Assessment and Impact study of surface soil on thermoelectric generator energy efficiency

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Abstract—The main aim of this research is to find the effectiveness of the thermo-electric power, renewable sources of heat flow in the soil depending on the influence of various factors on its surface. The necessity of taking into account the state of the soil surface conditions when designing and determining the optimal operating conditions of such power sources.

Index Terms—Thermo-electric generator (TEG), Heat sink, Soil structure, Thermal power (TP)

1 INTRODUCTION

A process of heat generation and distribution of heat flow in soils of natural composition well researched and described in the literature [1]

Increased interest in reviewing the processes occurring in the soil-air, and to study the various factors influencing the soil surface and have an influence on the formulation of TP in it [2-3]. A study of the impact of increasingly interest and experts professionals who consider the soil research, independent object suitable for use as an inexhaustible source of renewable low thermal energy [4].

The relevance of such studies is increased by the creation of new techniques and it can be effectively use as unlimited source of clean energy.

The studies [5-10] show that the efficiency of thermoelectric generator (TEG) importance and the influence of various factors occurring at the soil surface. They determine the amount of TP aimed deep into the soil (daytime) or surface (at night). However, these works are devoted to creating physical foundations of engineering TEG. Consideration of the various factors affecting the state of the soil surface and with-in a responsible manner and to work TEG, they paid relatively little space.

The purpose of this work – a more detailed coverage of the results of research the influence of various factors occurring at the surface of the soil, on the efficiency of the TEG.

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2 CONCEPTS AND PERFORMANCE OF TEG

The Schematic diagram of renewable thermoelectric power source; shown in Fig.1. It is used as a basis for the design and manufacture of the basic design TEG.

The dimensions of the manufactured for research TEG sample consisted of 86×86×250 (mm) Thermopile included 1550 thermo elements cross-section of 0.32×0.32 (mm^2) manufactured from $Bi_2T(e_3)$.

Dependence of TEG from the original capacity of the heat flow impinging on the heat sink manifold, is shown in Fig. 2, a performance sample shown in laboratory conditions, are presented in table 1.

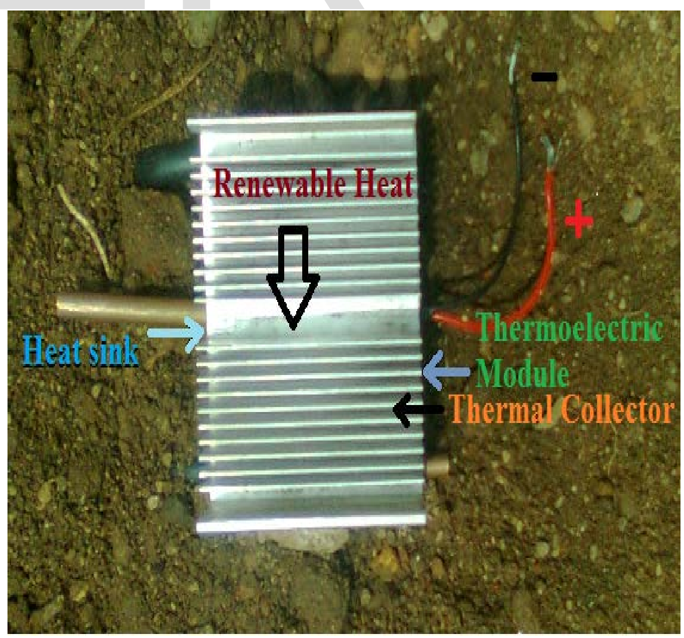

Fig. 1 Scheme of thermoelectric generator

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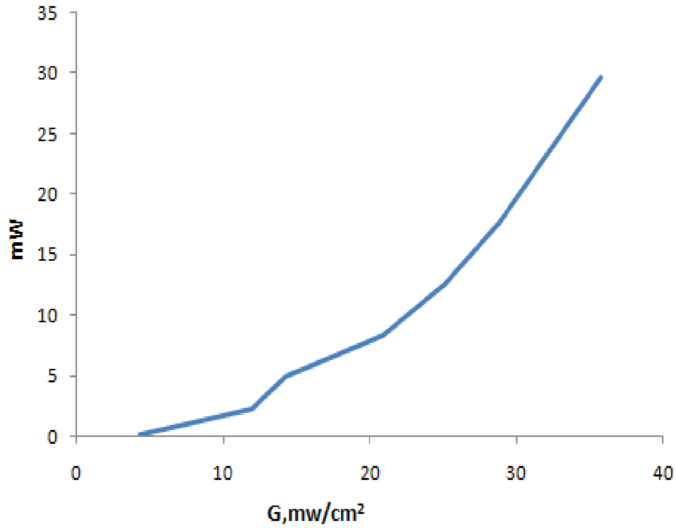

Fig. 2. TEG output power versus density

TABLE I

PERFORMANCE SAMPLE OF TEG

SI. no	Density (G) , mW/cm^2	Working Temp ΔT ,k	Output voltage V	Output Current (I_{sc}), mA	Output power TEG W, mW
1	4.3	2	0.40	0.2	0.08
2	6.4	5	0.93	0.67	0.623
3	11.9	10	1.75	1.27	2.222
4	14.3	15	2.62	1.88	4.925
5	20.9	20	3.38	2.47	8.348
6	25.1	25	4.22	2.97	12.533
7	28.9	30	5.11	3.46	17.680
8	35.8	40	6.61	4.49	29.678

3 FIELD RESEARCH TEG

Field studies were conducted to examine the effect on the efficiency of TEG, located in the active layer of soil (soil layer, in which the transformation of solar energy into other forms of energy) on the site prepared for this purpose, the following factors:

– Depth of reservoir TEG location;

– State of the soil surface (surface, presence of vegetation, snow, moisture);

– Size fractions (structure) of the soil.

Successively the research results influence of the above-mentioned factors on the efficiency of the TEG.

3.1 The influence of the depth of soil TEG arrangement

Based on an analysis of the literature on Thermophysics of the soil, it can be expected that maximum output power TEG will develop the collector when using heat sink at the soil surface. To test this assumption in July, the ground with vegetation-free surface at different depths of the model sample was installed with TEG and study of its output characteristics. The research results are presented in Figure3.

As you can see from Figure 3, even a small layer of soil on the surface of the heat sink reservoir in leaps and bounds reduces output characteristics TEG.

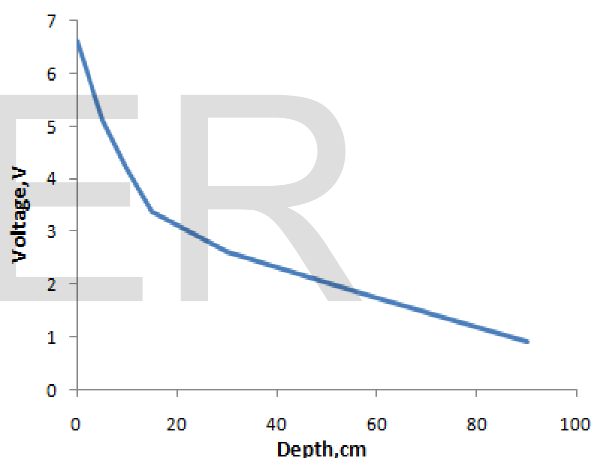

Fig.3. Measured Voltage of TEG variation with soil depth.

This result is an experimental confirmation of the assumptions made and demonstrates the feasibility of placing thermoelectric collector PTEG as close to the soil surface.

3.2 Influence of soil surface conditions

Significant impact on the effectiveness of TEG can have vegetation on the surface of the soil. It must manifest itself in some shading of the surface, which leads to a reduction of the heat flow in the soil. However, during the night of vegetal soil was reduced radiation. Evaporation through the herbaceous cover, which speeds up the drying of the soil and reduces its heat capacity. Some of the heat will climb from the ground for the formation of plant mass. In addition, the presence of vegetation greatly affects the turbulent exchange of air near the surface of the soil, affecting the thermal process in it.

The experimental results revealed that the average summer season density and stem length reduces thermoelectric TEG an average of 1.7 times, which reduces its power output by 2.9 times. Therefore, when you select a location in the soil TEG necessarily needs to take into account the presence of vegetation on the surface.

In addition to the vegetation, the formation of TP in the soil, and therefore to work TEG, actively influence and presence on the soil surface mulch (straw, leaves, etc.) contribute to the future of its insulation. As a result, the soil gets less heat than its free surface. However, it should be noted that both mulch retains TP from the soil. Because in cold soil with mulch on its surface will be warmer-free.

The results taken from the December/January experimental studies and distribution of monthly mean temperature in depth for the different soil surfaces are shown in table 2.

TABLE II

MONTHLY AVERAGE SOIL TEMPERATURE IN DEPTH FOR THE DIFFERENT SOIL SURFACES

Depth, cm	Monthly average soil Temperature° C		
	Free soil	Gravel	Field hay
Surface	25.6	26	20
5	24.2	25.6	19.3
10	22.5	23.1	18.6
15	20.5	20.6	17.5
30	19.7	18.3	16.2
60	18.6	16.9	15

The data in table 2 confirm the significant dependence of the magnitude of temperature wave, which extends deep into the soil, the nature of its coverage to the surface. Thus, difference of temperature between the free surface and the soil at a depth of 60 cm approx. 7°C. TEG output power Vs working temperature is shown in Figure4.

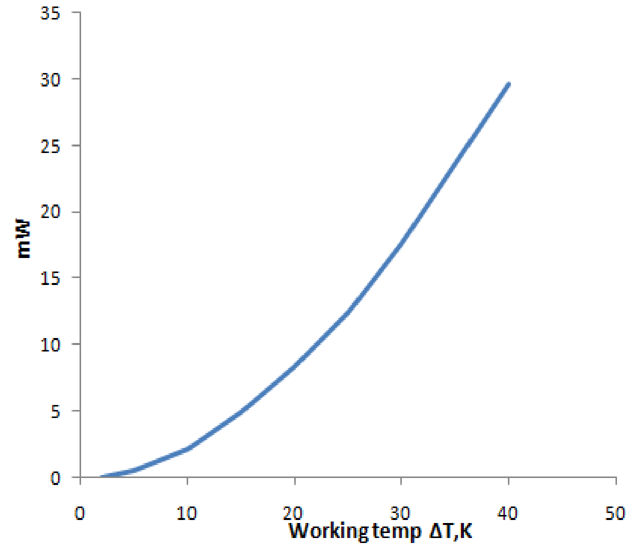

Fig.4. TEG output power versus working temperature

For the soil, covered with hay, similar to the difference of temperature is 5° C.

At first glance, the difference in gradients of temperature is very important for the efficient operation of TEG, working temperature fluctuations which, for example, for middle latitudes, are at 10-12° C.

One of the important factors affecting the thermal dissipation in soil is moisture. If the soil surface is a lot of moisture, the amount of heat absorbed by soil, is spent on evaporation. If natural heat passed on the dry surface soil, warms it, creating a significant temperature gradient. It determines the occurrence of significant, but more TP in the soil than in the case of wet surfaces.

The study undertaken by the TEG layout in both dry and damp soil, that in the absence of losses for evaporation, TP, falling on the heat sink manifold TEG may grow to 42% compared with damp soil.

It is impossible to ignore the influence of snow cover on the formation of TP in the soil, according to literary sources [11] snow significantly affects its warm mode.

In the afternoon, most of the solar radiation reflected from the snow, but at night the snow well absorb the heat, so its temperature decreases.

According to estimates, at a depth of 10 cm of snow cover on the soil surface is only 25 to 30% of the energy of solar radiation in soil.

3.3 Impact of size fractions of soil

Heat transfer Conditions on heat sink reservoir also depend on the size of the fractions of soil and its surface contact. In this study is to identify such dependencies by using typical soil from the Mountains view at Nagercoil-

Tirunelveli Highways. Accidentally taken in different places of a soil sample had the following composition of particle size ranging from 2 to 14 mm (40%), the rest is less than 1 mm particles (dust) measurement was carried out with the thermoelectric side and live coverage of test results are shown in Figure 4, the best result is obtained for the soil with the faction 1.5 to 2.5mm.

Studies also have shown that the gain in improving TEG for by optimizing the structure of the soil-size fractions up to 30%, but the amount may be reduced by losses falling on the heat sink integrated thermoelectric generator.

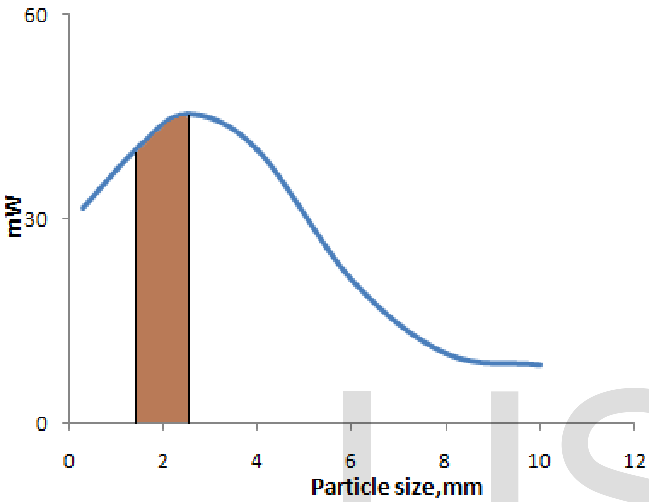

Fig.5. The characteristic dependence of TEG output and the size fractions of the soil.

4 CONCLUSIONS

In this research confirmed that the efficiency of the TEG can be increased not only from the meteorological conditions on the surface of the soil, but it depends on the state of soil surface and its structure.

The result makes it possible to formulate recommendations for the design and management of TEG.

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