Optical study of a new sun-pointing sensor detector for a sun tracking system applied to a parabolic trough collectors

Amor GAMA, Fatiha YETTOU
Unité de Recherche Appliquée en Energies Renouvelables, URAER, Centre de Développement des Energies Renouvelables, CDER, 47133, Ghardaïa, Algeria.
Gama_amor@yahoo.fr

Ali MALEK
Centre de Développement des Energies Renouvelables, CDER, 16340 Algiers, Algeria

Chérif LARBES
National polytechnic School
10 Hassin BADI Avenue, El Harrach
Algiers, Algeria.

Abstract— **Generally there are two types of solar tracking, blind and sensitive; the sensitive solar tracking system is based on the sun-pointing sensor detector. In this work we will study a proposal of a new sun-pointing sensor detector, In order to have a sun tracking device, who tracking the sun with reliability and accuracy throughout the year in an optimal way. Before starting the phase of realization, it is important to have an idea about the behavior of the proposed detector, for that we started with a detector design using SolidWorks, after that we have introduced the designed detector in optical simulation software 'TracePro'. The obtained results have shown that the proposed detector is reliable, with few problems during system startup in the winter where we have proposed some solutions.**

Keywords-component; sun-pointing sensor detector; Sun tracking system; Simulation software TracePro.

I. INTRODUCTION

Solar concentration is the most cost effective solution in the field of renewable energy, many countries have now launched various investment projects in this field, Algeria with a large solar potential [1] is one of those countries with the realization a 150 MW power plant at Hassi Rmel and other plants, programmed in the near future, which we cite for example the project of Naama and El Mgheier ... etc.

We can decompose a solar thermal power plant in three parts: the part of the solar field consists of several concentrators placed on a large area, and the part of the thermodynamic cycle for converting thermal energy into mechanical and electrical energy, then the command part and control, comprises a telemetry system associated with sophisticated software which manages the facility. The sun tracking is part of this system of management. In this work we simulate optimal proposal for a new sun-position sensor detector using optical simulation software, We simulate the operation of the device during the year in order to know its behavior and its effectiveness, the results found are encouraging for practical realization of the sun-position detector.

II. OPERATING PRINCIPLE

Generally we used in parabolic trough collectors the solar tracking systems with single axis of rotation [2], the operating principle of our detector is very simple: we fix two photos resistors (LDR) on each side of a plate placed horizontally and when the sun touches one of the LDR, the second will be automatically under the shadow, knowing the difference in resistance between the two LDRs can easily deduce the position of the sun relative to the detector, once resistance of two LDRs is identical we can say that the sensor is oriented to the sun.

III. MECANICAL DESIGN

Using software SOLIDWORKS [3] we made the mechanical design of the device Fig. 1 consists of a vertical plate ① 75 mm long and 20 mm wide, another horizontal plate ② attached to the top of the first plate.

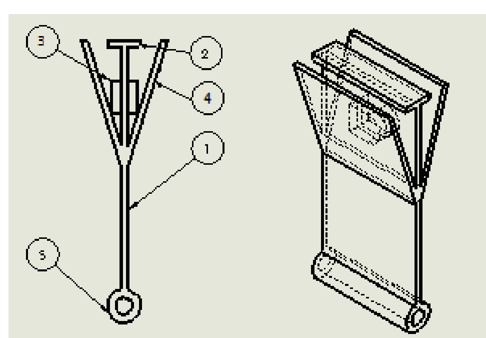

Figure 1. Mechanical design of the sun-position sensor detector.

Two LDRs ③ attached to the front of the first plate, two inclined plates ④ fixed under the LDRs to eliminate the diffuse radiation, and a support for fixing ⑤.

IV. Optical Simulation

After the mechanical design, we used optical simulation software TracePro to get a behavior idea of the proposed sun-position sensor detector, where we simulated the device in several positions for the shortest and longest days of the year. The simulation has two different aspects, the first is for the solar rays distribution aspect taking into account the obstacles (shadow), the second aspect is the value of sunlight fallen on the face of LDR Fig. 2.

For the parameters of the simulation we assume that the sun-position sensor detector is mounted on a parabolic trough concentrator with one axe of rotation solar tracking system, located in the region of Ghardaia. We tilt the parabolic trough concentrator (PTC) to 10°, 20°, 30°, respectively, until the PTC is pointing towards the sun Fig. 4.

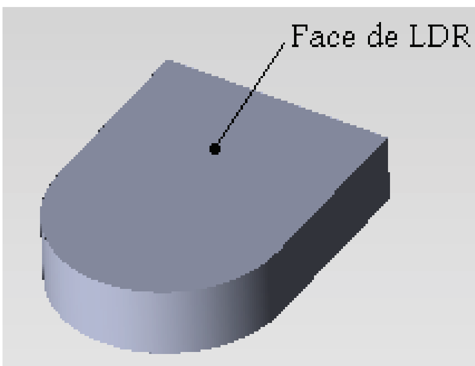

Figure 2. View of the LDR used in the detector.

At the beginning of the simulation we assume that the detector is in a vertical position (Fig. 3) by introducing the position of the sun for December 21 and June 21 respectively at 10:00 am.

Figure 3. Initial status of the sun-position detector.

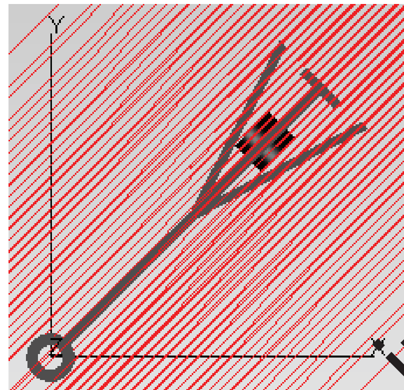

Figure 4. The detector pointing toward the sun at 10:00 on December 21.

V. Results and Discussions

For December 21 at 10:00 am, in the vertical position, the LDR does not touched by the rays sun, we tilted the PTC to angle 10°, the LDR is still far from the rays sun, we continuously tilt PTC to angle 20° we have the distribution shown in Fig. 5, the LDR barely touched by the rays sun but that face was almost perpendicular to it, where we have a uniform radiation of 300W/m², this value is sufficient for the tracking control system understands that it is on the right track in seeking the position of the sun. Continuing the tilt detector to angle 30°, the face of LDR will be completely exposed to the sunlight Fig. 6 but with a large angle of incidence, which influences on the value of the radiation where it decrease but it does not effect on the estimation of the sun position. Reaching angle 40° the angle of incidence on the face of LDR increases the distribution of sun rays decreases; it indicates that the sensor is very close to the sun position.

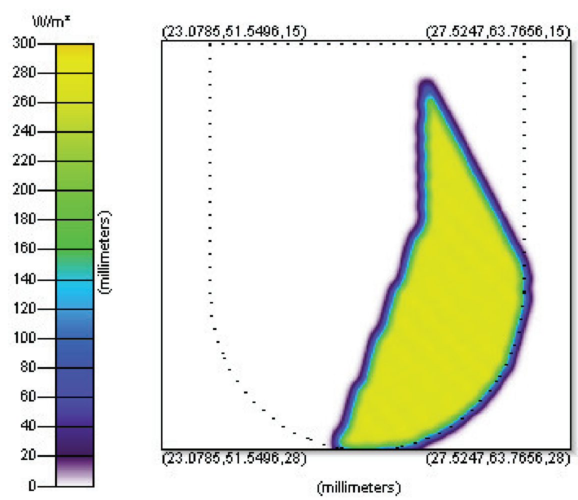

Figure 5. Distribution of sunlight fallen on the face of LDR for a 20 inclination.

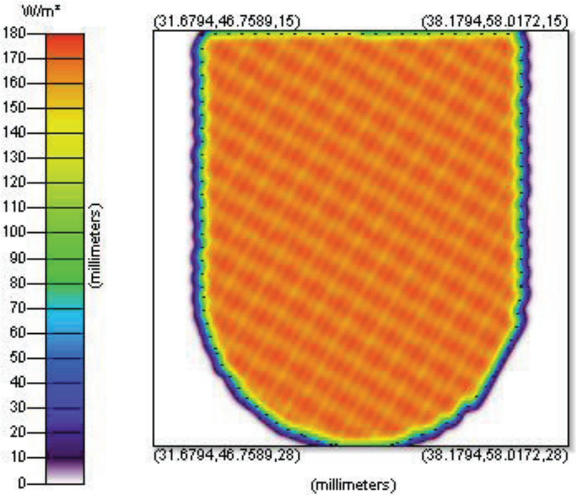

Figure 6. Distribution of sunlight fallen on the face of LDR for a 30 inclination.

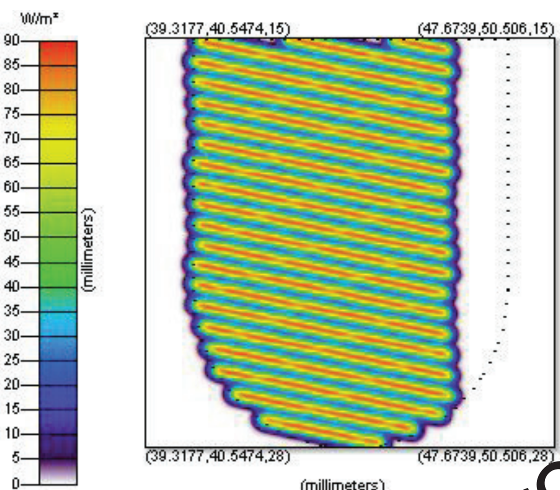

Figure 7. Distribution of sunlight fallen on the face of LDR for a 40 inclination.

For summer, June 21 at 10:00 am, different to the first case, in the vertical position of the PTC the LDR receives sun rays with a very important radiation 500W/m² Fig. 8, which facilitates the tracking control system to start to detect the direction in which we must to seek the sun position. At 10° angle tilt of the PTC, the incidence angle starts to increase, the radiation decreases to 320W/m² Fig. 9, the distribution of solar radiation on the front of the LDR is uniform, the sun rays cover all LDR face, and here the system continues to seek the sun position as well as the sun rays touched the LDR face. At 20° tilting of the PTC the LDR is always exposed to sun rays with a value of irradiance decrease to 140W/m² due to the increase of the incidence angle Fig. 10. At 27° angle tilt of the PTC, the LDR is in the shade, the sun-position detector and PTC is pointing towards the sun.

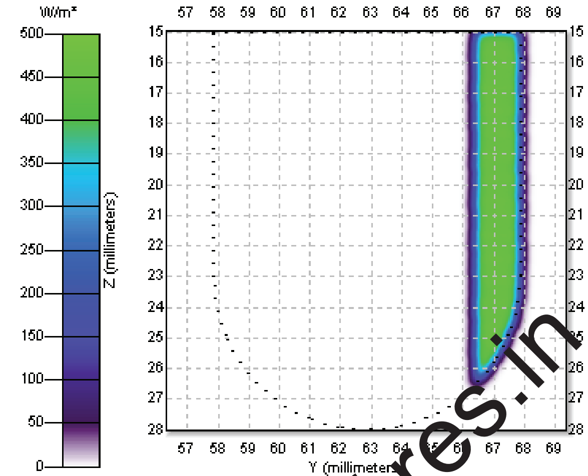

Figure 8. Distribution of sunlight fallen on the face of LDR for a verticale position.

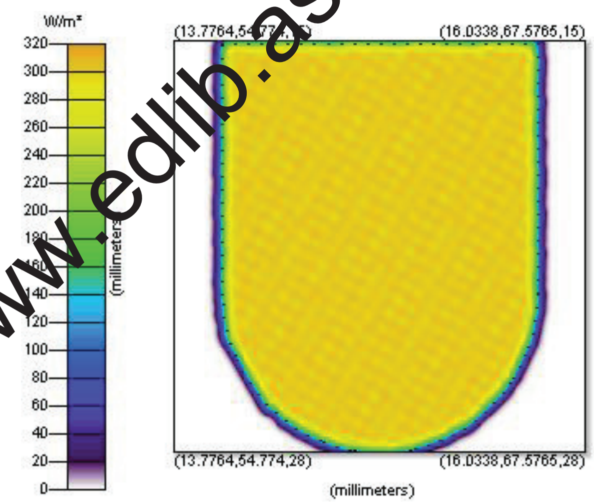

Figure 9. Distribution of sunlight fallen on the face of LDR for a 10 inclination.

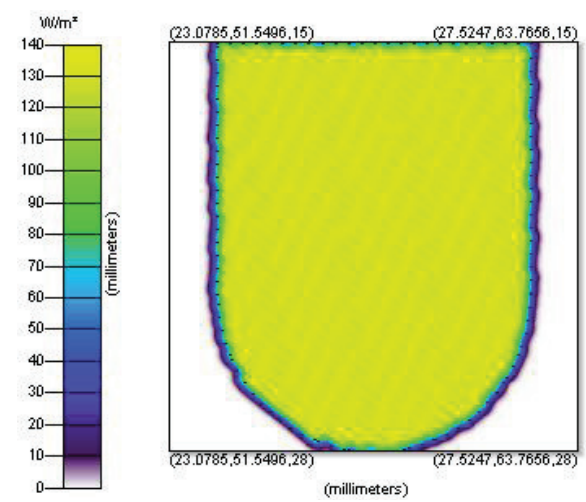

Figure 10. Distribution of sunlight fallen on the face of LDR for a 20 inclination.

VI. CONCLUSION

In this work we proposed a new sun-position sensor detector that meets all the requirements of optimization and precision. To determine the efficiency of the detector, we used an optical simulation software, we chose the longest and shortest day of the year to know the behavior of the proposed system, the simulation of the detector for December 21 at 10:00 am, shows that at the start of the tracking system from the vertical position, the sun position finding is difficult the LDR is touched by solar radiation from 20° tilt, here it is proposed to in the winter we must increases the angle of plates ④ Fig. 1, in order to intercept the sun rays in the beginning of the sun tracking. In summer (June 21), the system functions perfectly without any problems.

REFERENCES

[1] Boudghene Stambouli, A., Algerian renewable energy assessment: The challenge of sustainability. Energy Policy (2010), doi:10 1016/j.enpol.2010.10.005.

[2] M.M. Abu-Khader et al. Evaluating multi-axes sun-tracking system at different modes of operation in Jordan, Renewable and Sustainable Energy Reviews 12 (2008) 864–873 865

[3] SolidWorks, SolidWorks Corporation, 300 Baker Avenue, Concord, MA 01742. Available from: http://www.solidworks.com/.

[4] TracePro Lambda Research Corporation, USA. TracePro software for opto-mechanical modeling user manual release 6 revision 03; 2010. p. 2.7-2.13.