CLAIMS

1. A heat machine for realizing a heat cycle, the heat machine operating with a thermal fluid and configured to function with a combined heat cycle using hot air and aqueous vapour, featuring unidirectional continuous motion of the thermal fluid, the heat machine, comprising:

- a drive unit comprising:

  - a casing delimiting therein an annular chamber and having dimensioned inlet or discharge openings in fluid communication with conduits external to the annular chamber, wherein each inlet or discharge opening is angularly spaced from the adjacent inlet and discharge openings so as to define an expansion/compression path for a working fluid in the annular chamber;

  - a first rotor and a second rotor rotatably installed in said casing; wherein each one of the two rotors has three pistons that are slidable in the annular chamber; wherein the pistons of one of the rotors are angularly alternated with the pistons of the other rotor; wherein angularly adjacent pistons delimit six variable-volume chambers;

  - a primary shaft operatively connected to said first and second rotor;

  - a transmission that is operatively interposed between said first and second rotor and the primary shaft and configured to convert the rotational motion with respective first and second periodically variable angular velocities of said first and second rotor that are offset relative to each other into a rotational motion having a constant angular velocity of the primary shaft; wherein the transmission is configured to confer, on the periodically variable angular velocity of each of the rotors, six periods of variation for each complete revolution of the primary shaft;

  wherein said drive unit is a rotary volumetric expander operating with said thermal fluid;

- a first section of the drive unit, where, following the movement of the two pistons away from each other, the thermal fluid, passing through the inlet opening, is suctioned into the chamber;

- a second section of said drive unit, where, following the movement of the two pistons towards each other, the previously suctioned thermal fluid is compressed in the chamber and then, on passing through the discharge opening, a pipe and a check valve, it is conveyed into a compensation tank;

- a compensation tank configured to accumulate the compressed thermal fluid to make it available, via specific pipes and the check valve, for subsequent use thereof, in a continuous mode;

- a regenerator, in fluid communication via specific pipes with said drive unit and configured to preheat the thermal fluid prior to its entry in a heater;

- a heater configured to superheat the thermal fluid circulating in a serpentine coil, using the thermal energy produced by a burner;

- a burner with a combustion chamber attached thereto, said burner being apt for operating with various types of fuel and being capable of supplying the necessary thermal energy to the heater;

- a third section of said drive unit, in fluid communication with said heater, via specific pipes, and capable of receiving, via the inlet openings, the thermal fluid heated to a high temperature under pressure in the heater so as to have it expand in the chambers, which are delimited by the pistons, respectively, for the purpose of having said pistons rotate and produce work;

- a fourth section of said drive unit, in fluid communication with the regenerator through the discharge openings and specific pipes, and wherein, due to the reduction in volume of the two chambers brought about by the movement of the two pairs of pistons towards each other, the exhausted thermal fluid is forcedly expelled;

- wherein said regenerator, in fluid communication with said drive unit, is further configured to acquire heat-energy from the exhausted thermal fluid and to use it to preheat the thermal fluid to be sent to the heater.

2. The heat machine according to claim 1, wherein the first section of the drive unit is in fluid connection with the external environment via a pipe, so that the ambient air can be suctioned into the chamber, and wherein the heat machine comprises a metering pump in fluid connection with a distilled water tank and arranged so as to enable a predefined amount of distilled water to be injected in an air circuit by means of an injector, said predefined amount being capable of increasing the unit power of the drive unit and of ensuring lubrication of the cylinder.

3. The heat machine according to claim 1, comprising:

- a cooler that is operatively interposed between the low temperature outlet of the regenerator and the inlet of the heater,

wherein the thermal fluid, exiting from the cooler at temperature T1, passes into a pipe, passes through a condensate trap, where the water in the thermal fluid is condensed and separated from the air, passes into a pipe at temperature T1', passes through the suctioning opening and following the movement of the two pistons away from each other, is suctioned into the chamber of said first section, and wherein, pushed by a high-pressure pump, the condensate water previously extracted from the air by the trap travels through specific pipes and reaches an injector arranged so as to inject, in an air circuit, a predefined amount of condensate water, which is capable of increasing the unit power of the drive unit and of ensuring lubrication of the cylinder.

4. The heat machine according to claim 1, comprising:

- a cooler that is operatively interposed between the low temperature outlet of the regenerator and the inlet of the heater;

wherein the thermal fluid, exiting from the cooler at temperature T1, passes into a pipe, passes through a condensate trap, where the water in the thermal fluid is condensed and separated from the air, passes into a pipe at temperature T1', passes through the suctioning opening and following the movement of the two pistons away from each other, is suctioned into the chamber of said first section, and wherein, pushed by a high-pressure pump, the condensate water previously extracted from the air by the trap travels through the pipes and reaches an evaporator that is configured to heat and vaporize the condensate water and send it to an injector arranged so as to inject, in an air circuit, a predefined amount of aqueous vapour, which is capable of increasing the unit power of the drive unit and of ensuring lubrication of the cylinder,

wherein said evaporator is operatively interposed, with its high temperature side, between said high pressure pump and said injector,

and wherein said evaporator is configured to receive as incoming fluid, on its low temperature side, the exhausted thermal fluid expelled from the outlet of the drive unit, so as to acquire residual heat-energy from this exhausted thermal fluid and to use it to preheat the thermal fluid to be sent to the heater.

5. The heat machine according to claim 1, comprising:

- a cooler that is operatively interposed between the low temperature outlet of the regenerator and the inlet of the heater;

wherein the thermal fluid, exiting from the cooler at temperature T1, passes into a pipe, passes through a condensate trap, where the water in the thermal fluid is condensed and separated from the air, passes into a pipe at temperature T1', passes through the suctioning opening and following the movement of the two pistons away from each other, is suctioned into the chamber of said first section, and wherein, pushed by a high-pressure pump, the condensate water previously extracted from the air by the trap travels through the pipes and reaches an evaporator that is configured to heat and vaporize the condensate water and send it to a superheater, which, by extracting energy from the hot combustion fumes downstream of the burner, is configured to superheat the saturated vapour exiting from the evaporator, so as to supply energy thereto;

wherein said superheater is configured to send the vaporized and superheated condensate water to an injector, which is arranged so as to enable injection, in an air circuit, of a predefined amount of superheated aqueous vapour, which is capable of further increasing the unit power of the drive unit and of ensuring lubrication of the cylinder,

wherein said evaporator is operatively interposed, with its high temperature side, between said high pressure pump and said superheater,

and wherein said evaporator is configured to receive as incoming fluid, on its low temperature side, the exhausted thermal fluid expelled from the outlet of the drive unit, so as to acquire residual heat-energy from this exhausted thermal fluid and to use it to preheat the thermal fluid to be sent to the heater.

6. The heat machine according to claim 5, and provided with a cooling circuit comprising:

- a first recuperator, located upstream of the burner, where combustion air is drawn from the environment;
- a cooling unit associated with the drive unit;
- a second recuperator, located downstream of the burner and the heater, and preferably downstream of said superheater, along the exit path of the hot combustion fumes;
- a plurality of cooling pipes connecting in series said first recuperator, said cooling unit and said second recuperator, so as to form a circular path, and bearing an amount of cooling fluid (preferably water);
- a cooling pump located in said circuit and that is operatively active on one pipe of said plurality of cooling pipes so as to bring about circulation of said cooling fluid in the cooling circuit;

wherein:

- said first recuperator is configured to cool said cooling fluid by surrendering heat-energy to said combustion air;
- said cooling unit is configured to cool the drive unit by transfer of heat-energy from the drive unit to the cooling fluid, which undergoes an increase in temperature;
- said second recuperator is configured to heat said cooling fluid by acquiring heat-energy from the hot combustion fumes.

7. The heat machine according to any one of the preceding claims and equipped with an auxiliary hydraulic circuit comprising:

- an auxiliary recuperator, located downstream of the burner and the heater, along the exit path of the hot combustion fumes;
- a plurality of auxiliary pipes configured to pass through said auxiliary recuperator and to be connected with one or more auxiliary uses, preferably devices for space heating and/or production units for domestic hot water;
- an auxiliary pump, located in said circuit and that is operatively active on one pipe of said plurality of auxiliary pipes so as to bring about circulation in said auxiliary circuit;

wherein said auxiliary recuperator is configured to recover energy from the combustion fumes and to transmit it to the fluid circulating in said auxiliary circuit, said energy thus being available for said auxiliary uses.

8. The heat machine according to any one of the preceding claims, further comprising:

- a fan located upstream of the burner and configured to draw combustion air from the environment and to send it forcedly to said burner to feed the combustion process; and/or
- one or more check vales located along the pipes of the heat machine and configured to facilitate circulation of the thermal fluid in a unidirectional manner and prevent the outflow of the thermal fluid in the opposite direction.

9. A method for realizing a heat cycle, the method operating with a thermal fluid and being configured to function with a combined heat cycle using hot air and aqueous vapour, featuring unidirectional continuous motion of the thermal fluid, the method comprising the steps of:

- arranging a heat machine, according to one or more of claims 1 to 8;
- carrying out the following steps:
    - starting up the primary shaft and the transmission of the drive unit, setting the pistons into motion;
    - activating the burner and starting up the combustion process;
    - when the thermal fluid circulating in the heat machine has reached a pre-established minimum operating state, the drive unit produces the work needed to be able to turn independently;
    - following the movement of the two pistons away from each other, the thermal fluid is suctioned into the chamber through the suctioning opening;
    - following the movement of the two pistons towards each other, the previously suctioned thermal fluid is compressed in the chamber, undergoes an increase in temperature from T1' to T2, passes through the discharge opening and reaches the compensation tank;
    - with the intermittency determined by the rotation of the pistons and the resulting opening/closing of the inlet openings, the thermal fluid flows out from the tank and passes through the regenerator, where it undergoes an increase in temperature from T2 to T2';
    - the thermal fluid passes through the heater, where it receives heat-energy and increases in temperature from T2'' to T3;
    - rotating in the annular cylinder, when the pistons open the inlet openings, the superheated thermal fluid is admitted into the expansion chambers where it expands, with a decrease in its temperature from T3 to T4 and, as it makes the pistons rotate, it produces useful work;
    - following the movement of the pistons towards each other, the chambers diminish in volume, the exhausted thermal fluid is expelled from the drive unit, passes through the discharge openings, and through the regenerator, where it surrenders part of the heat-energy still possessed and undergoes a decrease in temperature from T4 to T4'.

10. The method according to claim 9, wherein in the step of suctioning the thermal fluid into the chamber, said thermal fluid is air suctioned from the environment at temperature T1', and wherein the method comprises the steps of:
- drawing distilled water from the tank;

- activating the metering pump and introducing a given amount of distilled water into the circuit by means of the injector, thereby bringing about a decrease in the temperature of the resulting thermal fluid from T2' to T2'';

and wherein, following the step of passing through the regenerator, the exhausted thermal fluid is discharged into the atmosphere.

11. The method according to claim 9, further comprising the following steps:

- the thermal fluid, exiting from the cooler at temperature T1, passes into a pipe, passes through a condensate trap, where the water in the thermal fluid is condensed and separated from the air, passes into a pipe at temperature T1', passes through the suctioning opening and following the movement of the two pistons away from each other, is suctioned into the chamber of said first section;

- pushed by a high-pressure pump, the condensate water previously extracted from the air by the trap travels through pipes and reaches an injector arranged so as to enable injection, in an air circuit, of a predefined amount of condensate water, which is capable of increasing the unit power of the drive unit and of ensuring lubrication of the cylinder.

12. The method according to claim 9, further comprising the following steps:

- the thermal fluid, exiting from the cooler at temperature T1, passes into a pipe, passes through a condensate trap, where the water in the thermal fluid is condensed and separated from the air, passes into a pipe at temperature T1', passes through the suctioning opening and following the movement of the two pistons away from each other, is suctioned into the chamber of said first section;

- pushed by a high-pressure pump, the condensate water previously extracted from the air by the trap travels through the pipes and reaches an evaporator that is configured to heat and vaporize the condensate water and to send it to an injector arranged so as to enable injection, in an air circuit, of a predefined amount of aqueous vapour, which is capable of increasing the unit power of the drive unit and of ensuring lubrication of the cylinder;

wherein said evaporator is configured to receive as incoming fluid, on its low temperature side, the exhausted thermal fluid expelled from the outlet of the drive unit, so as to acquire residual

heat-energy from this exhausted thermal fluid and to use it to preheat the thermal fluid to be sent to the heater.

13. The method according to claim 9, further comprising the following steps:

- the thermal fluid, exiting from the cooler at temperature T1, passes into a pipe, passes through a condensate trap, where the water in the thermal fluid is condensed and separated from the air, passes into a pipe at temperature T1', passes through the suctioning opening and following the movement of the two pistons away from each other, is suctioned into the chamber of said first section;
- pushed by a high-pressure pump, the condensate water previously extracted from the air by the trap travels through the pipes and reaches an evaporator that is configured to heat and vaporize the condensate water and to send it to a superheater, which, by extracting energy from the hot combustion fumes downstream of the burner, is configured to superheat the saturated vapour exiting from the evaporator, so as to supply energy thereto;

wherein said superheater is configured to send the superheated aqueous vapour to an injector, which is arranged so as to enable injection, in an air circuit, of a predefined amount of said superheated aqueous vapour, which is capable of further increasing the unit power of the drive unit, of increasing the overall yield and of ensuring lubrication of the cylinder,

and wherein said evaporator is configured to receive as incoming fluid, on its low temperature side, the exhausted thermal fluid expelled from the outlet of the drive unit, so as to acquire residual heat-energy from this exhausted thermal fluid and to use it to preheat the thermal fluid to be sent to the heater.

14. The method according to claim 13, further comprising the following steps:

- arranging a cooling circuit, comprising:
    - a first recuperator, located upstream of the burner, where combustion air is drawn from the environment;
    - a cooling unit associated with the drive unit;
    - a second recuperator, located downstream of the burner and the heater, and preferably downstream of said superheater, along the exit path of the hot combustion fumes;

- a plurality of cooling pipes connecting in series said first recuperator, said cooling unit and said second recuperator, so as to form a circular path, and bearing an amount of cooling fluid;

- a cooling pump located in said circuit and that is operatively active on one pipe of said plurality of cooling pipes so as to bring about circulation of said cooling fluid in the cooling circuit;

- carrying out the following steps:

- cooling the cooling fluid by means of said first recuperator by surrendering heat-energy to said combustion air;

- cooling, by means of said cooling unit, the drive unit by transfer of heat-energy from the drive unit to the cooling fluid, which undergoes an increase in temperature;

- heating, by means of said second recuperator, said cooling fluid by acquiring heat-energy from the hot combustion fumes.

15. The method according to any one of claims 9 to 14, further comprising the following steps:

- arranging an auxiliary hydraulic circuit, comprising:

- an auxiliary recuperator, located downstream of the burner and the heater, along the exit path of the hot combustion fumes;

- a plurality of auxiliary pipes configured to pass through said auxiliary recuperator and to be connected with one or more auxiliary uses, preferably devices for space heating and/or production units for domestic hot water;

- an auxiliary pump, located in said circuit and that is operatively active on one pipe of said plurality of auxiliary pipes so as to bring about circulation in said auxiliary circuit;

- carrying out the following steps:

- recovering energy from the combustion fumes, by means of said auxiliary recuperator;

- transmitting said energy to the fluid circulating in said auxiliary circuit;

- making said energy available for auxiliary uses.