METHOD AND APPARATUS FOR HARVESTING WATER AND LATENT ENERGY FROM A GASEOUS MIXTURE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method for harvesting latent energy and nonvaporous water from atmospheric air.

2. Background Art

There has been an increasing interest in environmental energy harvesting. The most well-developed methodologies focus on wind energy, solar energy, and the energy of water flowing under the influence of gravity. A number of strategies have also been developed for harvesting latent energy from atmospheric air. Some of these strategies depend on added water vapor and vertically decreasing atmospheric pressure to stimulate an upward movement of air. Such air within an enclosed, vertical conduit is forced by a pressure differential to rise through a wind turbine driving an electric generator to extract energy. In another strategy, air at the conduit base is warmed; and warm water vapor is added. The vapor is assumed to condense as air rises within the enclosed conduit, warming the air and enhancing upward motion. The condensed water is removed in an upper region of the conduit. Other strategies seek similar results but depend on evaporating liquid water into air, thus cooling the air and stimulating the air to move downwardly rather than upwardly. This process finds useful application, for example, in cleaning pollution from industrial stacks, where there is no interest in energy harvesting. Another strategy has liquid water pumped to a high elevation and sprayed into environmental air at that level to cool the air by evaporation. The evaporative air cooling is performed within a conduit that extends from a high to a low altitude, and kinetic energy of the resulting downdraft of air is extracted by a wind turbine driving an electric generator.

Still other strategies do not depend on pressure-altitude differences but disclose machine means for harvesting energy from water vapor provided by a boiler. At least one other strategy uses a flash evaporator to produce steam and a steam-driven turbogenerator to produce energy, and another depends on elaborate machine means to harvest energy by liquefying air itself rather than merely liquefying water vapor.

A number of strategies disclose the removal of condensed liquid water from an air-water mixture contained within a closed volume. One discloses means to control the formation of condensate into liquid droplets using a condensing surface of inverted circular cones attached to a metal plate. Another discloses means for collecting water blown off a cooling coil by high velocity air, improving such collection by coils used in low-fluid-velocity water collection systems. Yet another discloses the use of charged aerosol sources powered directly by the wind. The means comprise a large area electrode screen, which emits charged water droplets into a wind stream as a wind-electric power transducer. Still another discloses means for harvesting water from air that involve an isothermal compression to a saturated state that requires means to remove energy from the process to maintain the isothermal compression. In contrast, the process of the present invention adiabatically decompresses, with no exchange of energy with an external environment, a controlled volume of atmospheric air to a pressure at which resident water vapor reaches a saturated state.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a process for harvesting latent energy and nonvaporous water, that is, liquid or solid water, from water vapor in atmospheric air. In carrying out the foregoing object, the process for harvesting latent energy includes decompressing a controlled volume of the atmospheric air so that the temperature of the air is decreased to a point where the water vapor reaches saturation; and the water vapor changes state by condensation, and possibly by deposition, and releases latent heat. Nonvaporous water resulting

WHAT IS CLAIMED IS:

1. A method of operating a mechanically and thermodynamically closed system that is at least one magnitude smaller than devices that depend on natural, altitude-dependent air density differences for harvesting latent energy and water from atmospheric air, one of a desired number of cycles of the method comprising the steps of:

(a) ingesting a mechanically controlled volume of atmospheric air into a thermally insulated chamber;

(b) adiabatically decompressing the controlled volume of air to decrease the temperature and pressure within the chamber to a point where (1) the pressure equals the saturation vapor pressure of water vapor within the chamber, (2) the water vapor commences to change state to nonvaporous water, (3) the adiabatic decompression continues to decrease pressure, temperature, and saturation vapor pressure, producing a continuation of the water vapor phase change to nonvaporous water, and (4) the water vapor change of phase continues to release latent energy into the air within the chamber;

(c) extracting from the chamber the nonvaporous water that resulted from the state change of the water vapor to nonvaporous water and retaining the nonvaporous water in a separate, insulated reservoir, at the same pressure as that of the decompressed air within the chamber, to render the process of latent energy release nearly irreversible;

(d) adiabatically recompressing the previously decompressed air in the chamber so that, as a result of having absorbed the latent energy released by the water vapor, the recompressed air has a much higher temperature, and a greater amount of thermal energy, than had the ingested air before being decompressed because the recompressed air retains the thermal energy that would be required to change the state of the nonvaporous water back into vapor had the nonvaporous water not been extracted from the chamber;

(e) extracting the recompressed air from the chamber and conducting the recompressed air to an external thermal energy harvesting device and harvesting the greater amount of thermal energy from the recompressed air.

2. The method of claim 1, further comprising step (f) of harvesting nonvaporous water extracted from the thermally insulated chamber during step (c).

3. The method of claim 1, further comprising a step before step (a), the additional step comprising prewarming the controlled volume of atmospheric air before the air is ingested.

4. The method of claim 1, further comprising a step before step (a), the additional step comprising prehumidifying the controlled volume of atmospheric air, sufficiently to ensure a saturated adiabatic decompression, before the air is ingested.

5. The method of claim 1, further comprising steps before step (a), the additional steps comprising prewarming and prehumidifying the controlled volume of atmospheric air, sufficiently to ensure a saturated adiabatic decompression, before the air is ingested.

6. The method of claim 1, wherein recompressing the decompressed air during step (d) is terminated when the measured pressure of the recompressing air reaches that of the initial controlled volume of air.

7. The method of claim 1, wherein recompressing the decompressed air during step (d) is terminated when the controlled volume of the recompressing air reaches that of the initial controlled volume of air.

8. The method of claim 1, wherein recompressing the decompressed air during step (d) is terminated when the pressure and the volume of the recompressing air are at a state represented by a point along an unsaturated adiabat between a point where the pressure of the recompressing air reaches that of the initial pressure of air and a point where the volume of the recompressing air reaches that of the initial controlled volume of air.