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(54) **Systems and methods for power generation from multiple heat sources using customized working fluids**

(57) A power generating system employs a Rankine cycle system that is coupled to multiple heat sources (106, 108). The Rankine cycle system includes a customized working fluid that comprises a mixture of a plurality of constituent fluids, the selection of which gives the mixture a working fluid profile. In one embodiment, the working fluid profile includes a temperature glide portion selected and optimized based on operating conditions of the heat sources, wherein the temperature glide portion includes a constituent phase point at which one of the constituent fluids undergoes a phase change before the other constituent fluids of the mixture.

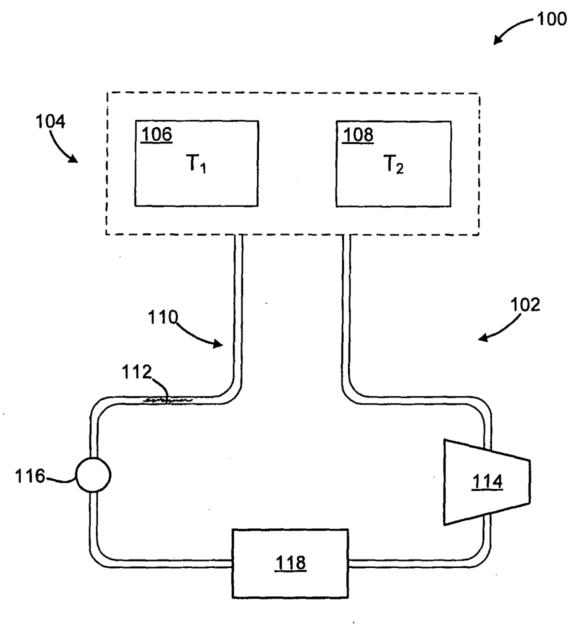

FIG. 1

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Description

TECHNICAL FIELD

[0001] The subject matter of the present disclosure relates generally to closed loop Rankine cycle power systems, and in one embodiment to a power system that comprises a customized working fluid configured as a mixture of constituent fluids, wherein the mixture is customized to the heat streams of the system.

BACKGROUND

[0002] Rankine cycle power systems and in particular organic Rankine cycle ("ORC") systems are used for the purpose of generating electrical power. These systems implement a vapour power cycle that utilizes an organic fluid as the working fluid instead of water/steam. Functionally these ORC systems resemble the steam cycle power plant, in which a pump increases the pressure of the condensed working fluid, the condensed working fluid is vaporized, and the vaporized working fluid interacts with a turbine to generate power.

[0003] Implementation of these systems is useful to harness waste energy in many forms including geothermal wells and waste heat generated by industrial and commercial processes and operations. Other sources of waste heat include biomass boilers, engine cooling systems, and industrial cooling processes. However, because such configurations of ORC systems generally use single constituent working fluids with particularly well defined "pinch points", or points in the temperature profile where the difference between the temperature of the working fluid and the heat source is smallest, the range of temperatures with which these conventional ORC systems exchange heat is limited. The limiting effect of the pinch point is particularly important in implementations wherein the ORC system is used to generate power with heat from multiple sources, and more particularly from multiple sources at disparate operating temperatures.

[0004] To address the issues with the pinch point, and thus improve efficiency, conventional solutions may utilize heat transfer systems for each of the heat sources. While effective in that the individual heat transfer systems can be customized to the specific heat source, such solutions are limited to transfer heat at the temperature prescribed by the properties of the working fluid. These properties include the pinch point at which temperature of the working fluid rises quickly to the vaporization point and then the remaining heat is transferred in the working fluid at one temperature.

[0005] Other solutions are also available in which the working fluid is manipulated to control the thermal characteristics of the working fluid. These characteristics can influence the ratio of the heat transferred at a variety of temperatures, which permits better temperature driven heat transfer and simplifies the heat transfer system. Such solutions require manipulation of the chemical compounds and composition of the working fluid. But in addition to requiring extensive research to understand and manufacture the resulting working fluid, the manipulation of chemical compounds to formulate new and exotic working fluids does not address the fundamental problem. That is, although the working fluid is appropriate for the specific heat sources for which it was designed, the resulting working fluid still has a tight single instance pinch point, which will limit its further application in connection with other heat sources or combination of heat sources and flexibility during off design operation of the equipment.

[0006] There is a need for systems to generate power from multiple heat sources, but that utilize the advantages of a single circuit ORC system despite the disparate temperature between the multiple heat streams. There is likewise a need for a working fluid and/or a system employing such working fluid that addresses the problems and limitations associated with the fluid pinch point, the effect the thermodynamic limitations of the pinch point has on determining the specific ratio of energy that is transferable from each of the various heat sources, and the impact of this ratio on efficiency, optimization, and utilization of resources to generate power from multiple heat sources.

SUMMARY

[0007] There is described below in accordance with the present disclosure embodiments of systems and power generating systems that utilize a customized working fluid that comprises a mixture of working fluids including, but not limited to, organic fluids used in ORC systems. The content of the mixture, e.g., the selection of the working fluids, is configured so as to provide the customized working fluid with thermodynamic properties conducive to heat transfer from the multiple sources, and in one example each of the multiple sources is at their existing nominal operation points. Each of the working fluids, however, retains its initial chemical properties, thereby simplifying the implementation of the resultant customized working fluid and the control of the specific mixture.

[0008] Further discussion of these and other features is provided below in connection with one or more embodiments, examples of which appear immediately below:

In one embodiment, a power generating system comprises a heat source and a customized working fluid in heat exchange relation to the heat source. The customized working fluid comprises a mixture of a plurality of constituent fluids. In one example the mixture exhibits a working fluid profile comprising at least one constituent phase point at which at least one of the constituent fluids undergoes a phase change before the other constituent fluids of the mixture.

[0009] In another embodiment, in a power generating system that comprises a first heat source having a first temperature and a second heat source having a second temperature that is greater than the first temperature, the power generating system employs a Rankine cycle system. The Rankine cycle system comprises a heat exchange system coupled to each of the first heat source and the second heat source and a customized working fluid flowing in the heat exchange system. The customized working fluid comprises a first constituent fluid and a second constituent fluid. In one example, the first constituent fluid undergoes a phase change before the second constituent fluid.

[0010] In yet another embodiment, a system comprises a plurality of heat sources, a power generator coupled to each of the plurality of heat sources, and a plurality of customized working fluids flowing in the power generator. In one example, each of the customized working fluids comprises a mixture of a plurality of constituent fluids. In another example, the mixture exhibits a working fluid profile with at least one constituent phase point at which one of the plurality of constituent fluids undergoes a phase change before any of the other of the plurality of constituent fluids.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] So that the manner in which the above recited concepts of the present disclosure may be understood in detail, a more particular description is provided by reference to the embodiments, which are illustrated in the accompanying drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments and are therefore not to be considered limiting of its scope, for the concepts of the present disclosure may admit to other equally effective embodiments. Moreover, the drawings are not necessarily to scale, emphasis generally being placed upon illustrating the principles of certain embodiments.

[0012] Thus, for further understanding of these concepts and embodiments, reference may be made to the following detailed description, read in connection with the drawings in which:

Fig. 1 is a schematic diagram of an example of an ORC system that is made in accordance with concepts of the present disclosure; and

Fig. 2 is a temperature-enthalpy phase diagram that illustrates a working fluid profile for another example of an ORC system of the present disclosure.

DETAILED DESCRIPTION

[0013] Broadly stated, embodiments of the present disclosure are useful to convert thermal energy to mechanical energy and further to electrical energy by way of closed loop Rankine cycle systems, e.g., Organic Rankine Cycle ("ORC") systems and related technology. These heat transfer systems employ working fluids that allow their use in heat to mechanical conversions. Such working fluids in the embodiments discussed below are particularly customized to the heat sources and related processes to which is coupled the heat transfer system. This customization can occur in the form of formulated mixtures of constituent fluids, which comprise organic and inorganic compounds such as refrigerants for use in ORC systems. The constituent fluids are mixed such as at relative percentages and weights, wherein the resulting mixture has thermodynamic properties that optimize the efficiency of heat transfer between the working fluid and the heat sources, and ultimately the amount of power generated.

[0014] However, the mixture of constituent fluids is provided so that each of the constituent fluids substantially retains its physical and chemical properties in the mixed fluid. That is, the mixture of organic fluids is a product of mechanical blending, without chemical bonding or other chemical changes as among and between the organic fluids in the mixture. Each ingredient substance thus retains its own chemical properties and makeup.

[0015] In one embodiment, the inventors propose customized working fluids in which the selection and mixture of a plurality of constituent fluids result in a working fluid profile (e.g., as defined by a temperature-enthalpy diagram (T-H diagram)) without the characteristic pinch point(s) of conventional single-constituent working fluids. The mixture is formulated so that, in place of the pinch point, there is found a temperature glide portion in which changes in the temperature of the working fluid occur gradually during the thermodynamic cycle. More particular to one example, the temperature glide portion comprises at least one operating temperature wherein one of the constituent fluids undergoes a phase change (e.g., from a liquid phase to a vapour phase) before the other constituent fluids of the mixture. Details of this and other concepts are provided in the discussion that follows below.

[0016] Referring now to Fig. 1, there is shown a schematic illustration of a system 100 that is made in accordance with concepts of the present disclosure. The system 100 includes a heat exchange system 102 and a heat source 104 coupled in thermal relation to the heat exchange system 102. This coupling permits the heat exchange system 102 to capture heat from the heat source 104, and in one construction the captured heat is transformed into power such as by way of a mechanical expander (e.g., a turbine). The heat source 104 comprises a low temperature or first source 106 and a high temperature or second source 108. Each of the first source 106 and the second source 108 exhibit an operating temperature, generally identified in the present example as T_1 and T_2. While two heat sources are schematically illustrated in the disclosed non-limiting embodiment, it should be understood that the disclosure is applicable to systems with multiple (more than two) sources.

[0017] In one embodiment, the heat exchange system 102 comprises a fluid circuit 110 through which flows a customized working fluid 112. Examples and construction of the fluid circuit 110 can vary; however, those familiar with Rankine cycle systems will generally recognize that the customized working fluid 112 flows amongst various components of the fluid circuit 110, some of which are discussed in more detail below. Here the fluid circuit 110 comprises a turbine generator 114, a pump 116, and a condenser 118. These components are typically coupled together as closed-loop systems, which are substantially hermetically sealed from the environment.

[0018] Related to the operation of systems such as the system 100, the fluid circuit 110 is configured to flow the customized working fluid 112 among the first source 106 and the second source 108. This flow facilitates heat transfer to and from the customized working fluid 112 and one or more of the first source 106 and the second source 108. The transfer of heat effectuates changes in the temperature of the customized working fluid 112. These changes are influenced by the configuration of the system 100, and in the present example heat transfer is influenced by the operating temperatures of the first source 106 and the second source 108 (e.g., operating temperatures T_1 and T_2). In one example, the system 100 is configured for pre-heating of the customized working fluid 112 at the first source 106 and vaporizing of the customized working fluid 112 at the second source 108. In another example, the system 100 is configured for preheating and partial vaporizing of the customized working fluid 112 at the first source 106, and complete vaporizing of the customized working fluid 112 at the second source 108. In yet another example, the system 100 is configured for partial pre-heating of the customized working fluid 112 at the first source 106 and partial pre-heating and complete vaporizing of the customized working fluid 112 at the second source 108. Super-heating of the customized working fluid 112 is likewise possible such as in one or more of the examples above where the customized working fluid 112 is superheated in the second source 108. Other configurations of the system 100 are also contemplated in which occurs super-critical heating of the customized working fluid 112.

[0019] The customized working fluid 112 passes to the turbine generator 114, thereby providing mechanical power to generate, e.g., electricity. Upon leaving the turbine generator 114, the vapour passes next to the condenser 118 wherein the vapour is condensed by way of heat exchange relationship with a cooling medium (not shown). The resulting working fluid, now substantially condensed as liquid, is then circulated by the pump 116 to the first source 106, which is at an operating temperature T_1. This essentially completes the cycle of the system 100.

[0020] The heat source 104, including each of the first source 106 and the second source 108, is generally instantiated by heat rejection devices that exhibit heat streams of varying temperatures. Suitable heat streams are found, for example, in internal combustion engines (ICE) by way of, but not limited to, the exhaust gas, charge air cooler, and the jacket water. Other heat streams can be found in renewable power sources such as fuel cells, solar, and geothermal applications. Combinations (e.g., solar applications in combination with geothermal applications) and derivations of these and other devices, systems, and the like are also contemplated within the scope and spirit of the present disclosure.

[0021] Flowing the customized working fluid 112 in heat transfer relation to these devices facilitates the exchange of heat. This exchange, as discussed above, can optimize the heat recovery of the system 100 and boost power generation of, e.g., the Rankine cycle system. To optimize the system 100, for example, the inventors have discovered that the customized working fluid 112 can be configured to match the operating conditions of the heat source 104, e.g., the operating temperature T_1 of the first source 106 and the operating temperature T_2 of the second source 108.

[0022] Such configuration can be in the form of a mixture of constituent fluids such as, but not limited to, organic fluids used as the working fluid in ORC systems. In one embodiment, the constituent fluids of the mixture are selected based on parameters of the system 100. These parameters include the operating temperatures T_1 and T_2, desired heat recovery rates as between the resulting customized working fluid 112 and the heat source 104, desired power generation for the system 100, and other functional parameters, which will be recognized by those artisans with skill in the field of this disclosure.

[0023] By way of example, mixtures for use as the customized working fluid 112 can comprise a plurality of constituent fluids such as a first fluid and a second fluid. These constituent fluids can be mixed together, with the amount (e.g., as a percentage and/or fraction of the whole) of each of the first fluid and the second fluid determined in accordance with the operating temperatures T_1 and T_2. The resulting customized working fluid 112 is compatible with operating temperatures for a low temperature (e.g., the first source 106) and for a high temperature (e.g., the second source 108). In one embodiment, the first fluid undergoes a phase change (e.g., from a liquid phase to a vapour phase) before the second fluid. While two heat sources are schematically illustrated in the disclosed non-limiting embodiment, it should be understood that the disclosure is applicable to systems with multiple (more than two) sources.

[0024] With continued focus on the customized working fluid, and with reference now to Fig. 2, there is illustrated an operating profile 200 for an example of a customized working fluid (e.g., the customized working fluid 112 (Fig. 1)) of the present disclosure. The operating profile 200 is in the form of a T-H diagram (i.e., a temperature-enthalpy diagram) on which is illustrated a thermodynamic cycle 202. Superimposed on the thermodynamic cycle 202 is a set of temperature profiles, generally identified by 204, and which include a cooling profile 206, a first profile 208, and a second profile 210. The first profile 208 and the second profile 210 are indicative of the heat source with which heat is exchanged with the customized working fluid. When considered in view of the example of Fig. 1, the first profile 208 and the second profile 210 are consistent with, respectively, the first source 106 and the second source 108 of the system 100. Each of the first profile 208 and the second profile 210 includes a maximum temperature and a minimum temperature, as well as a temperature difference that is measured therebetween. In the present example, the cooling profile 206 includes a minimum temperature 212 and a maximum temperature 214. Likewise the first profile 208 (e.g., the first high temperature profile) includes a minimum temperature 216 and a maximum temperature 218 and the second profile 210 (e.g., the second higher temperature profile) includes a minimum temperature 220 and a maximum temperature 222.

[0025] Also depicted in Fig. 2 is a working fluid profile 224 that includes one or more temperature glide portions 226. In the present example, the temperature glide portions 226 include an evaporator glide portion 228 and a condenser glide portion 230. Each of the temperature glide portions 226 comprises a constituent phase point 232, at which at least one of the constituent fluids of the mixture undergoes a phase change. By way of example, but not limitation, the evaporator glide portion 228 comprises a constituent vaporization point 234 and the condenser glide portion 230 comprises a constituent condensation point 236. In one example, the constituent vaporization point 234 identifies the operating conditions in which at least one of the constituent fluids of the mixture is completely vaporized. In another example, the constituent condensation point 236 identifies the operating conditions in which at least one of the constituent fluids of the mixture is completely condensed.

[0026] The number and location of the constituent phase points 232 can vary as with, for example, the number of constituent fluids that are mixed together to form the customized working fluids of the present disclosure. The example that is depicted in Fig. 2 is indicative of a mixture of two constituent fluids, wherein one of the constituent fluids undergoes a phase change before the other. It is contemplated that for mixtures of, e.g., three constituent fluids, each of the temperature glide portions 226 may comprise constituent phase points 232 that identify the operating conditions at which each of the constituent fluids undergo the phase change. In one embodiment, fluids such as organic fluids are selected and mixed together in particular percentages to yield initial and final temperatures for the temperature glide portions 226, as well as the location of the constituent phase points 232. The combination of constituent fluids can be used to define the slope and/or profile of the temperature glide portions 226. This combination is useful to reduce and/or eliminate the pinch points that are typical of conventional single constituent working fluids. These percentages may take into consideration characteristics, e.g., the temperature, of the cooling source 206 and the first profile 208 and the second profile 210, thereby allowing heat recovery with a single customized working fluid from each of the first source 106 (Fig. 1) and the second source 108 (Fig. 1) discussed above.

[0027] Manipulation of the working fluid profile 224 by way of the mixture (e.g., the percentages of the constituent fluids) is beneficial because it provides better matching in systems in which the heat source is defined by one or more of the first high temperature profile 208 and the second higher temperature profile 210. For example, the mixture of constituent fluids can be selected so as to define the characteristics, e.g., the slope and/or arc, of one or more of the evaporator glide portion 228 and/or the condenser glide portion 230. Such characteristics can be used to promote efficient heat exchange, and in one implementation the mixture is tuned so that the evaporator glide portion 228 is in the temperature range of at least one of the first high temperature profile 208 and the second higher temperature profile 210.

[0028] Referring back to Fig. 2, it is seen that the working fluid profile 224 also includes several process stages, identified generally by the numerals 238, 240, 242, 244, 246, 248, 250, and 252 (collectively, "process stages"). These process stages describe the various states of the customized working fluid as the customized working fluid flows through the system, e.g., the system 100. By way of the process stages and in consideration of the Rankine cycle system generally, an exemplary embodiment of a method of generating power using the customized working fluid is described below.

[0029] In one embodiment of the method, the customized working fluid is preheated from stage 238 to stage 240 such as by way of heat transfer from the low temperature or first source (e.g., the first source 106). The customized working fluid is then evaporated, from stage 240 to stage 242, when introduced to the high temperature or second source (e.g., the second source 108). As discussed above, complete vaporization of the constituent fluids that comprise the customized working fluid can occur variously, such as at one or more of the constituent vaporization points 234. In one example, the mixture of the constituent components causes vaporization of a first fluid from stage 240 to the constituent vaporization point 234 and then vaporization of a second fluid, such as by normal latent heating, from the constituent vaporization point 234 to stage 242. Communication between the fluid and the second source can likewise superheat the vaporized customized working fluid, as illustrated in the working fluid profile 224 from stage 242 to stage 244. The vapour is thereafter expanded between stage 244 and stage 246, de-superheated between stage 246 and stage 248, and condensed between stage 248 and stage 250. As with the evaporative portion of the working fluid profile 224 discussed above, complete condensation of the constituent fluids that comprise the customized working fluid can occur at one or more of the constituent condensation points 236. In one example, the mixture of the constituent components causes condensation of a first fluid from stage 248 and constituent condensation point 236 and then condensation of a second fluid from constituent condensation point 236 to stage 250. Sub-cooling can occur between stage 250 and stage 252, before the customized working fluid is reflowed in proximity to the first source.

[0030] It is to be noted that the composition of the customized working fluid, e.g., the mixture of organic fluids, can be tuned to provide appropriate and adequate initial and final temperatures for the temperature glide portion 226 so as to facilitate one or more of the process stages and steps discussed above. Varying the combinations of organic fluids can change the working fluid profile 224 so that the process stages occur at different temperatures and pressures. In one example, such variations can promote and improve pre-heating (e.g., from stage 238 to stage 240) by matching the customized working fluid to the temperatures of the heat sources.

[0031] For further clarification, instruction, and description of the concepts above, embodiments of the present disclosure are now illustrated and discussed in connection with the following examples:

EXAMPLE I

[0032] In one example, a customized working fluid comprises compounds such as, but not limited to, hydrofluorocarbons, hydrocarbons, fluorinated ketones, fluorinated ethers, chloro- and bromo-fluoro olefins, hydrofluoroolefins, hydrofluoroolefin ethers, hydrochlorofluoroolefin ethers, and linear and/or cyclic siloxanes. By way of illustration, these compounds can be further defined as one or more of propane, cyclopropane, isobutene, isobutane, n-butane, propylene, n-pentane, isopentane, cyclopentane, R-134a, R-30, R-32, R-123, R-125, R-143a, R-134, R-152a, R-161, R-1216, R-227ea, R-245fa, R-245cb, R-236ea, R-236fa, R-365mfc, HT-55, R-43-10mee, HFE-7000, Novec-649, CF_3I, R-1234 (ye and yf), R-1234ze, R-1233 (zd(E) and zd(Z)), R-1225 (ye(Z) and ye(E)), C_5F_9Cl, $C_5H_2F_{10}$, R-1243zf, E-134a, E134, E125, E143a, siloxane MM, dimethylether, and CO_2. Still other compounds, though not necessarily listed above, can be selected that have characteristics that can enhance system performance, enhance heat transfer characteristics, provide fire suppression, provide flame retardation, provide lubrication, provide compound stabilization, provide corrosion inhibition, as well as provide solubility compatibility, tracing, prognostics or diagnostics.

EXAMPLE II

[0033] In another example, a customized working fluid is configured to utilize available energy from multiple heat sources generated by an internal combustion engine. The temperature of first said heat source, the higher of the two available sources, is about 90.5° C (195° F) and experiences a temperature drop of about 25-30° C throughout the evaporator of an embodiment of an ORC system (e.g., the system 100 (Fig. 1)). The temperature of the second said heat source, the lower of the two available sources, is about 71° C (160° F) and experiences a temperature drop of about 20-25° C throughout the pre-heater/evaporator of an embodiment of an ORC system (e.g., the system 100 (Fig. 1)).

[0034] As discussed above, implementation of the concepts contemplated herein may define the amount of heat available from the two heat sources as well to dictate whether pre-heating, evaporation, or superheat, will occur in the ORC system design. In one implementation, the cooling water inlet temperature and cooling water outlet temperature to the condenser dictate the maximum allowable temperature glide of the customized working fluid. This characteristic will allow for matching of multiple heat sources.

[0035] To illustrate, the customized working fluid of the present example can comprise a binary mixture of about 40% isobutene and about 60% isopentane (by mass fraction). This customized working fluid is designed for an embodiment of an ORC system (e.g., system 100) in which the pinch point in the evaporator is assumed to be about 5.6° C (10° F). This assumption defines the bubble temperature of the mixture of the customized working fluid at the high-side pressure be about 65-67.5° C (150-154° F). Table 1 lists the temperature variation throughout the ORC system using the customized working fluid of the present example.

TABLE 1

Location	Working Fluid Temperature (° C)	Working Fluid Temperature (° F)
Pump Inlet	5.6	42.1
Pump Outlet	6.1	43.0
Evaporator Inlet	6.1	43.0
Evaporator Bubble Point	66.1	151.0
Evaporator Dew Point	76.7	170.0

(continued)

Location	Working Fluid Temperature (° C)	Working Fluid Temperature (° F)
Turbine Inlet	76.7	170.0
Turbine Exit	44.0	111.2
Condenser Inlet	44.0	111.2
Condenser Outlet	5.6	42.1

[0036] While an example of a customized working fluid has been described with respect to this specific implementation, those skilled in the art will appreciate that there are numerous variations and permutations of the above described systems and customized working fluids that fall within the spirit and scope of the present disclosure.

[0037] Further, it is contemplated that numerical values, as well as other values that are recited herein are modified by the term "about", whether expressly stated or inherently derived by the discussion of the present disclosure. As used herein, the term "about" defines the numerical boundaries of the modified values so as to include, but not be limited to, tolerances and values up to, and including the numerical value so modified. That is, numerical values may include the actual value that is expressly stated, as well as other values that are, or may be, the decimal, fractional, or other multiple of the actual value indicated, and/or described in the disclosure.

[0038] While the present disclosure has shown and described details of exemplary embodiments, it will be understood by one skilled in the art that various changes in detail may be effected therein without departing from the spirit and scope of the disclosure as defined by claims that may be supported by the written description and drawings. Further, where these exemplary embodiments (and other related derivations) are described with reference to a certain number of elements it will be understood that other exemplary embodiments may be practiced utilizing either less than or more than the certain number of elements.

Claims

1. A power generating system comprising:

a heat source; and
a customized working fluid in heat exchange relation to the heat source, the customized working fluid comprising a mixture of constituent fluids, the mixture exhibiting a working fluid profile comprising at least one constituent phase point at which at least one of the constituent fluids undergoes a phase change before the other constituent fluids of the mixture.

2. A power generating system according to claim 1, wherein the constituent fluids comprise at least one organic fluid, which is preferably compatible with operation in a Rankine cycle system.

3. A power generating system according to claim 1 or claim 2, wherein the heat source comprises a first heat source and a second heat source, and wherein the customized working fluid exchanges heat with each of the first heat source and the second heat source.

4. A power generating system according to any preceding claim, wherein the working fluid profile includes a constituent phase point for each of the constituent fluids of the mixture, and wherein the constituent phase points define different temperatures at which occur the phase change.

5. A power generating system according to any preceding claim, further comprising a heat exchange system coupled to the heat source and in which flows the customized working fluid, the heat exchange system comprising at least one of a pump, an evaporator, a condenser, and a turbine generator.

6. A power generating system according to any preceding claim, wherein the mixture comprises a first constituent fluid and a second constituent fluid, and wherein the constituent phase point identifies a portion of the working fluid profile at which the phase change of first constituent fluid is completed before the phase change of the second constituent fluid.

7. A power generating system as claimed in claim 1, comprising:

a first heat source having a first temperature and a second heat source having a second temperature that is greater than the first temperature, and employing a Rankine cycle, comprising:

a heat exchange system coupled to each of the first heat source and the second heat source; and
said customized working fluid flowing in the heat exchange system, the customized working fluid comprising a first constituent fluid and a second constituent fluid,
wherein the first constituent fluid undergoes a phase change before the second constituent fluid.

8. A system according to claim 7, wherein at least one of the first constituent fluid and the second constituent fluid is an organic fluid compatible with the Rankine cycle system.

9. A system according to claim 7 or claim 8, wherein the first constituent fluid completely vaporizes before the second constituent fluid.

10. A system according to any of claims 7 to 9, wherein the first constituent fluid completely condenses before the second constituent fluid.

11. A system according to any of claims 7 to 10, wherein the heat exchange system comprises at least one of a pump, an evaporator, a condenser, and a turbine generator.

12. A power generating system as claimed in claim 1, comprising:

a plurality of heat sources;
a power generator coupled to each of the plurality of heat sources; and
a plurality of said customized working fluids flowing in the power generator,
wherein each of the customized working fluids comprises a mixture of a plurality of constituent fluids, and wherein the mixture exhibits a working fluid profile with at least one constituent phase point at which one of the plurality of constituent fluids undergoes a phase change before any of the other of the plurality of constituent fluids.

13. A system according to claim 12, wherein the power generator comprises a plurality of heat exchange systems that flow the customized working fluid in heat transfer relation to the heat sources.

14. A system according to any of claims 1 to 6, 12 or 13, wherein the constituent fluids comprise one or more of a hydrofluorocarbon, a hydrocarbon, a fluorinated ketone, a fluorinated ether, a chloro-fluoro olefin, a bromo-fluoro olefin, a hydrofluoroolefin, a hydrofluoroolefin ether, a hydrochlorofluoroolefin ether, a linear siloxane, a cyclic siloxane, and combinations and derivations thereof.

15. A system according to any of claims 7 to 14, wherein the first constituent fluid and the second constituent fluid comprise compounds selected from the group consisting of propane, cyclopropane, isobutene, isobutane, n-butane, propylene, n-pentane, isopentane, cyclopentane, R-134a, R-30, R-32, R-123, R-125, R-143a, R-134, R-152a, R-161, R-1216, R-227ea, R-245fa, R-245cb, R-236ea, R-236fa, R-365mfc, HT-55, R-43-10mee, HFE-7000, Novec-649, CF_3I, R-1234 (ye and yf), R-1234ze, R-1233 (zd(E) and zd(Z)), R-1225 (ye(Z) and ye(E)), C_5F_9Cl, $C_5H_2F_{10}$, R-1243zf, E-134a, E134, E125, E143a, siloxane MM, dimethylether, and CO_2, and combinations and derivations thereof.

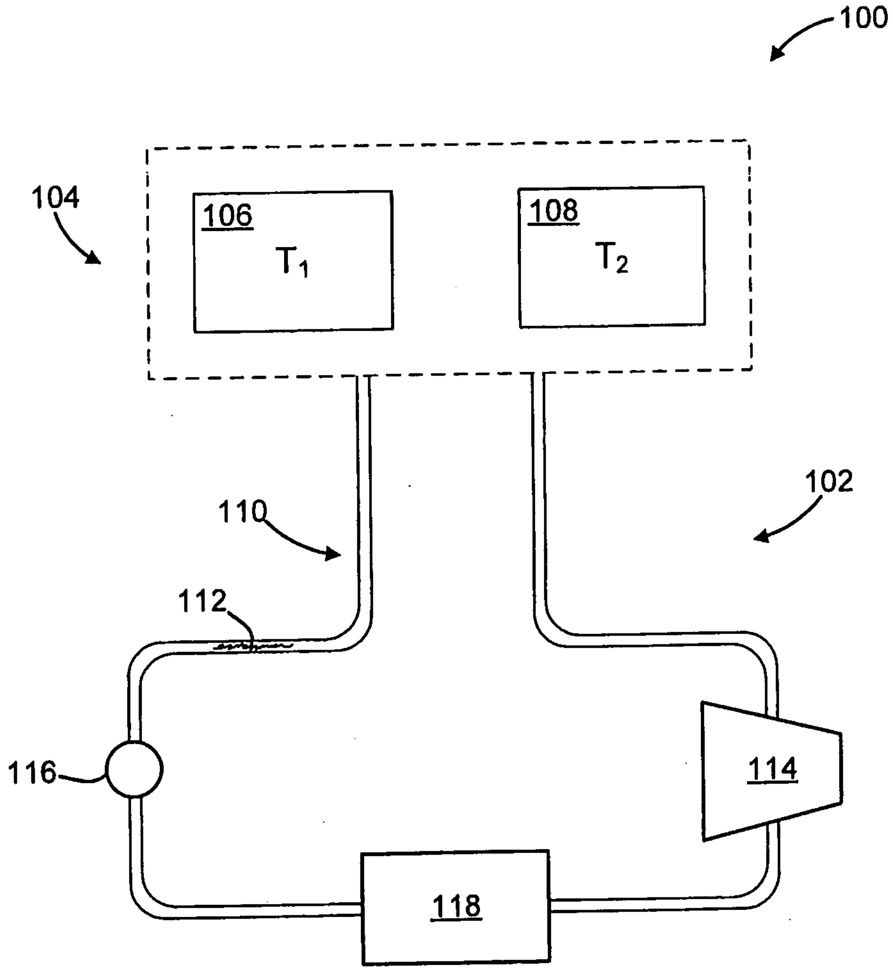

FIG. 1

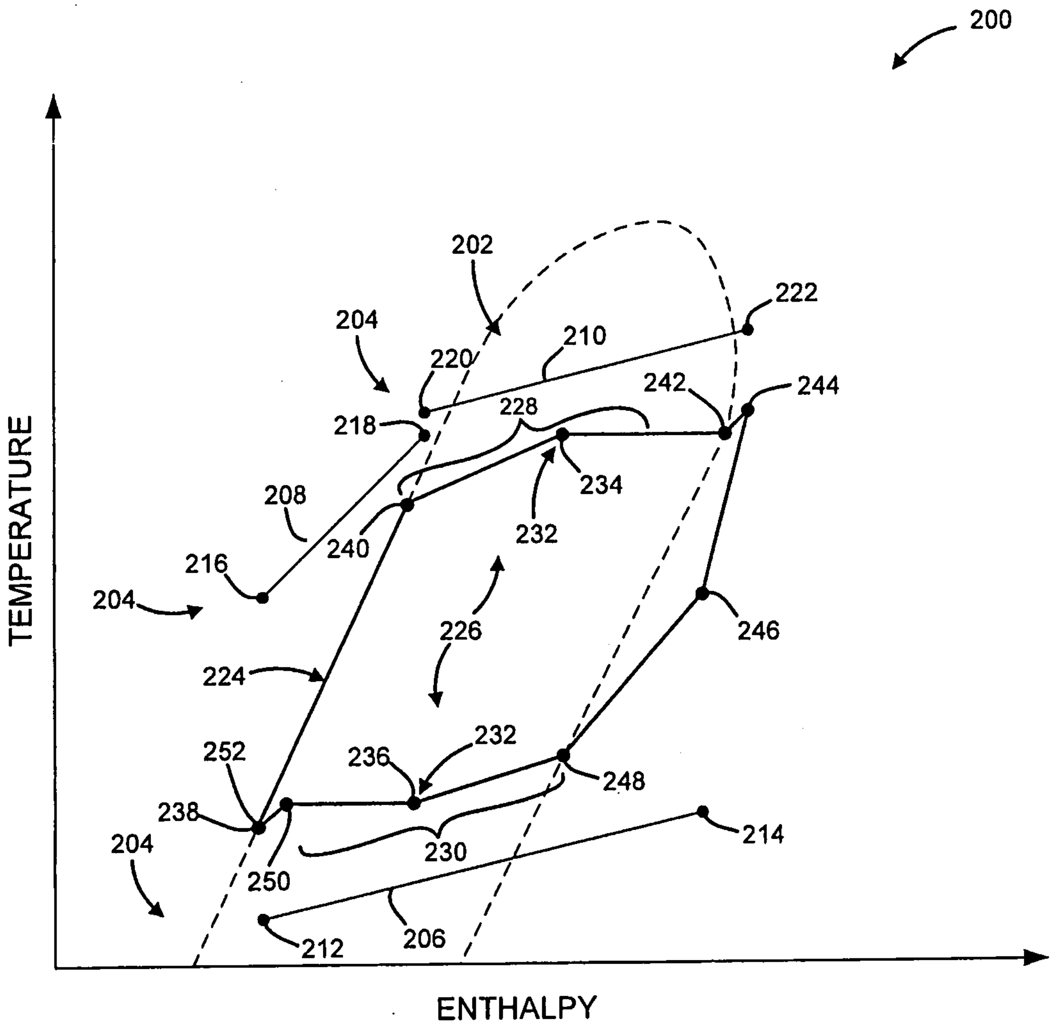
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FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 11 25 0808

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	FR 2 575 787 A1 (MENDOZA ROSADO SERAFIN [ES]) 11 July 1986 (1986-07-11) * page 1, line 1 - page 9, line 30; figures 1-3 *	1-15 8,15	INV. F01K25/06 F01K25/10
Y	US 4 982 568 A (KALINA ALEXANDER I [US]) 8 January 1991 (1991-01-08) * column 1, line 1 - column 3, line 68 *	8,15	
A	EP 1 283 393 A2 (BWX TECHNOLOGIES INC [US]) 12 February 2003 (2003-02-12) * figure 1 *	1	
A	DE 44 42 859 A1 (KLEMM MANFRED [DE]) 5 June 1996 (1996-06-05) * figures 1-3 *	1	

TECHNICAL FIELDS SEARCHED (IPC)

F01K
F22B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 January 2012	Lepers, Joachim

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CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
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D : document cited in the application
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 25 0808

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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13-01-2012

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82