The Application of Solar Energy in Solar Cells and Heat Accumulation

Matthew, I. Ibeh[1], *Ikem, Azorshubel Ikem[2], Saviour, E. Ofem[3], Paschal, A. Ubi[4],
[1]Department of Mechanical Engineering, Faculty of Engineering, Michael Okpara University of Agriculture, Umudike, Nigeria
[2,3]Department of Mechanical Engineering, Faculty of Engineering, Cross River University of Technology, Nigeria
[4]Department of Mechanical Engineering, Faculty of Engineering, University of Calabar, Nigeria
E-mail: azors9kee@yahoo.com

Abstract : Solar energy is one of the promising areas of renewable energy, based on the direct use of solar radiation to generate energy for heating, electricity and hot water. The sun is an inexhaustible, environmentally safe and cheap source of energy. Solar energy has been converted different forms of energy for the benefit of mankind. Majorly, the application of solar cellsis in converting the solar irradiance directly from the sun storing the converted energy for other useful purposes. Solar energy has found a wide application including heat storage or accumulation which is one of the interests in this paper.

Keywords: Solar energy, cheap energy, environmentally safe, heat accumulation

Introduction : Solar energy is the energy from the sun the reaches our planet to keep life going. The amount of solar energy that enters the surface of the Earth within a week exceeds the energy of all the world's reserves of oil, gas, coal and uranium[8]. The Sun sends huge powers to the Earth, the transformation of which allows satisfying almost any energy demand of humanity for many hundreds of years. And, solar energy is "clean" and does not have a negative impact on the ecology of the planet[12].

The world's solar energy is developing at a high rate, solar power plants are becoming part of the energy infrastructure, the rapid growth in the number and total capacity of power plants operating on solar raw materials, also implies an increase in the influence of solar technology on the economy. First of all, in the coming decades solar energy will become an incentive for the economic development of the equatorial countries with the maximum "solar" resource[10].

Today, several technological directions are developing independently; one of the interesting solutions is plans for the construction of solar power plants in the earth's orbit. At first glance, such projects seem utopian, if we do not take into account that the construction of five orbital power plants has already been announced.

1.1 The Physical Principle of the Solar Cell

The most effective, from an energy point of view, devices for converting solar energy into electrical energy are semiconductor photovoltaic cells (solar cells), since it is a direct, one-stage transition of energy. The efficiency of produced on an industrial scale by solar cells is on average 16%, the best samples up to 25%. In the laboratory, the efficiency of 43.5% has already been achieved[6].

A photocell is an electronic device that converts photon energy into electrical energy. The first solar cell, based on the external photoelectric effect, was created by Alexander Stoletov at the end of the 19th century. The energy conversion by (solar cells) is based on the photoelectric effect that occurs in inhomogeneous semiconductor structures when exposed to solar radiation.

The heterogeneity of the solar cells structure can be explained by the doping of the same type of semiconductor with different impurities (the creation of p-n junctions), or by joining different semiconductors with an unequal band gap-the electron detachment energy from the atom (creating heterojunctions), or by changing the chemical composition of the semiconductor resulting in the appearance of a gradient of the width of the band band (the creation of the valine structures). Various combinations of these methods are also possible[2].

The conversion efficiency depends on the electrophysical characteristics of the inhomogeneous semiconductor structure, as well as the optical properties of the solar cells, among which the most important role is played by the photoconductivity. It is caused by the phenomena of the internal photoelectric effect in semiconductors under irradiation by sunlight.

1.2 Solar Panel Device

Modern solar panels are made mainly based on silicon. There are two manufacturing techniques - monocrystalline and polycrystalline. The latter is more modern and is used to produce cheaper solar panels. There are also solar panels created on the basis of cadmium telluride, indium and Galium copper selenides, as well as amorphous silicon.

Each solar cell consists of solar cells. Solar cell assemblies are used to create modules to generate electricity from solar energy. Such assemblies are mounted together to obtain a group of solar modules, which in turn are installed on special rotary devices or racks that orient a group of solar modules to the sun, which also includes another electronic body kit. Such assemblies are called solar panels [4].

The efficiency of the conversion depends on the electrophysical characteristics of the inhomogeneous semiconductor structure, as well as the optical properties of the photoconductivity, among which photoconductivity plays the most important role. It is caused by the phenomena of the internal photoelectric effect in semiconductors when they are irradiated with sunlight.

1.3 Applications of Solar Panels

Photovoltaic modules are usually enclosed in a unique housing. Above, they are covered with glass, which allows sunlight to penetrate to the cells themselves, while at the same time protecting them from external mechanical and chemical influences. Behind the modules are protected by a plastic cover with fasteners.

Solar cells are usually connected in modules in series to create sufficient voltage, in which case they are connected in a sequential manner.

The parallel connection of the cells gives more current, but it is problematic due to the environmental conditions and electrical effects occurring in the panels. For example, shading individual rows of cells (the solar module has a lowercase structure) can lead to reverse currents through the shaded cells from the lit mates. This can lead to a serious decrease in efficiency and even the failure of the cells. The lines from the cells must be independent elements, for example, four lines of ten volts. Special parallelization and string protection schemes are used to prevent shadow effects.

Solar modules can be connected in series or in parallel in the panel to achieve the required voltage-to-current ratio. However, specialists recommend using special independent distribution system load - MPPT (maximum power point trackers). Distribution systems help to avoid a fixed circuit by switching modules in parallel or sequential modes to compensate for shaded areas of the solar panel [4].

The energy collected from the solar panel is supplied to consumers through voltage inverters. In Autonomous systems, energy is stored in batteries and used as needed.

Parallel connection of the cells gives more current, but it is problematic due to the environmental conditions and electrical effects occurring in the panels. For example, the shading of individual rows from cells (the solar module has a line structure) can lead to reverse currents through shaded cells from illuminated companions. This can lead to a serious reduction in efficiency and even the failure of the cells. The rows of cells must be independent elements, for example, four lines of ten volts. To prevent shadow effects, special schemes for parallelizing and protecting strings are used.

Solar modules can be connected in panels in series or in parallel, to achieve the necessary ratio of voltage and current. However, experts recommend the use of special independent load sharing systems - MPPT (maximumpowerpointtrackers). Distribution systems help to avoid a fixed circuit by switching modules in parallel or sequential modes to compensate for shaded areas of the solar panel.

The energy collected from the solar panel goes to consumers through voltage inverters. In stand-alone systems, energy is stored in batteries and used as needed.

2.0 Heat Accumulation In Solar Heating Systems

The use of a heat accumulator (HA) is the most important factor for increasing the efficiency and reliability of MTR(magnetization transfer ratio).The need for heat accumulation in solar systems is due to the discrepancy in time and the quantitative indicators of solar radiation intake and heat consumption.

2.1 Classification of Heat Accumulators

Heat accumulators can be classified according to the nature of the processes taking place in the heat-accumulating material: capacitive-type accumulators, in which the heat capacity of the heated (cooled) accumulating material is used without changing its aggregate state; phase transition accumulators of matter, in which the heat of melting (solidification) of the substance (eutetic salts) is used.

In passive MTRs, solar radiation is absorbed by the building elements and stored as a thermal mass [7]. Then this heat radiates into the building. Thermal mass is integrated into passive MTR in various ways: walls, floors, partitions, containers with water, etc. If most of the windows are facing south, but there is no heat stock, then such a house will not be energy efficient.

2.2 Determining Solar Mass

Providing thermal mass is usually the most difficult task for designing passive MTRs. Specific mass and volume of heat-storage elements, per 1 m^2 of the area of glazed surfaces oriented to the south is determined depending on the fraction f (%) of solar energy in the cover of the thermal load for heating [11]:

$$t_{ak} = C_t f, V_{ak} = C_v f$$

Where t_{ak} and V_{ak} - mass and volume of heat storage material;

C_t and C_v - the ratio of the specific gravity and volume of the heat storage material; f is the replacement ratio.

The coefficients C_t and C_v are determined by the type of heat storage material. For example, for a water tank C=3 kg / (%m^2) and C_v = 0.003 m^3 / (%m^2); for concrete or stone wall (floor) C =15 kg / (%m^2) and C_v = 0.0075 m^2 / (% m^2)

The value of f is practically equal to the percentage reduction in heat consumption from a conventional fuel source. If it is required to reduce the heat consumption of the building by 40% (f = 40%), the required mass and volume of water HA is t_{ak} =

120 kg / m^2 and V_{ak} = 0.12 m^3 / m^2; concrete wall (floor), respectively - 600 kg / m^2 and 0.3 m^3 / m^2. At f = 10 ... 80%, the specific volumeV_{ak}, relative to 1 m^2 of the sun-catching surfaces of the southern facade, is equal to 0.03 ... 0.24 m^3 / m^2 for water tanks; for concrete wall (floor) 0.08 ... 0.6 m^3 / m^2. With the same energy capacity, concreteHArequires 3 times more volume than the volume of the water tank.

As a heat-accumulating material, the greatest use is made of pebble nozzles and water tanks. PebbleAT are mainly used in air MTR. Gravel packs can be structurally constructed in volumes of various shapes, in vertical and horizontal massifs, and give large surfaces for heat exchange. The main disadvantage of gravel packs is low heat capacity, which requires the use of large volumes of HA to provide the necessary energy intensity.

Of all the heat-storage materials used, water has the greatest heat capacity. In water accumulators, containers of several cubic decimeters are traditionally used, which are placed on racks providing their free flow around the air. The main advantage of using containers with water is the possibility of their placement in the form of arrays as in the case of gravel packs. Another advantage is that a smaller amount of water space is required to accumulate the same amount of heat as the stones. With a porosity of 50% between the containers, the water retains 2150 kJ / (m^3 deg.). Stones, with 30% porosity will hold 1675 kJ / (m^3 deg.) of energy. If containers with water are placed with 30% porosity, then under the same conditions, 2880 kJ / (m^3 deg.) will be retained.

The use of plastic bottles with a capacity of 0.5 ... 2 liters filled with water, as heat-storage elements allows to combine high heat capacity of water, large heat exchange surfaces and a variety of gravel packing arrangements.

Used plastic bottles are cheap materials. In addition to their industrial utilization, they are widely used as the elements of HA [3].

PB are made of polyethylene terephthalate, have high strength, chemical resistance, sealed, durable, long-term operation temperature + 70 ^{0}C, do not collapse at a temperature of -60 ^{0}C [7]. The use of used plastic bottles as containers with water as heat accumulating elements allows combining high heat capacity of water, large heat exchange surfaces and a variety of gravel packing arrangement. The use of plastic bottles expands the possibilities of creating water HAs of any capacity and configuration.

3.0 CONCLUSION Solar energy has found wide applications using the solar cells and other heat storage devices in heating systems for the benefit of mankind.

COMPETING INTEREST

All authors declared that there is no competing interest among them

List of references:

i. *Amerkhanov R. A., Bogdan A.V., Verbitskaya S. V., K. A. Garkavy. Design of power supply systems. Energy atomization, 2010.*

ii. *Galchenko, A. High-impact anti-vandal sheet material of polyethylene terephthalate. Helvetica-T.webmaster@helvetica - t / ru, 2008. - p4.*

iii. *Gusarov, A. S., Avezov R. R. Temperature conditions of the room with a reflex passive solar heating system and a heat accumulator. Solar engineering, 2000 - № 4, p50-54.*

iv. http://gisee.ru

v. http://rusenergetics.ru

vi. *International Energy Agency (2014). "Technology Roadmap: Solar Photovoltaic Energy" iea.org. IEA.Archived from the original on 7 October 2014.Retrieved 7 October 2014.*

vii. *Nikolaev, K. Solar systems with heat storage // Energy conservation, - M.: 2007,№ 4, p14-15.*

viii. *Philibert, Cédric (2005). "The Present and Future use of Solar Thermal Energy as a Primary Source of Energy".IEA.Archived from the original on 12 December 2011.*

ix. *Sibikin Y.D, SibikinM.Yu. Unconventional and renewable sources of energy. Publisher: KnoRus. P240.*

x. *Somerville, Richard. "Historical Overview of Climate Change Science".Intergovernmental Panel on Climate Change.Retrieved 29 September 2007.*

xi. *Sunny home.* http://www.nashekodom.ru/proect/proekt10.htm/

xii. *Vissarionov V. I., Deryugina G. V., Kuznetsova V. A., Malinin N. K. Solar energy. Publisher: MEI, 2011. - p276.*