SOLAR PLANTS WITH AUTOMATICALY ORIENTATION TO THE SUN

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Abstract – *One of the new, highly topical and perspective, directions of the research is the use of renewable energies, which are regarded as one of the best and vital options for the future. Solar energy is one of the future potential sources of energy, used either to permanently replace conventional sources of energy such as: coal, oil, natural gas, etc. or to use it as an alternative to conventional sources of energy especially during summer, the latter being currently the most spread one all over the world. Known orientation mechanisms have reduced orientation capabilities or in case of lack of this defect, they have a relatively complicated construction, which reduces their reliability. The goal of this work is to develop a mechanism of orientation of photovoltaic plants to the Sun with large orientation capabilities, simple construction and high reliability.*
Keywords – *renewable energies, mechanisms of orientation, solar plants.*

СОЛНЕЧНЫЕ СИСТЕМЫ С АВТОМАТИЧЕСКОЙ ОРИЕНТАЦИЕЙ НА СОЛНЦЕ

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Реферат – *Одним из новых, весьма актуальных и перспективных, направлений исследований является использование возобновляемых источников энергии, которые считаются одной из лучших и жизненных вариантов на будущее. Солнечная энергия является одним из будущих потенциальных источников энергии, используются либо для постоянной замене традиционных источников энергии, таких как уголь, нефть, природный газ и т.д., либо использовать его в качестве альтернативы традиционным источникам энергии, особенно в летний период. Последний является в настоящее время наиболее распространенным один во всем мире. Простые механизмы ориентации сократили возможности ориентации или в случае отсутствия этого дефекта, они имеют относительно сложную конструкцию, что снижает их надежность. Целью данной работы является разработка механизма ориентации фотоэлектрических станций к Солнцу с большим возможностям ориентацию, простотой конструкции и высокой надежностью.*
Конверсии *– возобновляемые источники энергии, система наведения, фотоэлектрические панели.*

INSTALAŢII SOLARE CU ORIENTARE AUTOMATĂ LA SOARE

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Rezumat – *Una dintre cele mai noi, de mare actualitate şi de perspectivă, direcţii de cercetare este utilizarea surselor regenerabile de energie, care sunt considerate ca fiind una dintre cele mai bune opţiuni si vitale pentru viitor. Energia solara este una din sursele viitoare potenţiale de energie, utilizate fie pentru a înlocui permanent sursele convenţionale de energie, cum ar fi: cărbune, petrol, gaze naturale, etc., fie ca o alternativă la sursele convenţionale de energie, în special, vara. Mecanisme cunoscute de orientare au redus capacităţile de orientare sau în cazul lipsei de acest defect, ele au o construcţie relativ complicată, care reduce fiabilitatea lor. Scopul acestei lucrări este de a dezvolta un mecanism de orientare pentru panourilor fotovoltaice la soare, cu capacităţi mari, cu mecanism de orientare de construcţie simplă şi fiabilitate ridicată.*
Cuvinte cheie – *energii regenerabile, sistem de orientare, panou fotovoltaic.*

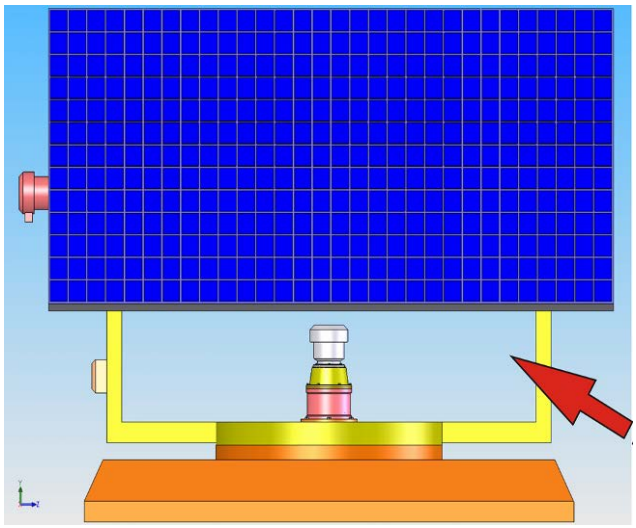
1. INTRODUCTION

Solar energy is the most accessible of renewable energies. Extracting useable electricity from the sun was made possible by the discovery of the photoelectric mechanism and subsequent development of the solar cell – a semi-conductive material that converts visible light into a direct current. By using solar arrays, a series of solar cells electrically connected, a DC voltage is generated which can be physically used on a load. Solar arrays or panels are being used increasingly as efficiencies reach higher levels, and are especially popular in remote areas where placement of electricity lines is not economically viable. Renewable energy is seen as an alternative to the world's dwindling supply of fossil fuels and as a means of reducing greenhouse gas emissions. One of the driving

forces for solar thermal and photovoltaic power generation systems in recent years has been their ability to generate electricity during the daytime hours, when demand is at its highest. The output power produced by high-concentration solar thermal and photovoltaic systems is directly related to the amount of solar energy acquired by the system, and it is therefore necessary to track the sun's position with a high degree of accuracy. Advances in the algorithms of sun tracking systems have enabled the development of many solar thermal and photovoltaic systems for a diverse variety of applications in recent years. Compared to their traditional fixed-position counterparts, solar systems which track the changes in the sun's trajectory over the course of the day collect a far greater amount of solar energy, and therefore generate a significantly higher output power. A solar tracker is a generic term used to describe devices that orient various payloads toward the sun. Payloads can be photovoltaic panels, reflectors, lenses or other optical devices [1, 2].

2. PHOTOVOLTAIC PANELS ORIENTA-TION SYSTEMS

It is known that the efficiency of a photovoltaic system depends largely on the orientation of the solar panels toward the sun standing both in azimuth and zenith. For this purpose they use different driving mechanisms. Because the motions of rotation around the two axes must be very slow (in the azimuthal plane the device must revolve from 10 to 16 ½ hours), the gear ratio of these mechanisms (if done on the basis of gears) must be very high. Planetary gears (most common for such cases) should include 3 to 4 steps, which considerably increases the number of elements and hence their cost. In order to simplify construction and reduce costs of these orientation mechanisms, the research team of the Department of Theory of Mechanisms and Machine Parts, at the Technical University of Moldova, designed and patented the self-orientation solar unit conceptual scheme [3, 4]. The photovoltaic panel is oriented to the sunlight, being rotated in azimuthal and zenithal planes by driving mechanisms with precessional transmission (Fig. 1).



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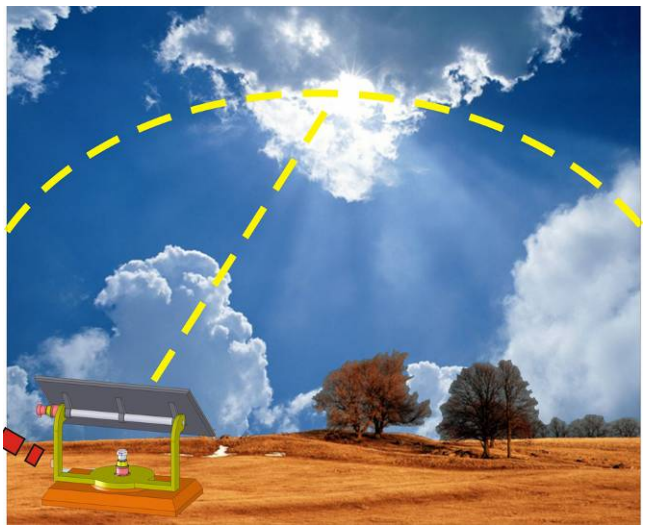

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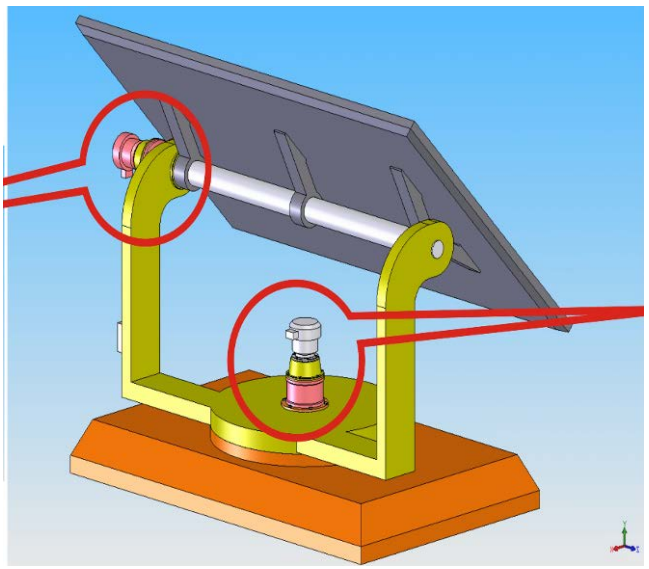

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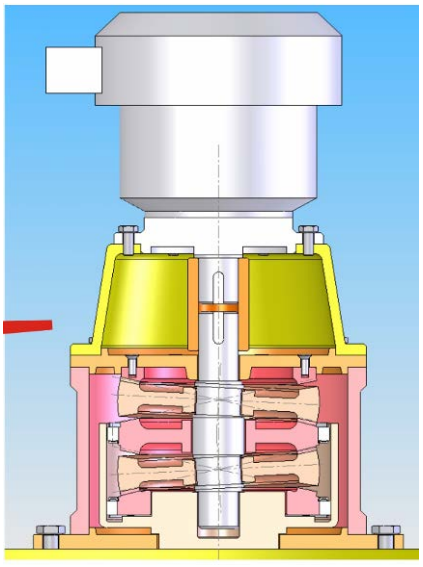

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Fig. 1 Photovoltaic solar system orientation unit: author's elaboration [3].

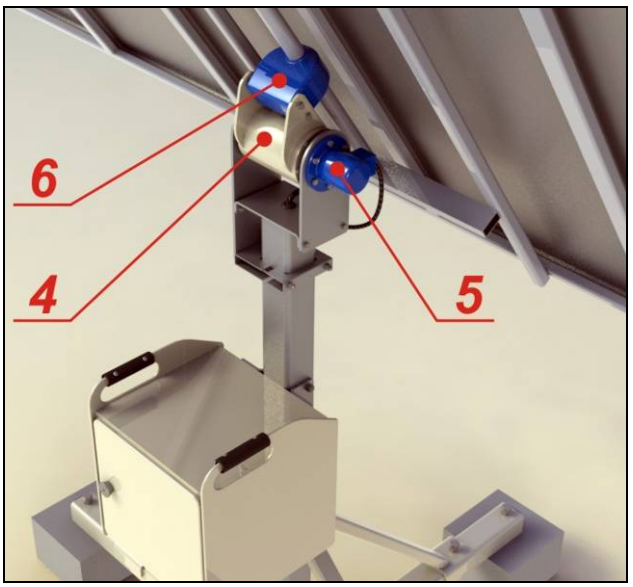
Very broad cinematic options of precessional transmissions ensure very slow rotation around the two axes (one revolution in 24 hours). In the developed system, slow motions of rotation, necessary for the revolution of the solar panel in azimuthal and zenithal planes, are performed by precessional planetary transmissions in two steps: for the rotation of the solar system in the zenithal plane (Fig. 1 c) and in the azimuthal one (Fig. 1), subject to the motion of the sun in the sky (actually the earth rotating around the sun). Precessional transmission gear ratio in one step is determined from the relation:

$$i = Z_2 Z_4 / \left(Z_1 Z_3 - Z_2 Z_4 \right), \qquad (1)$$

where: Z_1, Z_2, Z_3, Z_4 is the number of crown wheel serrated teeth (see fig. 1 c).

a

b



c

Fig. 2 Photovoltaic system with solar astronomical orientation, assembled systems at the Centre for Renewable Energy Development, TUM.

A simple calculation shows that, to ensure rotation of the solar system in azimuthal plane within 24 hours with a 1500 min-1 servomotor, reducer gear ratio must be equal to *i=2160000*. To achieve this transmission ratio, it is recommended to choose the following gear ratios of the precessional gear reducer: for the first step less required *i = -2115 (Z_1=46; Z_2=47; Z_3=46; Z_4=45)*; for the second step *i = - 1023 (Z_1=32; Z_2=33; Z_3=32; Z_4=31*). To achieve this transmission ratio, a 5-speed planetary gear would be required, which includes at least 25 gear wheels; while the precessional gear reducer in two steps includes only 4 gear wheels and two satellite wheels with two toothed crowns. Relatively simple construction of the driving mechanism (to obtain a high transmission ratio, dictated by the necessity of very slow rotation, using a small number of elements), and high reliability ensures relatively low cost of the solar photovoltaic installation and long period of operation.

Based on the research, the authors have developed, designed and manufactured four types of photovoltaic systems for use in various fields. Fig. 2 a, b, shows a photovoltaic system endowed with four modules of solar cells with summary power of 700 watts, installed in a common housing mounted on the support by the sun orientation mechanisms 4 and 5 *(Fig. 2 c)*. Fig. 2 a shows another option of assembling a photovoltaic system with two modules of solar cells. Orientation of photovoltaic panels to the Sun is done by two axes - the horizontal one with the angular extension of 95^o through a solar motor Sun Tracer Pump 4 operated by the Time derived Astronomical Positioning System (TdAPS). Photovoltaic panels are oriented on the azimuth with angular extension of 75^o through the drive mechanism 5 with 2K-H type precessional gear with gear ratio *i = 144*, driven by a solar motor Sun Tracer + electric motor step by step. In this case the rotational motion of the drive shaft reduced by the gear ratio of planetary precessional transmission is forwarded to body 3 on which the housing with solar

panels is assembled.

3. CONCLUSIONS

The essence of the proposed orientation mechanism consists in the following:

- two-stage precessional gear units provide huge transmission ratios with self-locking effect, which prevents uncontrolled movement of the panel with solar batteries;
- presence of freewheel clutch ensures rapid return of the panel with solar batteries to the original position "dawn", which reduces energy consumption by the servomotors;
- operation of the drive shaft with different axial inclinations ensures a partial balancing of forces in the wheelwork;
- coaxial construction provides orientation mechanisms with compactness;
- control system allows the orientation of the panel with solar batteries during any season of the year and at any latitude on the Earth, depending on the provided information;
- the given control system avoids errors caused by temporary eclipse of the Sun;
- small number of elements increases the reliability of construction;
- the plant has modulated construction, which simplifies its construction.

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