0011P00031

AMBIENT HEAT ENGINE

[0001] **[Field of the Invention]**

The invention relates to an Ambient Heat Engine that is powered by a pressurized cryogenic fluid carbon dioxide (CO_2) in a closed loop cycle. Cryogenic in this context is temperature below freezing solid water ice but above melting point of element or compound used in the working fluid. Energy is added by absorbing ambient heat solely or boasted by waste heat from boiler or industrial process; or from reactor that decomposes waste or chemical compound.

[0002] **[Background to the Invention]**

The world living standard has advanced sharply for the last 100 years due to using more energy. However, the energy used is mainly from fossil fuels and is now creating a dire consequence of destroying the earth eco-system by emitting more carbon dioxide gas which was sequestered millions of year ago that made this planet Earth habitable.

[0003] Internal Combustion Engine (ICE) using refined fossil fuel has been used for about a century and it is now realized that it is not sustainable. The crude oil is depleting and also emits toxic and greenhouse gas that is threatening the earth ecology and also human civilization.

[0004] Various solutions have been developed like harnessing energy from solar, wind, ocean wave, and conversation of biomass to biogas or biofuel. Unfortunate, the cost of implementation, unsteady output and limited scale cannot make it the main alternative energy source to replace fossil fuels.

[0005] Ambient heat has been harnessed with heat sink source from deep underground; deep sea or using liquefied air. However, not a single one becomes successful due to deployment problem and high cost of maintenance especially in refurnishing liquefied air.

[0006] Solutions to provide renewable and non-polluting source of energy as well as clean water and efficient waste disposal are urgently needed.

[0007] The present applications claims priority dates of International Patent Application PCT/SG2014/000164 that was filed on 16 April 2014. Entire content or subject matter of the International Patent Application is hereby incorporated by reference.

[0008] **[Summary of the Invention]**

Heat is the main source of energy for work. The Sun and burning of hydrocarbon compounds are the main fuel source of heat. In ICE (Internal Combustion Engine) concept, it uses the heat to cause rapid expansion of pressure of air in its engine cylinder to push the piston causing it to move in rotating action to perform work. Similarly for a boiler, the heat is used to increase the fluid pressure and the pressurized fluid then performs work.

[0009] In this invention, the heat is not necessary directly from standard hydrocarbon fuels. The heat energy source is the ambient heat which is mostly leftover by the Sun or human activities. The ambient heat is most abundant energy source which should be harnessed for performing work.

[0010] Ambient heat alone and or waste heat from industrial sources can be recovered to increase the volume of a working fluid like CO_2. The increased volume of a pressurized fluid in a cylinder of a piston-driven reciprocating engine or a spindle rotary device will perform mechanical works. The exhausted working fluid of low pressure is passed through a cryogenic chamber to condense back to higher density state and then pumped back to working fluid storage cylinder to the same input pressure by the return stroke of the piston or a separate transfer pump. Thus completes the closed loop of performing works.

[0011] Liquid CO_2 when confined to a sealed cell and when the sealed volumetric cell is allowed to suddenly expand its original size, the pressure on the confined liquid CO_2 will suddenly become lower to below its critical point, the liquid CO_2 will become gaseous as it cannot exist in liquid state below its triple point. This expansion of CO_2 to gaseous volume with the same mass results in higher pressure that can perform work.

[0012] The work performed by the pressurized fluid can drive an electric generator. A portion of the electricity will provide the electrical power to maintain the system operation.

[0013] A portion of the return cryogenic liquid working fluid can go through a heat exchange to transfer the chilled energy out for other chilling applications.

[0014] The Ambient Heat Engine is scalable for use as battery charger in an electric vehicle to distributed power plant.

[0015] According to a first aspect of the invention, the present application provides an Ambient Heat Engine that comprises an expander with heat exchanger for increasing the temperature of the cryogenic working fluid and exhausts out of a lesser density to a cryogenic condenser which is chilled by a portion of the cryogenic working fluid not flowing through the expander. The cryogenic condenser connects to a compressor for receiving and compressing a cryogenic working medium to a higher pressure. The cryogenic working medium is configured to be circulated around the expander, the cryogenic condenser and the compressor forming a closed loop.

[0016] The heat exchanger which is attached to the expander will absorb the ambient heat or other heat source. The Ambient Heat Engine does not generate waste heat. Both cryogenic condenser and expander chamber of the Ambient Heat Engine have their body temperature lower than ambient temperature such that the working medium chills its environment.

[0017] The Ambient Heat Engine can further comprise a working medium that comprises carbon dioxide, air, ammonia or a combination of both. In particular, phase diagram of the carbon dioxide shows a critical point of 31.1^{o}C and 73.8bar that the carbon dioxide can exist in a supercritical region, as a supercritical fluid. The carbon dioxide has a triple point of 518 kPa at −56.6°C. Since carbon dioxide is a naturally occurring medium, industrial application of carbon dioxide is inherently safe. Refrigeration experiments of carbon dioxide gives good indication

of efficiency, as compared to other refrigerants, such as R11 (Trichlorofluoromethane) and R121 (1,1,2,2-Tetrachloro-1-fluoroethane).

[0018] The expander may comprise a turbine that is configured to produce mechanical movement. The turbine is a highly efficient mechanical device that expanding volume of a fluid/gas can provide for mechanical or rotary movement. Some types of turbine can operate at high pressure, which especially suitable for application with carbon dioxide.

[0019] The Ambient Heat Engine can include an electric generator that is connected to the expander for converting the mechanical movement into electricity. The Ambient Heat Engine may further include a transformer, a power inverter, rectifier or other electric devices for providing electricity of predetermined voltage value, current parameter or frequency. The electricity generated may be used for driving electric motors or disassociating water.

[0020] The expander can further comprise a compressor, a reciprocate engine or both. Since the working fluid increase its volume after passing the expander, the process of expansion can propel the reciprocate engine, the compressor or other mechanical devices, which produces useful work for fully utilizing the energy.

[0021] The reciprocate engine may comprise a piston for achieving reciprocating movement within a chamber of the reciprocate engine.

[0022] The reciprocate engine can comprise a relief valve that is configured to cooperate with the piston for injecting or discharging the working medium into or from the chamber. The relief valve may be synchronized with the movement of the piston such that the reciprocate engine can suck the working medium of higher pressure and expel the working medium of lower pressure for providing continuously revolution.

[0023] The reciprocate engine may further comprise a cam connected to the piston for activating the release valve. The cam is simple and reliable when design and installed properly for linking the movements of the relieve valve and the piston.

[0024] According to a second aspect of the invention, the present application provides a method of using an Ambient Heat Engine. The method comprises a step of injecting a working medium into the Ambient Heat Engine. Since the Ambient Heat Engine can accept more than one type of working medium, the Ambient Heat Engine may be discharged or filled different types of working medium repeatedly, periodically or progressively. For example, carbon dioxide can be introduced into the Ambient Heat Engine.

[0025] The method can further include a step of compressing the working medium by the compressor such that pressure of the working fluid is raised to be equal or higher than a critical point of the working fluid in forming a highly compressed fluid. When equal or beyond the critical point, the carbon dioxide can be converted to gas, liquid or even solid instantly or directly with sudden decrease of pressure, temperature or both. Such rapid phase transformation is beneficial circulating the carbon dioxide and exchanging heat using the working medium.

[0026] The method may further comprise a step of expanding the working medium rapidly for reducing temperature of the working medium. With the rapid or sudden expansion, the working medium (e.g. carbon dioxide) will drastically lower its temperature, and be converted into liquid or solid forms.

[0027] The method can further comprise a step of absorbing heat from ambient of the Ambient Heat Engine. Since the temperature of the working medium can be reduced below the ambient temperature, a container of the expanded working medium can absorb heat from the ambient, thereby providing a cool engine.

[0028] The method may further comprise a step of heating the working medium by an artificial heat source. The artificial heat source includes an oven, blast furnace, an Internal Combustion Engine, a nuclear reactor, or any other manmade devices that can give away heat.

[0029] The step of heating of the working medium can comprise a step of removing heat from waste water, room air, sea water or any other heat generators. In other

words, the working medium can reduce temperature of coolants that passes through it. Such application in large scale may be known as waste heat recycle.

[0030] The method may further comprise a step of raising temperature of the working medium by beyond its critical point. Alternatively speaking, the working medium/fluid can transit between supercritical fluid, liquid, gas or solid such that heat exchange of different phases can be flexible adopted various parts of the Ambient Heat Engine.

[0031] The method further can comprise a step of changing temperature of the working medium beyond or below its triple point. The triple point provides an alternative point of operating with the working medium (carbon dioxide) at lower temperature or pressure.

[0032] According to a third aspect of the invention, the present application provides an ambient heat engine system that comprises of a cylinder, expander cum compressor, pump, heat exchangers and electric generator which a high pressure cryogenic working fluid flows in a closed loop. The cryogenic working fluid expands to perform work and lose heat to close to its freezing point. The working fluid regains heat by absorbing from ambient and waste heat from other process. The Ambient Heat Engine works as a freezer. The Ambient Heat Engine uses like a high temperature reactor. The Ambient Heat Engine uses as to perform mechanical work. The Ambient Heat Engine works as a clean water generation. The Ambient Heat Engine performs all or combination of the freezer, the high temperature reactor for performing the mechanical work or generating clean water. An Ambient Heat Engine expander is an integrated expander and compressor. An Ambient Heat Engine provides a reactor with a HHO heating source. The heating element of the HHO heating has narrow through cavities. The Heating element narrow through cavities can have spiral design.

[0033] According to a fourth aspect of the invention, the application provides a cool Ambient Heat Engine operates by a high pressure fluid to turn a mechanical load as well as produce a freezing thermal source; and the exhausted fluid return in a close loop chilled back by a cryogenic condenser, to the same high pressure by a

transfer pump. The fluid may be carbon dioxide. In other words, the application provides an Ambient Heat Engine that has carbon dioxide working under high pressure and around 40 degrees C below the critical point to liquid state for absorbing heat from waste material and ambient.

[0034] According to a fifth aspect of the invention, the present application provides an engine that deliver mechanical energy and freezing thermal energy with power source from ambient thermal energy and or thermal energy from other energy sources that have higher temperature than the freezing thermal output.

[0035] The system works with CO_2. A lump of liquid CO_2 at -40 degree Celsius the density is 1.15kg per liter and is filled into a closed volume cell of 1 liter. That lump of CO_2 at -40 deg. C, the pressure in that closed cell can be 10 bar to about 200 bars and above based on the CO_2 PH diagram. But when the sealed cell volume suddenly increase and the pressure drop to below its triple point pressure, as CO_2 cannot be in liquid state below triple point, liquid CO_2 expand to gaseous before settle to the final pressure with the new density level. Example, if that cell volume suddenly increases to 2 liters, the density of the liquid CO_2 drops to 0.575 kg per liter. The final pressure of the CO_2 can only be about 70 bars at around 31 deg. C. If the ambient temperature is 40 deg. C, then the pressure of that lower density can be around 80 bars which will be in the supercritical region. From CO_2 PH diagram, the pressure will be at about 70 bars even if the ambient temperature is -50 deg. C as rapid change to pressure with lower density will cause the temperature to rise to 31 deg. C before the density gets lower with increase cell volume to lower pressure and lower temperature.

[0036] As the volume of the cell further increase, the density drop further. And at 31 deg. C ambient temperature, with lower density, the pressure keeps dropping. So if CO_2 enter into the cryogenic condenser at 20 bars, the temperature will get colder into the two phase region (vapor and liquid). If the cryogenic condenser temperature is maintained at -40 deg. C or lower, the vapor will be saturated to liquid at 20 bars or lower.

[0037] The cryogenic condenser is maintained at temperature below 40 deg. C by feeding in with dry ice made on the spot. The Dry Ice making section of the cryogenic condenser has a different pressure level to the cryogenic condenser chamber where the exhaust of the expander enters. The dry ice is transferred to the cryogenic chamber by a mean (known to person with the skill to build) to maintain the pressure difference. If 1 kg of CO_2 from the expander will exhaust to 40% liquid and 60% vapor at -20 deg. C, 1 kg of dry ice would be more than enough to condense the 0.6kg of vapor to liquid at -40 deg. C.

[0038] The liquid CO2 collected in cryogenic condenser is distributed back to the expander and another portion through a transfer pump or compressor for higher pressure before discharging back to the dry ice section of the cryogenic condenser to form dry ice.

[0039] In another embodiment, the dry ice is separated from the working fluid in the cryogenic condenser chamber. Through a heat exchanger in the cryogenic condenser chamber, the dry ice becomes liquid and is circulated back through a pump to higher pressure before discharging back. The exhausted CO_2 from expander become liquid again in the cryogenic condenser chamber and feed back to the expander.

[0040] The liquid CO_2 pumped back to be discharged again for making dry ice can go through a heat exchanger with ambient heat and the coldness is transferred for other application.

[0041] A working fluid of the similar PH features may be able to substitute CO_2 if it has the same no liquid state below its triple points.

[0042] [Brief Description of Drawings]

Fig. 1 illustrates an Ambient Heat Engine flowchart;

Fig. 2 illustrates the Ambient Heat Engine with heat exchanger flowchart;

Fig. 3 illustrates a cryogenic condenser that is connected to a regulator; and

Fig. 4 illustrates another cryogenic condenser includes another regulator.

[0043] **[Detailed Description]**

In one embodiment as shown in Figure 1, the invention of the ambient heat engine system **1** is a closed loop work performance comprises an accumulator cylinder **2**, expander **7**, cryogenic condenser **5** and transfer pump **6**. The accumulator cylinder **2** containing a working fluid of ambient temperature, high pressurized CO_2 close to its critical points or above. The high pressurized CO_2 is then released when the stop valve **3** is opened to the dry ice maker **4**. The dry ice from the dry ice maker **4** is transported out to the cryogenic condenser **5** chamber by a transport device **14** as shown in Figure 3. In Figure 4, the dry ice maker **4** is inside the cryogenic condenser **5** chamber and the dry ice splash inside the wall of the dry ice maker **4** and the heat is transferred through the wall to cryogenic condenser **5** chamber condensing the exhaust CO_2 to liquid. The temperature of low pressure CO_2 in the cryogenic condenser **5** chamber can be around -40 degrees C. The cryogenic condenser **5** chamber internal is thermal insulated. The dry ice maker **4** inside the cryogenic condenser **5** is designed with material and shape that can transfer cold heat out easily. Some of the cryogenic CO_2 from point **12** goes to the expander **7** input while remaining goes back to the accumulator cylinder **2** through transfer pump (compressor) **6** the cryogenic CO_2 pressure becomes higher. Alternatively, the cryogenic CO_2 can go to the expander **7** input after the transfer pump **6** at the expense of lowering the capacity for the chilling purpose. The cryogenic CO_2 that enters expander **7** chamber come in contact with the warm surface of the expander **7** chamber which has a high temperature maintained by the heat source **8**. The cryogenic CO_2 volume expands as its temperature rises close to critical point. Depending on the type of expander **7,** the volume expansion causes the vanes or piston of the expander **7** to rotate and perform work **9**. The work **9** can be turning a generator (not shown in the diagram) or other mechanical function. The CO_2 becomes medium pressure and warmer. It exhausts out into the cryogenic condenser **5** at exhaust input point **13**. The exhausted CO_2 gets colder with increasing density by the cryogenic condenser **5** freezing temperature. The cryogenic CO_2 splits into 2 paths, one for chilling the cryogenic condenser **5** and the other to expander **7** for performing work **9** and all return back before the transfer pump **6** to complete the closed loop cycle. The second stop valve **16** is used for starting or stopping the expander **7** operation.

[0044] In another embodiment Figure 2, the ambient heat engine system **1A** of a closed loop performance comprises of an accumulator cylinder **2**, cryogenic condenser **5**, transfer pump **6** and another closed loop comprises the expander **7**, cryogenic condenser **5**. Dry ice maker **4** is inside the cryogenic condenser **5**. In one closed loop, the cryogenic CO_2 feed into the expander **7** from cryogenic condenser **5**, and the exhausted CO_2 from the expander **7** is returned to cryogenic condenser **5** via input point **13**. When the exhausted CO_2 enters into the cryogenic condenser **5**, it gets colder and denser into cryogenic liquid where it is fed back to the expander **7**. The input point **13** and output point **12** each has a check valve (not shown) to hold the CO_2 inside the cryogenic condenser **5** when expander **7** is not operation. CO_2 can only circulate around expander **7** and cryogenic condenser **5** in one direction. The cryogenic condenser **5** is chilled by the high pressure CO_2 discharged via point **11** to low pressure forming dry ice in the dry ice maker **4** with transfer pump **6** pumping back to high pressure forming another closed loop.

[0045] The heat source **8** can be just direct ambient heat. For producing a larger power by the expander **7**, a high temperature reactor (not shown in the diagram) can be incorporated to reduce the size of heat exchanging surface of the expander **7**. The high temperature reactor can be powered by HHO gas and use for gasification of waste and create more heat energy. This is particular helpful for a very power generation and for area where the ambient temperature is too low for a generating a good power level.

[0046] The heat exchanger **10** is optional in both system **1** and **1A**. The high pressure cryogenic CO_2 before returning to the accumulator cylinder **2** passes through a heat exchanger **10** where its cold temperature is transferred out for other application.

[0047] In the reactor, HHO is generating on the spot and on-demand. The heat generated by the HHO generation is recovered as component of the heat source **8.**

Claims

1. Ambient Heat Engine comprising:
An expander receiving a liquid work medium and expands to perform work and exhaust to a cryogenic condenser where work medium is chilled back to higher density and deliver back to expander, and
A compressor connects to the cryogenic condenser for receiving and compressing a working medium to higher pressure and delivers the working medium to the cryogenic condenser,
Wherein the cryogenic working medium is configured to be circulated around the expander, cryogenic condenser and the compressor in forming a closed loop.

2. Ambient Heat Engine of Claim 1 further comprising
a working medium that comprises carbon dioxide, ammonia or a combination of both.

3. Ambient Heat Engine of Claim 1 or 2, wherein
The expander comprises a rotary device that is configured to produce mechanical movement.

4. Ambient Heat Engine of Claim 3 further comprising
An electric generator that is connected to the expander for converting the mechanical movement into electricity.

5. Ambient Heat Engine of any of the preceding Claims, wherein
The expander comprises an accumulator cylinder for collecting the working medium.

6. Ambient Heat Engine of any of the preceding Claims, wherein
The expander further comprises a compressor, a reciprocate engine or both.

7. Ambient Heat Engine of Claim 6, wherein
The reciprocate engine comprises a piston for achieving reciprocating movement with a chamber of the reciprocate engine.

8. Ambient Heat Engine of Claim 6 or 7, wherein
The reciprocate engine comprises a relief valve that is configured to cooperate with the piston for injecting or discharging the working medium into or from the chamber.

9. Ambient Heat Engine of Claim 8, wherein
The reciprocate engine further comprises a cam connected to the piston for activating the release valve.

10. Ambient Heat Engine of any of the preceding Claims, wherein
The at least one heat exchanger direct contact with the expander comprises parts that are exposed to ambient for absorbing ambient heat.

11. Ambient Heat Engine of any of the preceding Claims, wherein
The at least one heat exchanger comprises a reactor that is configured to disassociate feedstock into gases.

12. Ambient Heat Engine of Claim 11, wherein
The reactor comprises electrodes for generating HHO gas.

13. Ambient Heat Engine of Claim 11 or 12, wherein
The reactor comprises a burner of high refractory index, a high melting point or both.

14. Ambient Heat Engine of Claim 13, wherein
The burner comprises spiral passages for conveying the feedstock in fluidic form.

15. Ambient Heat Engine of any of the preceding Claims, wherein
The at least one heat exchanger comprises a freezer module for chilling water or forming ice.

16. Method of using an Ambient Heat Engine according to any of the preceding Claims, the method comprising:
Injecting a working medium into the Ambient Heat Engine.

17. Method of Claim 16 further comprising
Compressing the working medium by the compressor such that pressure of the working fluid is raised to be equal or higher than a critical point of the working fluid in forming a highly compressed fluid.

18. Method of Claim 16 or 17 further comprising:
Expanding the working medium rapidly for increasing temperature of the working medium.

19. Method of any of the preceding Claims 16 to 18 further comprising
Absorbing heat from ambient of the Ambient Heat Engine.

20. Method of any of the preceding Claims 16 to 19 further comprising
Heating the working medium by an artificial heat source.

21. Method of any of the preceding Claims 16 to 20, where
The heating of the working medium comprises removing heat from waste water, room air, sea water or any other heat generators.

22. Method of any of the preceding Claims 16 to 21 further comprising
Raising temperature of the working medium by beyond its critical point.

23. Method of any of the preceding Claims 16 to 22 further comprising
Changing temperature of the working medium beyond or below its triple point.

24. A second Ambient Heat Engine comprising:
An expander receiving a liquid work medium and expands to perform work and exhaust to a cryogenic condenser where work medium is chilled back to higher density and return to expander,
A compressor connects to the cryogenic condenser for receiving and compressing a working medium to higher pressure and delivers the working medium to the cryogenic condenser,
Wherein the liquid working medium is configured to be circulated around the expander, cryogenic condenser in one closed loop and the cryogenic condenser and compressor forming another closed loop.

25. A cryogenic condenser chilled by using the same working fluid medium for the work expander.

26. A cryogenic condenser where the refrigerant and working fluid medium are mixed in the chamber for condensing process.

27. Cryogenic condenser of claim 26 where the refrigerant is carbon dioxide.

28. Cryogenic condenser of claim 26 where include making of dry ice.

29. Ambient Heat Engine of Claim 1 or 24, wherein
the liquid working medium is cryogenic.

30. Ambient heat engine comprising:
- an expander for receiving a refrigerant of liquid or supercritical form, and expanding the refrigerant to gas form;
- a condenser whose inlet is connected to an outlet of the expander for condensing the refrigerant of gas form back to liquid form;
- a compressor whose inlet is joined to an outlet of the condenser for increasing pressure of the refrigerant of liquid form, an inlet of the expander being connected to an outlet of the condenser for

circulating the refrigerant to the expander, the condenser, the compressor or a combination of any of these;

wherein the expander is configured to absorb ambient heat of the ambient heat engine for expanding the refrigerant of liquid or supercritical form.

31. Ambient heat engine of Claim 30 further comprising:

A heat exchanger connected to the inlet of the expander for regulating temperature of the refrigerant.

32 Ambient heat engine of Claim 31, wherein

The heat exchanger comprises a reactor for disassociating hazardous waste materials.

33. Ambient heat engine of Claim 31 or 32, wherein

The heat exchanger further comprises a chiller for freezing water.

34. Ambient heat engine of any of the preceding Claims 30 to 33 further comprising:

An accumulator cylinder joined to an inlet of the heat exchanger, the inlet of the expander or both for holding the refrigerant.

35. Ambient heat engine of Claim 34, wherein

An outlet of the accumulator cylinder is connected to another inlet of the condenser.

36. Ambient heat engine of Claim 35 further comprising:

At least one valve connected between the accumulator cylinder and the condenser.

37. Ambient heat engine of Claim 36, wherein

The at least one valve comprises a regulator, a check valve, a stop valve or a combination of any of these.

38. Ambient heat engine of any of the preceding Claims 30 to 37, wherein
The condenser is configured to condense the refrigerant below ambient temperature of natural environment at from about –50°C to about +50°C.

39. Ambient heat engine of any of the preceding Claims 30 to 38, wherein
The expander comprises at least one movable component for converting pressure difference to mechanical movements.

40. Ambient heat engine of any of the preceding Claims 30 to 39 further comprising:
Carbon dioxide or ammonia as the refrigerant.

41. Ambient heat engine of any of the preceding Claims 30 to 40, wherein
The condenser comprises a dry ice maker.

42. Ambient heat engine of any of the preceding Claims 30 to 41 further comprising
a pressure regulator connected to the inlet of the condenser for controlling pressure of the inlet of the condenser at a predetermined pressure.

43. Ambient heat engine of any of the preceding Claims 30 to 42, wherein
The refrigerant comprises a cryogenic fluid whose freezing temperature is lower than zero degree Celsius.

44. Ambient heat engine of any of the preceding Claims 30 to 43, wherein
The condenser is configured to condense the refrigerant of gaseous form or a mixture of gaseous and liquid form.