

DISC-TYPE SOLAR STIRLING ENGINE POWER GENERATION DEVICE CAPABLE OF OPERATING CONTINUOUSLY DAY AND NIGHT

FIELD OF THE INVENTION

[0001] The invention relates to a dish-type Stirling solar generator capable of running continuously day and night, and belongs to a complementary method for power generation combining conventional fossil energy with a Stirling solar unit, and belongs to the field of a complementary power generation combining biomass clean energy with the Stirling solar unit.

BACKGROUND OF THE INVENTION

[0002] As reserves of the conventional fossil energy (coal, oil, and natural gas) become smaller and smaller and the environmental pollution problems brought about by the fossil energy directly threatens the survival and the development of human, it is a consensus of governments of different countries to focus and emphasize the development of renewable and green energy. Solar energy has a wide distribution, limitless reserves, cleanness in collection and utilization, and zero-CO₂ emission. Thus, the solar energy has been concerned by more and more people.

[0003] According to the method for solar collection, the current method for power generation by using the solar energy includes: tower concentrating solar power generation, parabolic trough concentrating solar power generation, and a dish-type Stirling solar power generation.

[0004] The dish-type Stirling solar power generation unit is capable of automatically tracking the sun in two dimensions, and has a high the photoelectric convention efficiency and small starting loss. The dish-type Stirling solar power generation unit is so

far a system that has the highest efficiency of solar power generation, exceeding 30%. The system almost consumes no water, and an output efficiency reaches 26% (a self-tracking mechanism consumes energy).

[0005] However, as the sunlight collectable on the ground is available in daylight, non-available during night, intensive in sunny day, and weak in cloudy day. Thus, the dish-type Stirling solar power generator operates unstably and cannot continuously operates for 24 hours, which seriously restricts the use thereof.

[0006] As an organic matter produced by the photosynthesis of plants, biomass is characterized in its wide distribution, large reserves, much cleaner than fossil energy, and zero-CO₂ emission. Biomass is the only clean energy that is able to burn in solid state, liquid state, and gas-state; and it is also a very important renewable resource.

[0007] Various biomass liquefaction technology, biomass gasification technology, and combustor technology for combustible gas and combustible liquid have been well developed and well known by the public.

SUMMARY OF THE INVENTION

[0008] In order to overcome the above technical problems of the conventional dish-type Stirling solar generating set, and to solve problems of the unstable operation and discontinuous power generation of the dish-type Stirling solar generating set, it is one objective of the invention to provide a dish-type Stirling solar generator capable of running continuously day and night. Gas fuel or liquid fuel is used as a second heat source of the dish-type Stirling solar generator. During nocturnal periods or cloudy days when the sunlight is too weak and the generator cannot reach the rated speed or output the qualified energy, the combustible gas (combustible liquid) is replenished to supply heat for power generation, so that problems of incapability of power generation during

night and the unstable operation of the dish-type Stirling solar generating system are solved.

[0009] Furthermore, when using the biomass fuel as the second heat source, technical problems of combining the solar energy and the biomass energy are solved, thereby endowing the invention with advantages of zero-CO₂ emission and power generation using renewable and clean energy source.

[0010] Technical solution of the invention is: a dish-type Stirling solar generator capable of running continuously day and night comprises a dish-type Stirling solar generating set. The dish-type Stirling solar generating set comprises a combustor comprising an opening, and a position adjustment mechanism of the combustor. The position adjustment mechanism is capable of adjusting the opening of the combustor to align or deviate from a heat receiver of the dish-type Stirling solar generating set. The position adjustment mechanism is disposed on a bracket of the dish-type Stirling solar generating set. The combustor is disposed on the position adjustment mechanism. A fuel supply system of the combustor is connected to the combustor via a main switch valve, a branch switch valve, a regulating valve, and a flexible conveying pipe.

[0011] The position adjustment mechanism is a telescoping mechanism, a driver of the telescoping mechanism employs a linear actuator, and the combustor is disposed on an output end of the telescoping mechanism.

[0012] The position adjustment mechanism is a bended linkage mechanism. Connecting rods of the bended linkage mechanism are connected via rotary actuators (comprising a pneumatic rotary actuator, a hydraulic rotary actuator, and an electric rotary actuator). The combustor is disposed on an output end of the bended linkage mechanism.

[0013] Preferably, the bended linkage mechanism is a triple linkage mechanism comprising a first connecting rod, a second connecting rod, and a third connecting rod. The connecting rods communicate with each other via the rotary actuators. The first

connecting rod is connected to the bracket of the dish-type Stirling solar generating set via the rotary actuator.

[0014] The fuel supply system is a combustible gas supply system comprising a gas-storage tank, a pump, the main switch valve, the branch switch valve, the regulating valve, and the flexible conveying pipe, which are connected via pipes.

[0015] Preferably, the fuel supply system is a biomass supply system comprising a biomass gasification device, a purifier, the gas-storage tank, the pump, the main switch valve, the branch switch valve, the regulating valve, and the flexible conveying pipe, which are connected via pipes.

[0016] The fuel supply system is a liquid fuel supply system comprising a gas-storage tank, a pump, the main switch valve, the branch switch valve, the regulating valve, and the flexible conveying pipe, which are connected via pipes.

[0017] Preferably, the fuel supply system is a liquefied biomass supply system comprising a biomass liquefaction device, a purifier, the gas-storage tank, the pump, the main switch valve, the branch switch valve, the regulating valve, and the flexible conveying pipe, which are connected via pipes.

[0018] The position adjustment mechanism of the combustor is started at night (or in cloudy or rainy days when the sunlight is not sufficient) to allow the combustor to move to the position of the heat receiver of the dish-type Stirling solar generating set. The fuel is supplied and ignited to heat the heat receiver, so that the dish-type Stirling solar generating set continues generating power.

[0019] The gas fuel for the combustion device is natural gas (methane, coal mine gas, coking gas, blast furnace gas, or well collected gas). In conditions of no sunlight (or the sunlight is insufficient), the natural gas is burned to ensure that the Stirling solar generating set operates continuously day and night.

[0020] The gas fuel for the combustion device is diesel oil (kerosene, gasoline, black mineral oil, carbinol, or alcohol). In conditions of no sunlight (or the sunlight is not sufficient), the diesel oil is burned to ensure that the Stirling solar generating set operates continuously day and night.

[0021] Advantages of the invention are summarized as follows: the gas fuel or the liquid fuel is used as the second heat source of the dish-type Stirling solar generator. During nocturnal periods or cloudy days when the sunlight is too weak and the generator cannot reach the rated speed or output the qualified energy, the combustible gas (combustible liquid) is replenished to supply heat for power generation, so that problems of incapability of power generation during night and the unstable operation of the dish-type Stirling solar generating system are solved.

[0022] The invention particularly combines the biomass gasified or liquefied energy with the Stirling solar generating set to form a clean energy power generator being capable of operating continuously and stably.

[0023] The technical solution of the invention involves power generation by combining the solar energy with the biomass energy, which is superior in the stable power generation, small influence by the climate variation, almost consuming no water, and zero-CO₂ emission.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. **1** is a schematic diagram of a dish-type Stirling solar generator in accordance with one embodiment of the invention;

[0025] In the figure, the reference number **1** represents a dish-type Stirling solar generating set, **1a** represents a bracket of the dish-type Stirling solar generating set, **1b** represents a heat receiver of the dish-type Stirling solar generating set, **1c** represents a

dish-type mirror, **1d** represents a bracket of the dish-type mirror, the bracket comprising a sunlight tracker, **2** represents a combustor, **2c** represents a movement direction of the combustor, **2d** represents a movement terminal of the combustor, **3** represents a position adjustment mechanism of the combustor which may be an air-, liquid-, or electricity-driven telescoping mechanism, **4** represents a biomass gasification device or biomass liquefaction device, **4a** represents a gas-storage tank, **4b** represents a pump, **4c** represents a main switch valve, **4d** represents a purifier, **5** represents a branch switch valve, **6** represents a regulating valve, and **7** represents a flexible conveying pipe which is connected to a fuel inlet of the combustor **2**.

[0026] FIG. 2 is a schematic diagram of a position adjustment mechanism of a combustor of the invention where the position adjustment mechanism employs a bended linkage mechanism.

[0027] FIG. 3 is a local enlarged view of a bended linkage mechanism of the invention.

[0028] In FIGS. 2 and 3, the reference number **1** represents a dish-type Stirling solar generating set, **1a** represents a bracket of the dish-type Stirling solar generating set, **1b** represents a heat receiver of the dish-type Stirling solar generating set, **1c** represents a dish-type mirror, **1d** represents a bracket of the dish-type mirror, the bracket comprising a sunlight tracker, **2** represents a combustor, **2d** represents an optimum heating position of the combustor, **3d** represents a first connecting rod, **3e** represents a second connecting rod, **3f** represents a third connecting rod, **3g** represents rotary actuators, an initiating terminal of the first connecting rod **3d** is connected to **1a** via **3g1**, a terminal of **3d** is connected to an initiating terminal of **3e** via **3g2**, a terminal of **3e** is connected to an initiating terminal of **3f** via **3g3**, a terminal of **3f** is fixed on the combustor **2**, **5** represents a branch switch valve, **6** represents a regulating valve, and **7** represents a flexible conveying pipe which is connected to a fuel inlet of the combustor **2**. **5** is connected to a main switch valve via a fuel conveying pipe, and fuel supply systems in the figures are

the same as that in FIG. 1.

[0029] FIG. 4 is a systematic diagram of a Stirling electric power plant of the invention.

[0030] In the figure, four dish-type Stirling solar generating sets are combined which share a combustible gas (combustible liquid) supply system. The number of the dish-type Stirling solar generating set can be increased or decreased based on the desired gross power of a generating plant.

[0031] In the figure, the reference number **1** represents a dish-type Stirling solar generating set, **1a** represents a bracket of the dish-type Stirling solar generating set, **1b** represents a heat receiver of the dish-type Stirling solar generating set, **1c** represents a dish-type mirror, **1d** represents a bracket of the dish-type mirror, the bracket comprising a sunlight tracker, **2** represents a combustor, **2c** represents a movement direction of the combustor, **2d** represents a movement terminal of the combustor, **3** represents a position adjustment mechanism of the combustor which may be an air-, liquid-, or electricity-driven telescoping mechanism, **4** represents a biomass gasification device or biomass liquefaction device, **4a** represents a gas-storage tank, **4b** represents a pump, **4c** represents a main switch valve, **4d** represents a purifier, **5** represents a branch switch valve, **6** represents a regulating valve, and **7** represents a flexible conveying pipe which is connected to a fuel inlet of the combustor **2**.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0032] Structure arrangement, the best mode, and the technical process of the invention are described hereinbelow combined with drawings, and the invention is not limited to the examples.

[0033] A dish-type Stirling solar generator capable of running continuously day and night comprises a dish-type Stirling solar generating set provided with a combustor, a position

adjustment mechanism, and a fuel supply system. The position adjustment mechanism is disposed on a bracket of the dish-type Stirling solar generating system. The combustor is arranged on the position adjustment mechanism. The position adjustment mechanism is capable of adjusting an opening of the combustor to align with a heat receiver of the dish-type Stirling solar generating set, so that the heat receiver is heated by the flame of the combustor. The fuel supply system is connected to the combustor via a flexible conveying pipe.

Example 1

[0034] As shown in FIG. 1, a dish-type Stirling solar generator capable of running continuously day and night comprises a dish-type Stirling solar generating set **1**. Each dish-type Stirling solar generating set **1** is provided with a combustor **2**, a position adjustment mechanism **3**, and a fuel supply system. The position adjustment mechanism **3** is disposed on a bracket **1a** of the dish-type Stirling solar generating system. The combustor **2** is arranged on the position adjustment mechanism **3**. The position adjustment mechanism **3** is capable of adjusting the position of the combustor **2** to allow the heat receiver **1b** to continue receiving heat at night (or in cloudy and rainy days having no sunlight). The fuel supply system **4** of the combustor supplies fuel for the combustor via a main switch valve **4c**, a branch switch valve **5**, a regulating valve **6**, and a flexible conveying pipe **7**.

[0035] A driver of the position adjustment mechanism **3** is a linear actuator comprising a pneumatic linear actuator, a hydraulic linear actuator, and an electric linear actuator. A rod of the linear actuator **3** is connected with the combustor. A casing of the driver is fixed on the bracket **1a** (if the pneumatic linear actuator is employed, the casing of the air cylinder is fixed on the bracket **1a**, and a piston rod of the air cylinder is connected to the combustor).

[0036] Obviously, common hydraulic oil cylinder, gas cylinder, and electromagnetic lever can all be utilized as the position adjustment mechanism or part of the position adjustment mechanism.

[0037] The fuel supply system of the combustor comprises biomass gasification device or biomass liquefaction device **4** comprising a gas-storage tank **4a**, a pump **4b**, the main switch valve **4c**, the branch switch valve **5**, the regulating valve **6**, and the flexible conveying pipe **7**, which are connected via pipes. A purifier **4d** of the gas fuel (liquid fuel) is disposed in a pipe network arranged in front of the fuel storage tank. The purifier **4d** of the gas fuel is capable of purifying the fuel.

[0038] The regulating valve **6** is used to control the flow of the fuel and to change the intensity of the heat supply.

[0039] The branch switch valve **5** is used to control the start or the stop of the fuel supply of a single Stirling solar generator.

Example 2

[0040] As shown in FIGS. 2-3, the position adjustment mechanism of the combustor is a bended linkage mechanism. Connecting rods of the bended linkage mechanism are connected via rotary actuators (comprising a pneumatic rotary actuator, a hydraulic rotary actuator, and an electric rotary actuator). The combustor **2** is disposed on an output end of the bended linkage mechanism.

[0041] FIG. 2 is a schematic diagram of the position adjustment mechanism of the combustor of the invention where the position adjustment mechanism employs a bended linkage mechanism. FIG. 3 is a local enlarged view of the bended linkage mechanism of the invention. In FIGS. 2 and 3, the reference number **1** represents the dish-type Stirling solar generating set, **1a** represents the bracket of the dish-type Stirling solar generating

set, **1b** represents the heat receiver of the dish-type Stirling solar generating set, **1c** represents a dish-type mirror, **1d** represents a bracket of the dish-type mirror, the bracket comprising a sunlight tracker, **2** represents the combustor, **2d** represents an optimum heating position of the combustor, **3d** represents a first connecting rod, **3e** represents a second connecting rod, **3f** represents a third connecting rod, and **3g** represents the rotary actuators. An initiating terminal of the first connecting rod **3d** is connected to **1a** via **3g1**. A terminal of **3d** is connected to an initiating terminal of **3e** via **3g2**. A terminal of **3e** is connected to an initiating terminal of **3f** via **3g3**. A terminal of **3f** is fixed on the combustor **2**. **5** represents a branch switch valve. **6** represents a regulating valve, and **7** represents a flexible conveying pipe which is connected to a fuel inlet of the combustor **2**. The branch switch valve **5** is connected to a main switch valve via a fuel conveying pipe, and fuel supply systems in the figures are the same as that in FIG. **1**.

Example 3

[0042] FIG. **4** is systematic diagram of a Stirling electric power plant of the invention.

[0043] In the figure, four dish-type Stirling solar generating sets are combined which share a combustible gas (combustible liquid) supply system. The number of the dish-type Stirling solar generating set can be increased or decreased based on the desired gross power of a generating plant.

[0044] In the figure, the reference number **1** represents a dish-type Stirling solar generating set, **1a** represents a bracket of the dish-type Stirling solar generating set, **1b** represents a heat receiver of the dish-type Stirling solar generating set, **1c** represents a dish-type mirror, **1d** represents a bracket of the dish-type mirror, the bracket comprising a sunlight tracker, **2** represents a combustor, **2c** represents a movement direction of the combustor, **2d** represents a movement terminal of the combustor, **3** represents a position adjustment mechanism of the combustor which may be an air-, liquid-, or electricity-

driven telescoping mechanism, **4** represents a biomass gasification device or biomass liquefaction device, **4a** represents a gas-storage tank, **4b** represents a pump, **4c** represents a main switch valve, **4d** represents a purifier, **5** represents a branch switch valve, **6** represents a regulating valve, and **7** represents a flexible conveying pipe which is connected to a fuel inlet of the combustor **2**.

[0045] The position adjustment mechanism of the combustion device is started at night (or in cloudy or rainy days when the sunlight is not sufficient) to allow the combustor of the combustion device to move to the position of the heat receiver of the dish-type Stirling solar generating set, the fuel is supplied and ignited to heat the heat receiver, so that the dish-type Stirling solar generating set is continued generating power. Thus, the problem that the dish-type Stirling solar generating unit is unable to run stably and continuously work for 24 hours is solved. Particularly, when the biomass combustible gas or the biomass combustible liquid is employed as the fuel, the dish-type Stirling solar generating set is able to operate stably and continuously day and night.

[0046] The fuel for the combustion device can be substituted by natural gas (methane, coal mine gas, coking gas, blast furnace gas, or well collected gas) to allow the Stirling solar generating set to continuously operate day and night. Preferably, the biomass gasification gas is employed.

[0047] The fuel for the combustion device is biomass liquid fuel, diesel oil, kerosene, gasoline, black mineral oil, carbinol, or alcohol to allow the Stirling solar generating set to continuously operate day and night. Preferably, the biomass gasification liquid is employed.

[0048] A solar power station is provided with a plurality of dish-type Stirling solar generating sets (according to the power of the station and the collection area of the solar energy). Each dish-type Stirling solar generating set comprises the combustor arranged on the bracket thereof. The fuel supply system of the combustor is connected to the

combustor via the switch valves, the regulating valve, and the flexible conveying pipe to supply fuel to the combustor. The combustor is connected to the position adjustment mechanism. The position adjustment mechanism is disposed on the bracket of the dish-type Stirling solar generating set. Each dish-type Stirling solar generating set is provided with the fuel supply system, or a plurality of dish-type Stirling solar generating sets share the fuel supply system.

[0049] The key of the invention is that each dish-type Stirling solar generating set is provided with the combustion device. In conditions of no sunlight (or when the sunlight is not sufficient), the combustor of the combustion device moves to the position of the heat receiver of the Stirling solar generating unit, the combustor is then ignited to heat the heat receiver. Thus, those dish-type Stirling solar generating sets individually provided with the combustion device fall within the scope of the protection of the invention.

CLAIMS

1. A dish-type Stirling solar generator capable of running continuously day and night, comprising a dish-type Stirling solar generating set (1), **characterized in that** the dish-type Stirling solar generating set (1) comprises a combustor (2) comprising an opening, and a position adjustment mechanism (3) of the combustor; the position adjustment mechanism (3) is capable of adjusting the opening of the combustor (2) to align or deviate from a heat receiver of the dish-type Stirling solar generating set (1); the position adjustment mechanism (3) is disposed on a bracket (1a) of the dish-type Stirling solar generating set (1); the combustor (2) is disposed on the position adjustment mechanism (3); and a fuel supply system (4) of the combustor (2) is connected to the combustor (2) via a main switch valve (4c), a branch switch valve (5), a regulating valve (6), and a flexible conveying pipe (7).
2. The solar generator of claim 1, **characterized in that** the position adjustment mechanism (3) is a telescoping mechanism; a driver of the telescoping mechanism employs a linear actuator; and the combustor (2) is disposed on an output end of the telescoping mechanism.
3. The solar generator of claim 1, **characterized in that** the position adjustment mechanism (3) is a bended linkage mechanism; connecting rods of the bended linkage mechanism are connected via rotary actuators; and the combustor (2) is disposed on an output end of the bended linkage mechanism.
4. The solar generator of claim 3, **characterized in that** the bended linkage mechanism

is a triple linkage mechanism comprising a first connecting rod (3d), a second connecting rod (3e), and a third connecting rod (3f); the connecting rods communicate with each other via the rotary actuators (3g); and the first connecting rod (3d) is connected to the bracket (1a) of the dish-type Stirling solar generating set (1) via the rotary actuator (3g).

5. The solar generator of claim 1, 2, or 3, **characterized in that** the fuel supply system is a combustible gas supply system comprising a gas-storage tank (4a), a pump (4b), the main switch valve (4c), the branch switch valve (5), the regulating valve (6), and the flexible conveying pipe (7), which are connected via pipes.
6. The solar generator of claim 5, **characterized in that** the fuel supply system is a biomass supply system comprising a biomass gasification device, a purifier (4d), the gas-storage tank (4a), the pump (4b), the main switch valve (4c), the branch switch valve (5), the regulating valve (6), and the flexible conveying pipe (7), which are connected via pipes.
7. The solar generator of claim 1, 2, or 3, **characterized in that** the fuel supply system is a liquid fuel supply system comprising a gas-storage tank (4a), a pump (4b), the main switch valve (4c), the branch switch valve (5), the regulating valve (6), and the flexible conveying pipe (7), which are connected via pipes.
8. The solar generator of claim 7, **characterized in that** the fuel supply system is a liquefied biomass supply system comprising a biomass liquefaction device, a purifier (4d), the gas-storage tank (4a), the pump (4b), the main switch valve (4c), the branch

switch valve (5), the regulating valve (6), and the flexible conveying pipe (7), which are connected via pipes.

9. The solar generator of claim 4, **characterized in that** the fuel supply system is a combustible gas supply system comprising a gas-storage tank (4a), a pump (4b), the main switch valve (4c), the branch switch valve (5), the regulating valve (6), and the flexible conveying pipe (7), which are connected via pipes.

10. The solar generator of claim 9, **characterized in that** the fuel supply system is a biomass supply system comprising a biomass gasification device, a purifier (4d), the gas-storage tank (4a), the pump (4b), the main switch valve (4c), the branch switch valve (5), the regulating valve (6), and the flexible conveying pipe (7), which are connected via pipes.

11. The solar generator of claim 4, **characterized in that** the fuel supply system is a liquid fuel supply system comprising a gas-storage tank (4a), a pump (4b), the main switch valve (4c), the branch switch valve (5), the regulating valve (6), and the flexible conveying pipe (7), which are connected via pipes.

12. The solar generator of claim 11, **characterized in that** the fuel supply system is a liquefied biomass supply system comprising a biomass liquefaction device, a purifier (4d), the gas-storage tank (4a), the pump (4b), the main switch valve (4c), the branch switch valve (5), the regulating valve (6), and the flexible conveying pipe (7), which are connected via pipes.