Solar Energy Concentrating System

Field of the invention

The present invention relates to a solar system, and more particularly, to a solar energy concentrating system having a fixed solar circular reflector and a moving receiver.

Background of the invention

Solar thermal energy is required by industries and homes. The solar energy has a low density and available only at 0.8 kW/sq m. Taking into account various losses, the efficiency is in the range of 50 to 60%. Thus the useful energy is about 0.4 to 0.5kW/sq.m. Presently, solar thermal energy is being harnessed by using flat plate collectors and parabolic trough concentrators/paraboloids. All these solar systems are usually erected on ground and need large shadow less area. Usually, the cost of the land is not considered while calculating the cost of the system. The cost of land and its availability are major issues in implementing solar solutions. The cost of the land in the industrial area is quite high and may be greater than the cost of the solar system. As the cost of land in the industrial area is very high, there has been a constraint on the use of solar systems. Moreover, the solar systems placed on the ground get covered by dust from the ground. The dust reduces the performance of the solar system making it necessary to clean the reflector. One solution is to erect solar systems on the roof so as to convert slant roofs of industries into solar concentrator. The slanted roof of the industrial shade is provided for protecting the industry from the sun and there is good amount of solar energy falling on the roof. However, the solar systems such as the flat plate collectors are sufficiently heavy weighing about 35 kgs/ sq.m and offering a temperature of only 70 deg. Centigrade hence cannot be

placed directly on the roof. Even though, the parabolic trough solar concentrators can offer higher temperatures still they cannot be used as roof or cannot be substituted as roof due to the need of tracking. There are references of using reflectors of semicircular nature. However, in this case the ratio of the circumferential area to the projected area is high. This increases the cost and weight of the system. Further, with semi-circular reflectors, some area of reflector does not receive the solar radiation.

Accordingly, there is a need of a solar energy concentrating system that overcomes above mentioned drawbacks.

Objects of the invention

An object of the present invention is to provide a solar energy concentrating system having a fixed circular trough and a moving receiver.

Another object of the present invention is to provide a solar energy concentrating system that can replace the roof for collecting solar energy and has reduced tracking power and cost.

Brief description of drawings

Figure 1 shows a reflector of a solar energy concentrating system and solar radiations incident thereupon, in accordance with the present invention;

Figures 2 and 3 show different directions of reflection of oblique solar radiations incident upon the reflector, in accordance with the present invention; and
Figures 4-6 shows a receiver of the solar energy concentrating system of figure 1 that moves with the movement of sun with the reflector remaining stationary.

Detailed description of the invention

The foregoing objects of the present invention are accomplished and the problems and shortcomings associated with the prior art, techniques and approaches are overcome by the present invention as described below in the preferred embodiment.

The present invention provides a solar energy concentrating system having a fixed circular trough and a moving receiver. The solar energy concentrating system of the present invention serves as a roof for collecting solar energy and has reduced tracking power and cost.

The present invention is illustrated with reference to the accompanying drawings, throughout which reference numbers indicate corresponding parts in the various figures. These reference numbers are shown in bracket in the following description.

Referring now to figures 1-6, a solar energy concentrating system (not numbered) is illustrated in accordance with the present invention. The solar energy concentrating system comprises a reflector (10) and a receiver (not numbered).

The reflector (10) is a fixed circular trough of small rim angle. In an embodiment, the reflector (10) is an east west oriented fixed circular trough. The reflector (10) is used as a roof to concentrate solar beam radiation/rays (11, 12, 13, 14, and 15) incident thereupon parallel to the axis CO, where C is a centre (C) of the reflector (10) having a point (O) on a circumference thereof. The reflector (10) reflects the rays (11, 12, 13, 14, and 15) at a focus (F) on the receiver. The receiver is a moving receiver. The focus (F) lies on a line joining the sun and the centre (C) of the reflector (10). Further, the focus (F) is located such that CF=OF as shown in figure 1. The ray (13) passing through the centre (C) incident at the point (O) of the reflector (10) gets reflected by the reflector (10) in the same direction. However, the rays (11, 12, 14 and 15) upon reflection, get concentrated at the focus point (F) such that the distance CF = OF

means the focus point (F) is at half the distance between the centre (C) and the corresponding point (O) on the reflector (10).

The reflection of oblique rays (21, 22, 23 and 24) and (31, 32, 33, and 34) incident on the reflector (10) in two different directions are shown in figures 2 and 3 respectively. The rays (21, 32) passing through the centre (C) on reflection traces the same path. The rays (22, 23, 24) on reflection from the reflector (10) meet at F1 such that CF1=OF1 and the rays (29, 30, 31) on reflection from the reflector (10) meet at F2, such that CF2=O2F2.

With the movement of sun through an angle 'theta', the receiver/ focus (F) moves through the same angle theta as shown in figure 4. The focus (F) moves on path of a circular arc (F1-F-F2) of half the radius (CF) of the reflector (10) such that OC=O1C1=O2C2 and CF1=F1O1=FO=CF2=F2O2. As the focus moves due to the movement of sun, the circular reflector (10) remains in a fixed position as necessary for use as a slant roof.

The sun keeps moving in different directions. During day time, the sun moves at a constant velocity of 15 degrees per hour from east to west. This is an important factor while using a north-south orientated circular reflector (10). Since, the north-south oriented circular reflector (10) deals with the diurnal movement of the sun, the receiver has to track the sun continuously. During the year, the sun undergoes a simple harmonic motion at an angle of 46.9 degrees (approximately 47 degrees) to move from north to south positions. This motion is an important criterion while using an east-west oriented circular reflector (10). The end positions are on 21st June and 21st December. The industrial roofs being south facing and east-west oriented and hence are easily converted into the east-west oriented circular reflecting trough/reflector (10). For east-west oriented circular reflector (10), the tracking of the receiver is done through 47 deg in 6 months. The receiver of the circular reflector (10) need not be tracked diurnally but once in 2-3 days.

The positions of the receiver and the sun for equator (zero latitude) on 21stJune, 21st September, 21st December and 21st March along with the focus path is shown in figure 5. The position of the sun changes with a change in the latitude. As one moves towards north from equator, the latitude increases. As the latitude increases, the extreme positions of the sun move by the same angle, on right hand side. The included angle between the extreme positions of the sun remains 47 degrees at all latitudes. The movement of sun changes the position of the receiver towards left that is from F1 to F2 by the same angle of increase in latitude. Both the receiver/focus and the sun moves at an angle of 47 degrees. The receiver moves on an arc of radius CF at position F2, F, and F1. F is the position of the receiver on 21st March, F1 is the position of the receiver on 21st June, and F2 is the position of the receiver on 21st December. The arc joining the positions of F1 and F2 makes an angle equal of the latitude to the horizon. This is called as polar mounting of the solar energy concentrating system. The position of the sun on 21st June is exactly over one's head at 23.5 degrees north latitude as shown in figure 6. The position of the sun on 21st December will be at 47 degrees on the south latitude. The position of the extreme positions of focal points is shown and the angle made by the arc is 47 degrees. The chord of the circular arc makes an angle of 23.5 degrees to the horizontal.

In an embodiment, the solar energy concentrating system of the present invention further comprises a heat pipe or an extended receiver pipe (pipe) to enable uniform heating of the reflector (10). The pipe reduces the possibility of end loss that would otherwise occur due to the oblique rays in the morning and evening time. The end loss also depends upon the focal length and angle of incidence. However, the percentage goes on reducing as the length of the reflector (10) increases.

Advantages of the invention

1. The solar energy concentrating system of the present invention is erected on a strong structural support /roof hence the cost is reduced.
2. The solar energy concentrating system of the present invention uses a circular trough of small rim angle that increases the ratio of projected area to the area of reflector (10) and hence reduces the cost.
3. The solar energy concentrating system of the present invention is less vulnerable to dust problems thereby reducing the cost of cleaning and improving the performance.
4. The solar energy concentrating system of the present invention offers improved performance as the reflector (10) and the receiver has the same rim angle of 47 degrees.
5. The solar energy concentrating system of the present invention reduces the amount of heat entering through the roof to the inner side of the industry and hence the industry remains cooler.
6. The solar energy concentrating system of the present invention offers a unique solution for south facing industrial slant roofs that runs in east-west direction. Such roofs are easily converted into circular reflecting trough of the present invention. With continuous tracking of the receiver, the circular trough is also usable in north-south orientation.
7. The reflector (10) of the solar energy concentrating system of the present invention is be used for any latitude, provided that the reflector (10) is inclined at latitude angle or is polar mounted.
8. The solar energy concentrating system of the present invention allows calibration of the focal path of the receiver as the position of the sun during its travel in north-south direction will have fixed positions on the given days. Suitable arrangements can be made to lock the receiver in its position and track it to align at the exact position of the focus.

9. The open land of the industry has usually some trees, shrubs and grass. These add liveliness to the environment. However, for traditional solar systems, these will have to be removed. This may attract some or the other form of penalty from local bodies. The solar energy concentrating system of the present invention avoids such a situation.
10. The solar energy concentrating system of the present invention reduces the possibility of end loss.

The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the present invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiments were chosen and described in order to best explain the principles of the present invention and its practical application, to thereby enable others skilled in the art to best utilize the present invention and various embodiments with various modifications as are suited to the particular use contemplated. It is understood that various omission and substitutions of equivalents are contemplated as circumstance may suggest or render expedient, but such are intended to cover the application or implementation without departing from the spirit or scope of the present invention.

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