-hexafluoro-2-butene; (b) 2-chloropropane; and (c) at least one lubricant suitable for use at a temperature of at least about 150°C; wherein the 2-chloropropane is present in an amount effective to form an azeotrope or azeotrope-like combination with the Z-1,1,1,4,4,4-hexafluoro-2-butene.

9. A high temperature heat pump apparatus containing a working fluid comprising Z-1,1,1,4,4,4-hexafluoro-2-butene; wherein said high temperature heat pump includes an evaporator, a compressor, a condenser, and an expansion device; and wherein said high temperature heat pump operates at condenser temperatures of at least about 100°C.

10. The high temperature heat pump apparatus of claim 9 comprising a dynamic or a positive displacement compressor.

11. The high temperature heat pump apparatus of claim 9 having at least two heating stages arranged as a cascade heating system, each stage circulating a working fluid therethrough, wherein heat is transferred to the final stage from the preceding stage and wherein the heating fluid of the final stage comprises Z-1,1,1,4,4,4-hexafluoro-2-butene.

12. The high temperature heat pump apparatus of claim 9 having at least two heating stages arranged as a cascade heating system, each stage circulating a working fluid therethrough comprising:

    (a) a first expansion device for reducing the pressure and temperature of a first working fluid liquid;

    (b) an evaporator having an inlet and an outlet, wherein the first working fluid liquid from the first expansion device enters the evaporator through the evaporator inlet and is evaporated in the evaporator to form a first working fluid vapor, and circulates to the outlet;

(c) a first compressor having an inlet and an outlet, wherein the first working fluid vapor from the evaporator circulates to the inlet of the first compressor and is compressed, thereby increasing the pressure and the temperature of the first working fluid vapor, and the compressed first refrigerant vapor circulates to the outlet of the first compressor;

(d) a cascade heat exchanger system having:

(i) a first inlet and a first outlet, wherein the first working fluid vapor circulates from the first inlet to the first outlet and is condensed in the heat exchanger system to form a first working fluid liquid, thereby rejecting heat, and

(ii) a second inlet and a second outlet, wherein a second working fluid liquid circulates from the second inlet to the second outlet and absorbs the heat rejected by the first working fluid and forms a second working fluid vapor;

(e) a second compressor having an inlet and an outlet, wherein the second working fluid vapor from the cascade heat exchanger system is drawn into the compressor and is compressed, thereby increasing the pressure and temperature of the second working fluid vapor;

(f) a condenser having an inlet and an outlet for circulating the second working fluid vapor therethrough and for condensing the second working fluid vapor from the compressor to form a second working fluid liquid, thereby producing heat, wherein the second working fluid liquid exits the condenser through the outlet; and

(g) a second expansion device for reducing the pressure and temperature of the second working fluid liquid exiting the condenser and entering the second inlet of the cascade heat exchanger system;

wherein the second working fluids comprises Z-1,1,1,4,4,4-hexafluoro-2-butene; and wherein said high temperature heat pump operates at condenser temperatures of at least about 100°C.

13. The high temperature heat pump apparatus of claim 12, wherein the first working fluid comprises at least one fluoroolefin selected from the group consisting of HFO-1234yf and E-1234ze.

14. The high temperature heat pump apparatus of claim 12 wherein the first working fluid comprises at least one fluoroalkane selected from the group consisting of HFC-134a, HFC-134 and HFC-227ea.

15. The high temperature heat pump apparatus of claim 11, wherein the working fluid of the stage preceding the final stage comprises at least one fluoroolefin selected from the group consisting of HFO-1234yf and E-1234ze.

16. The high temperature heat pump apparatus of claim 11, wherein the working fluid of the stage preceding the final stage comprises at least one fluoroalkane selected from the group consisting of HFC-134a, HFC-134 and HFC-227ea.