УДК 621.311.243:629.786.2
№ держреєстрації 0117U004707
Інв. №

Міністерство освіти і науки України
Шосткинський інститут Сумського державного університету (ШІ СумДУ)
41100, м. Шостка, Сумська обл., вул. Гагаріна, 1
тел. (05449)4-28-28, факс (05449)4-01-76, E-mail: info@ishostka.sumdu.edu.ua

«ЗАТВЕРДЖУЮ»
Директорка інституту, к.ф.н.

_____________ Наталія ТУГАЙ

ЗВІТ
З НАУКОВО-ДОСЛІДНОЇ РОБОТИ

Знаходження оптимальних розрахункових показників для визначення масогабаритних параметрів енергостанції у залежності від її потужності

ПРОЕКТ КОСМІЧНОЇ СОНЯЧНОЇ ЕНЕРГОСТАНЦІЇ З ТЕПЛОВОЮ СИСТЕМОЮ ПЕРЕТВОРЕННЯ
(проміжний)

Наукові керівники
кан. пед. наук, доцент Ю. М. Мар’їнських

2021

Результати цієї роботи розглянуті Вченою радою ШІ СумДУ,
протокол № 3 від « 30 » 12 2020 р.

РЕФЕРАТ

Звіт про НДР: 8 с., 2 рис., 2 джерела.

Об'єкт дослідження — об'єктом дослідження є знаходження оптимальних розрахункових показників для визначення масогабаритних параметрів енергостанції у залежності від її потужності

Мета — Створення проекту космічної сонячної енергостанції нового класу з високим значенням коефіцієнту корисної дії в якості альтернативи існуючим проектам перетворення сонячної енергії в механічну і електричну.

Методи дослідження — розрахункове дослідження джерел на знаходження оптимальних розрахункових показників для визначення масогабаритних параметрів енергостанції у залежності від її потужності. Використання статистичного методу, графічного та аналітичного.

У роботі знайдені оптимальні розрахункові показники які визначають енергетичні параметри енергостанції у залежності від потужності випромінювання сонячної енергії. Розглянуто наукова і практична значимість розроблених проектів космічних сонячних енергосистем гіроскопічного і циклічного функціонування.

З'ясована складність розрахування вартістості виробництва необхідної кількості фотоперетворюющого матеріалу і робочих елементів з нього. Показана відсутність однозначності у вартості одного кіловата електроенергії, виробленої орбітальної КСЕС з урахуванням ресурсу фотоелементів в умовах космосу. Ці фактори, а також проблеми реалізації проектів теплових КСЕС, дають підстави знову переглянути традиційні методи перетворення теплової сонячної енергії в КСЕС.

ЗМІСТ

INTRODUCTION

Despite all the advantages of these projects, such as high efficiency (up to 40%), well-established production technology of turbo generators with good industrial base, no need in rare space radiation resistant materials, there is a range of factors, which delay their start. Among these, there is a high weight-to-power ratio of the conversion system, which averages to 3.4 kg/kW, and the necessity to produce a large temperature drop during the duty cycle, which means that the size of the solar collector increases and, thus, the solar tracking system becomes more complicated.

1 CALCULATION OF SPECIFIC ENERGY INDICATORS AND MASS AND DIMENSIONAL CHARACTERISTICS GSPS

The analysis of solar energy conversion methods in the projects of solar power satellites (SPS) has been conducted and the problems restraining their implementation analysed. Therefore, the article provides grounds for using promising heat-resistant materials of carbonic nanocomposite and low-temperature superconductors in the scheme of solar energy conversion with the purpose of creating SPS projects of a new type with improved weight and size parameters and physical and technical characteristics. The difference between the gyroscopic solar power satellites (GSPSs) with the new thermal conversion system (TCS) and superconductive generator projects and the previous ones lies in the absence of steam and gas turbine plants, a thermal radiator and a system of direction to the sun.The results of assessment of their energy and weight and size parameters have been presented: the thermal efficiency of conversion by the helium as working fluid at concentration of the solar energy of 74 and by the water steam at 38 has made 85% and 62.7% respectively; the specific weight of the entire thermal conversion system has made 2.17 kg/kW and 2.61 kg/kW; its specific capacity - 12.3 kW/m2 and 6.79 kW/m2, the specific weight of the GSPS with the new TCS and superconductive generator has made 0.46 kW/kg and 0,38 kW/kg. The suggested principle of functioning may be used in space power plants, being based on planets and the Moon.

Where the 4th term is the amount of heat, received from the connectives between the housings of the chambers;– specific heat conductivity of the composite element =0.008 m 2 – cross-sectional area of the elements; – temperature difference at distance of S=15m 2 – chamber housing area, where on the concentrated solar radiation is falling through the transparent low-emission coating of the thermal trap.

The time of steam superheating to 1278 K is determined based on the ratio – super heated steam volume; ΔT=715 K – temperature difference.

Steam cooling down to condensation point shall make determined based on where = 35*10^5 Pa – mean value of pressure in the heat drop section; S=30 m 2 –

Whole surface area of the chamber with connectives; V'= 5.56 – volume change in the heat drop section. The heat converter capacity shall make.

The diagram of these processes is shown in (Fig.5).

The thermal and power efficiency of solar energy conversion is given in Table 1, taking into account the consumption for mechanical work performed by the elements of carbon nanocomposite, which is the main structural material of the GSPS. It has resistance against hard space radiation and combines high strength and the modulus of elasticity from 150 ÷ 245 MPa at the coefficient of thermal expansion of 5.5· with the temperature increase from 20 ÷ 2500 [1].

These properties and the possibility to produce massive structures and self-lubricating parts of a complex shape from the carbon nanocomposite will ensure the unlimited service life of the module with smoothly changed load of its constituents at a minimum loss of mechanical energy in the kinematic motion type conversion units. The results of the conducted calculations convincingly show the advantage of the GSPS projects according to their specific performance(Table 2) over the projects with a photoelectric conversion system [2].

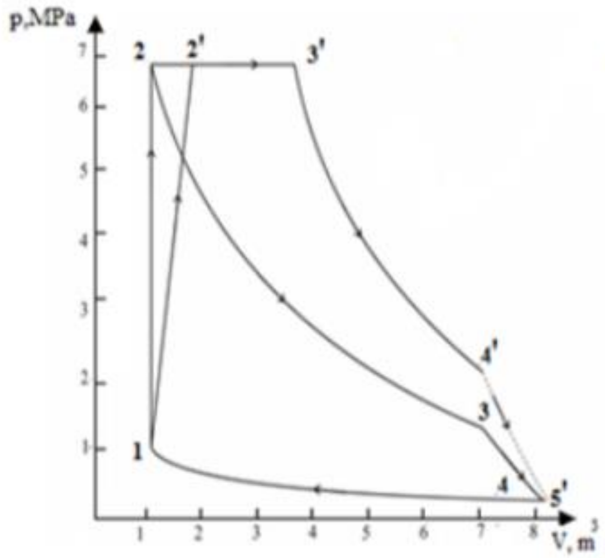
Table 1

2 EFFICIENCY OF THE SOLAR RADIATION HEAT CONVERTER WT.C., POWER EFFICIENCY OF THE SUPERCONDUCTOR GENERATOR WG. AND ITS SPECIFIC PERFORMANCE BASED ON THE SOLAR CONCENTRATION VALUES

n	30	32	34	36	38	40	42	44	72
Capacityt.c., kW	60	67	73	79.4	85.5	91.5	97.4	103	158
Capacity g., kW	57	63.6	69.4	74.6	82.2	87.8	93.5	99	152
Specific capacity, kW/kg	0.24	0.28	0.3	0.33	0.36	0.38	0.4	0.43	0.66

Table 2

3 ENERGY CHARACTERISTICS, WEIGHT AND DIMENSIONS OF THE GSPSWITH THE NEW TCS AND SUPERCONDUCTIVE GENERATOR



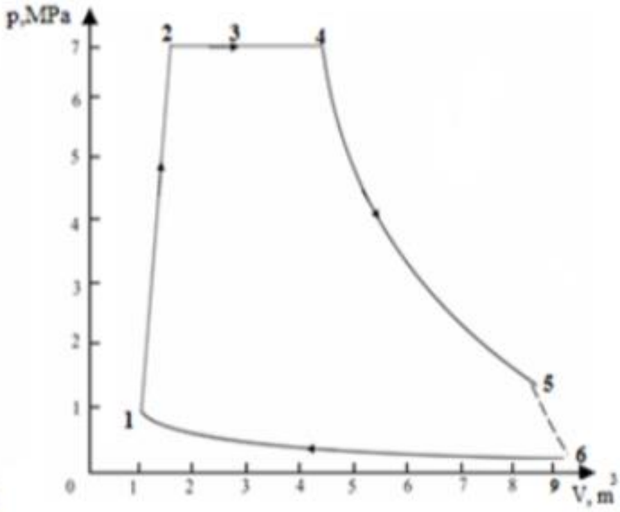


Fig.4. Cycles of the heat convertor, helium as an actuating medium 1-2'-3'-4'-5' variant of the heat converter operation cycle at high solar concentration, the 1-2' slope depends on the ratio of the load and solar concentration values.

Fig.5. Cycle of the heat convertor, water steam as an actuating medium; 1-2 – water heating to the boiling temperature at point 2; 2-3 – boiling at the isobaric-

isothermal process; 3-4 – steam superheating; 4-5 – intensive heat drop in the initial section at higher temperature of the chamber housing with the actuating medium; 5-6 – completion of steam condensation in the cooler; 6-1 – turning the piston and the condensate to the initial position and condition.

4 DIRECT PHOTOELECTRIC CONVERSION SYSTEM HAS SEVERAL ADVANTAGES

Direct photoelectric conversion system has several advantages on deploying flexible photoconverting panels with relatively low mass parameters in space. Today it is a priority and partially started to be implemented by leading space countries. However, it is difficult to calculate the cost of producing the required amount of photoconverting material and working elements from it. There is no unambiguity in the cost of one kilowatt of electricity produced by the orbital SPS, taking into account the resource of solar cells in space. These factors, as well as the problems of the implementation of projects of thermal solar power plants, give grounds to reconsider the traditional methods of converting thermal solar energy by solar power plants.

At the present stage, the possibility of using super-strong and lightweight structural materials made of carbon-carbon composites for the manufacture of the frame and load-bearing elements of power systems for space purposes has arisen. The use of high-temperature superconductors and superconducting electric generators created on their basis can significantly reduce the weight and size parameters of the superconducting SPS of the thermal conversion system.

CONCLUSION

Launching and deploying in space is a key issue for GSPS. Overcoming the problem is possible with the complete assembly of GSPS on the ground with the placement of the central part under the dome in the usable volume of the carrier rocket. The rods of the stator and rotor frames will come out of it; modules with a folded concentrator in the toroidal cavity are placed in a circle on the periphery of one of them. A promising option would be a torus acting as a stabilizer during flight and a heat trap in an orbit made of lightweight, durable material with a selective coating of the outer surface and “windows” for heat dissipation that will open when the concentrator is deployed.

REFERENCES

1. M. P. Vukalovitch, “Thermophysical properties of water and steam”,*Mechanical engineering*, pp. 160, 1967.
2. G. G. Raykunov, V. M. Melnikov, A. S. Chebotarev, V. I. Gusevskiy, B. N. Harlov, “Orbital solar power plants as a promising way to solve the energy and environmental problems”, *Teploenergetika*, vol. 11, pp. 35-37, 2011.