ISSN NO: 2770-4491
Date of Publication:17-02-2023

Investigation of Thermal Conductivity Efficiency and Application of Thermoelectric Generators as Sources of Alternative Energy

Turgunova Nadirakhon Bakhadirovna
Andijan machine-building institute

Abstract. This article discusses the relevance and prospects for the use of thermoelectric power converters as alternative energy sources. Interest in the problem is due to the development of technologies for obtaining modern materials and the need to search for alternative energy sources. Examples of areas of their practical use both in industry and in the domestic sphere of human activity are given. The advantages of their use in comparison with other types of electricity sources are noted. A practical solution for the use of thermoelectric generators at oil and fat plants is proposed.

Key words: modern technologies, thermoelectric effect, effect Seebeck, temperature, semiconductor materials, thermoelectric elements, generator

Introduction. The emergence of a contact potential difference when two dissimilar conductors come into contact, discovered by Alessandro Volta in the last decade of the 18th century, attracted the attention of many physicists to the processes occurring in chains of dissimilar materials.

The efficiency of thermoelectric conversion of heat flow into electrical energy for the best combination of thermoelectromotive force (thermoEMF) values of the series of pairs of materials, compiled by the discoverer of this effect Thomas Seebeck himself, could reach 2–3%, which significantly exceeded the efficiency of steam engines of that time. It is not known which way the development of power engineering would have gone if more attention had been paid to thermoelectricity in those years.

Today, thermoelectricity is making up for undeserved age-old oblivion in the energy sector. This accelerated movement began quite recently - in the 30s of the last century thanks to the work of A.F. Ioffe. It was during these years that the foundation for the development of modern thermoelectric power engineering was laid.

Materials and methods.

One of the first outstanding practical applications of thermoelectric semiconductor generators was the legendary “Partisan Pot” (TG-1, 1942) during the difficult years of the Great Patriotic War. This device made it possible to provide electrical energy with a power of 2–4 W to power the radio stations of partisan detachments and replaced galvanic batteries that were difficult to access and had a low capacity at that time. The temperature difference was sufficient to generate electrical energy [1,2].

As already noted, thermoelectric generation is based on the Seebeck effect - a thermoelectric effect, which consists in the occurrence of thermoelectric power when heating a contact (junction) of two dissimilar metals or semiconductors (thermocouples). The thermoEMF voltage Eteds is directly proportional to the Seebeck coefficient α and the temperature difference ΔT between the hot T_h and cold T_c sides (junctions) of the thermoelectric module (Fig. 1).

ISSN NO: 2770-4491
Date of Publication:17-02-2023

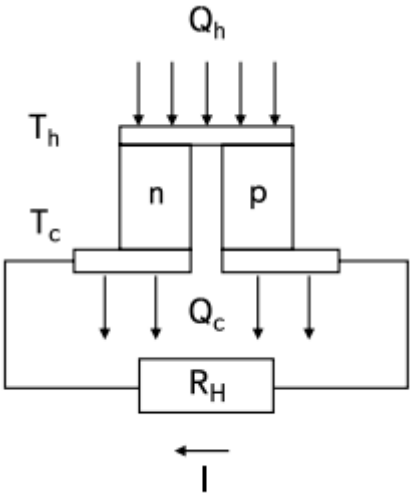

Fig.1. Schematic representation of the Seebeck effect on the example of a junction of thermoelectric elements of n- and p-type

The presented design of the thermocouple consists of heterogeneous n- and p-type semiconductor thermoelements interconnected on one side, the other two free ends are connected to the load Rн.

If the temperature of the contact point is different from the temperature of the free ends, then a current will flow through such a circuit, and useful power will be released at the load. The value of thermoEMF can be determined by the formula:

$E_{thEMF} = \alpha \times \Delta T$ (1)

To increase the resulting electrical power and voltage, thermocouples are connected in series, while they form a thermopile, or a thermoelectric module, a graphical representation of which is shown in Fig. 2 and 3.

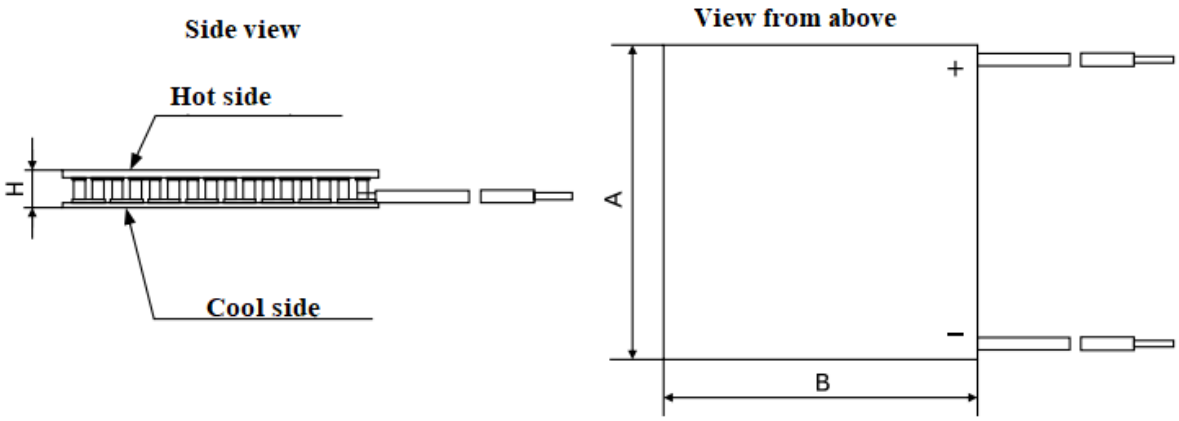

Fig.2. Drawing of thermoelectric generator module

The design of a standard generator module is not much different from refrigeration thermoelectric modules. Thermoelectric elements of n- and p-type are mounted electrically in series between two ceramic plates, and along the heat flow - in parallel.

ISSN NO: 2770-4491
Date of Publication:17-02-2023

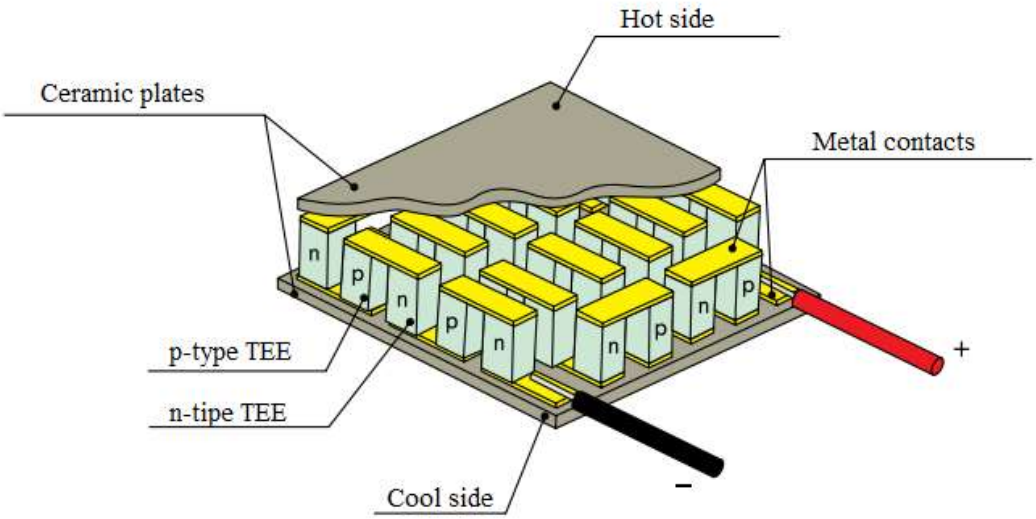

Fig.3. Sectional thermoelectric generator module

The practical application of thermoelectric converters is diverse. The following areas should be noted in this regard:

- autonomous power supplies to ensure the operability of boiler units, waste processing plants, etc.;
- autonomous power supplies to ensure the operability of offices and other devices with low power consumption of electrical energy;
- use for useful purposes the heat removed from various engines and power plants (automobile, ship, etc.), which is uselessly dissipated;
- use for useful purposes of the waste that circulates uselessly from steam plants (rectification columns, deodorizers, etc.);
- supplying power to a variety of electronics, telemetry and automation devices at facilities remote from power lines, for example, in geological parties;
- conversion of heat from natural sources, such as geothermal waters, geysers, solar radiation, into electrical energy;
- power supplies for cathodic protection of oil and gas pipelines;
- measurement of heat fluxes (heat meters).

The following factors can be attributed to the serious advantages of using this type of converters:

- long-term operation without laborious maintenance;
- use of heat from any sources of thermal energy;
- complete independence from the environment of use;
- operation regardless of location in space;
- lack of mechanically moving parts;
- the use of a one-stage static conversion system of the first kind [2,3].

Results of practical application. The practical application of semiconductor thermoelectric converters and the use for useful purposes of waste that uselessly circulating from steam plants (rectification columns, deodorizers, etc.) makes it possible to obtain autonomous electrical energy, as well as to save production costs, which in turn will ensure stable circulation of the production process.

In addition, the use of this thermoelectric generator can significantly affect the consumer limits of the electric energy of the enterprise and provide the possibility of distributing energy between the population without prejudice to the interests of the enterprise.

Andijan region is considered the most densely populated in the republic, since the total population of the region is about 3.2 million people. Accordingly, the consumer scale of electric energy is also proportional to the distribution of the general fund of energy resources. therefore, in this area, no matter where the topical issues and tasks set by the President and the Cabinet of Ministers of the Republic of

ISSN NO: 2770-4491
Date of Publication:17-02-2023

Uzbekistan on the development of alternative energy sources No. PP-5063 "On measures for the development of renewable and hydrogen energy in the republic of Uzbekistan"[1].

In this regard, we propose a technical solution for the use of a semiconductor thermoelectric generator in oil and fat plants. Below is a technological scheme for installing an autonomous thermoelectric generator on the basis of which it is possible to obtain electric energy up to 4 kW/h without destroying the production process (fig. 4).

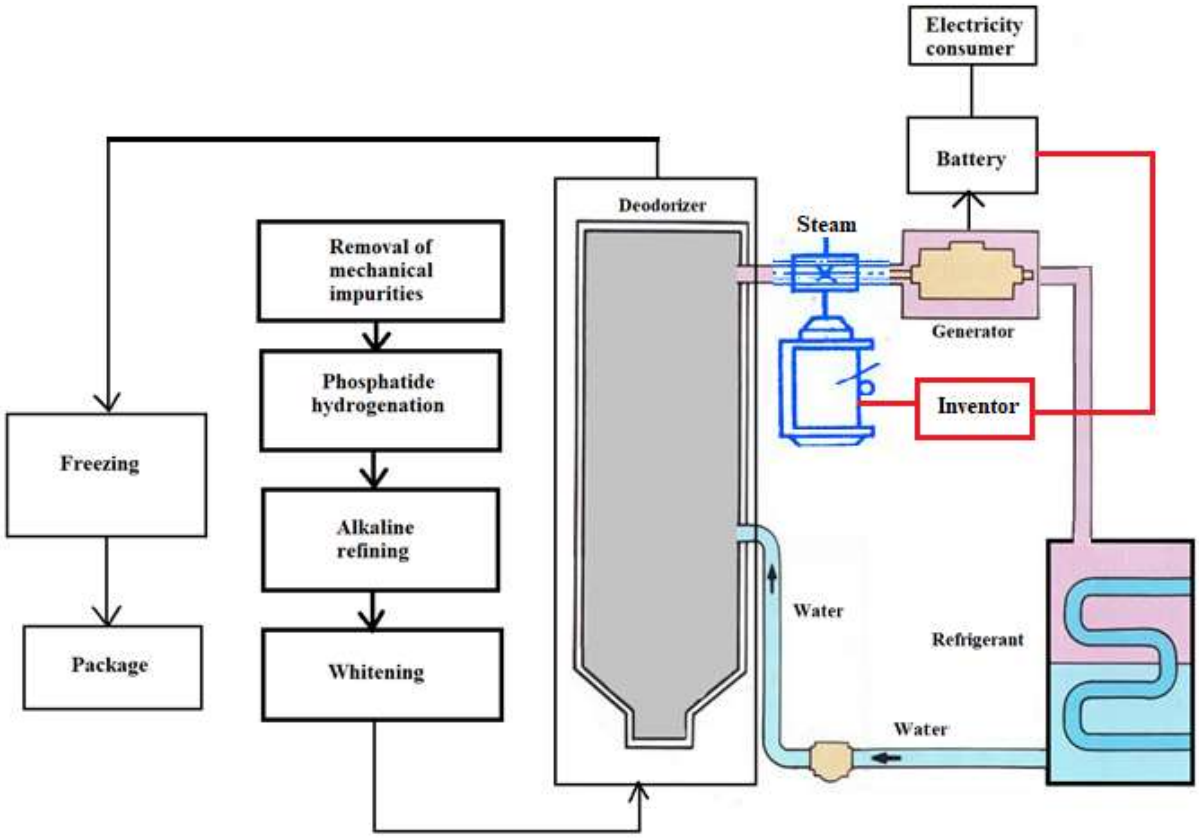

Fig.4. Technological scheme for obtaining autonomous electrical energy based on a semiconductor thermoelectric generator

This installation can provide electrical energy to such consumers as: low-power units, offices, autonomous backup energy sources in case of emergencies and switching, etc.

The principle of operation of this alternative energy source is similar to the "Seebeck's Partisan kettle", and is very effective, since it does not imply any costs for the production of electrical energy during the generation process. Because the steam used for deodorization of cottonseed (sunflower, etc.) oil is circulated and passing through the deodorizer is sent to the refrigerant where it is re-converted into water and transferred for re-generation of steam. By installing a thermoelectric generator between the deodorizer and the refrigerant, we obtain electrical energy by the Seebeck method, which we can direct to the accumulator and subsequently use it as a source of alternative energy.

Despite all the advantages, the noted converters are not widely used, especially on an industrial scale, because of the extremely low efficiency (5-7%, even for semiconductor materials).

The materials used to create thermocouples are varied, but not all are equally effective. Efficiency of metal thermocouples: negligible and reaches tenths of a percent at best. This is due to the irrational waste of a large amount of thermal energy supplied to the junction and the low value of the thermoelectric capacity of the pair. Since the concentration of free electrons in metals practically remains unchanged over a wide temperature range, and their kinetic energy depends little on temperature, the resulting diffusion of electrons is such that the resulting potential difference is insignificant.

[1] № PP-5063 "On measures for the development of renewable and hydrogen energy in the republic of Uzbekistan" at 09.04.2021 y. www.lex.uz

ISSN NO: 2770-4491
Date of Publication:17-02-2023

The materials used to create thermocouples are varied, but not all are equally effective. Efficiency of metal thermocouples: negligible and reaches tenths of a percent at best. This is due to the irrational waste of a large amount of thermal energy supplied to the junction and the low value of the thermoelectric capacity of the pair. Since the concentration of free electrons in metals practically remains unchanged over a wide temperature range, and their kinetic energy depends little on temperature, the resulting diffusion of electrons is such that the resulting potential difference is insignificant.

Therefore, in order to obtain highly efficient properties of thermoelectric generators based on semiconductor materials, it is necessary to study ways to optimize the properties of semiconductor materials and explore additional advantages of materials based on joining different alloys.

Conclusion. Thus, the practical application of the main thermoelectric effects discovered two centuries ago is now becoming more and more relevant, and new technologies for obtaining modern materials suggest that thermoelectric energy sources have an attractive future. In this paper, we have considered the practical application of a thermoelectric generator combined with a mini-steam generator, which makes it possible to double the yield of electricity and the efficiency of alternative energy obtained from waste steam in the production process.

Reference

1. Шостаковский П. Термоэлектрические источники альтернативного электропитания // Компоненты и технологии. – № 12. – 2010. – С. 131-138.
2. Тронев О.С., Кульков В.Г. “Перспективы использования автономных термоэлектрогенераторов” // Международный студенческий научный вестник. – 2018. – № 5; URL:https://eduherald.ru/ru/article/view?id=19161 (дата обращения: 26.11.2021).
3. Kasimakhunova A.M., Turgunova N.B., Research of thermal conductivity and applications of thermoelectric generators in production//Scientific Bullettin of NamSU 2022 № 7 (13.00.00.30)
4. Turg‘unova N.B. “Organik yarimo'tkazgichlarni tadqiq qilish istiqbollari”,//“Texnologik jarayonlarni avtomatlashtirish tizimlarini ishlab chiqarishning rivojlanishdagi o’rni va vazifalari” mavzusida respublika ilmiy-amaliy konferensiya materiallari,; Farg‘ona 22-23.10.2021 y.
5. Касимахунова А.М, Набиев М.Б., Усмонов Я., Латипова М.И., Ҳамиджонов З.М**.** “Исследование термоэлектрических полупроводниковых материалов для высоко эффективных термоэлектрогенераторов”//Научно-технический журнал наманганского инженерно-технологического института// ТОМ 5 - №1, 2020 с 125-130
6. Kasimakhunova A.M., Turgunova N.B., Research of the application of thermoelectric generators on oil-fat combines// Scientific-technical journal (STJ FerPI, 2021, T.24, №6) (05.00.00.20)
7. A. M. Kasimakhunova and others. “Photo Thermal Generator of Selective Radiation Structural and Energetic Features.” JAMP. Vol.07 No.06 (2019). DOI: 10.4236 / jamp.2019.76086
8. A. M. Kasimakhunova, S. I. Zokirov, M. A. Norbutaev. “Development and Study of a New Model of Photothermogenerator of a Selective Radiation with a Removable Slit.” IJARSET. Vol. 6, Issue 4, April 2019, India.