WORKING PROPERTIES OF CO-GENERATIVE SOLAR CONVERTERS UNDER WINTER CONDITIONS

Ing. Petr ČAMBALA, Doctoral Degree Programme (4)
Dept. of Electrical Power Engineering, FEEC, BUT
E-mail: cambala@feec.vutbr.cz

Ing. Petr MASTNÝ, Doctoral Degree Programme (4)
Dept. of Electrical Power Engineering, FEEC, BUT
E-mail: mastny@feec.vutbr.cz

Supervised by: Ing. Jan Gregor

ABSTRACT

This paper describes two different types of solar co-generative converters and their working properties under winter conditions. The paper is composed from four parts. The first part explains necessity of working temperature reduction. The second part describes co-generative solar converters originally designed for summer conditions, but working under winter conditions. The third part shows a several figures witch describing properties of co-generative solar converters under winter conditions. Finally the forth part (Conclusion) analyzes possibilities of further development of solar converters.

1 INTRODUCTION

A new trend of present society is effort to use of obtainable resources by sparing and effective way. Significant source is also solar energy, witch went on Earth's surface at recent time. (i.e. energy of water, wind, biomass etc.). Once from possible way is direct conversion of solar energy into electric power is using of photo-electric phenomenon in photovoltaic (pv) electric generator.

2 INFLUENCE OF WORKING TEMPERATURE ON PV GENERATORS

Only *from 8 to 14 % is converted into electric energy* in practice applications (depend on working conditions). *Rest is transformed into heat energy.* This rest is leading to rising of pv generator operating temperature while isn't heat absorption balanced by free-convection and radiation into surroundings. [1] [2] Quantity of electric energy production is markedly affected by working temperature T_p of pv. generator and intensity of lighting. So load characteristic is shifted down with increasing of temperature T_p. Especially is changed no-load voltage of pv generator with change of temperature T_p (see Fig 1). These characteristics was measured on Solar Laboratory of DEPE for Solartec solar cell – VA XX°C marks Load

characteristic for XX degrees of Celsia, P XX °C – are Power characteristics. Described changes have influence on efficiency of conversion from solar energy to electricity. This property of pv generator is good reason for reduction of operating temperature by additional cooling. We can decrease working (running) temperature by additional active cooling. Also we gain severalfold of electrical power from pv generator in the form of low-potentional heat. Efficiency of photoelectric conversion is increased too. Thus we obtaining co-generative solar converter basically.

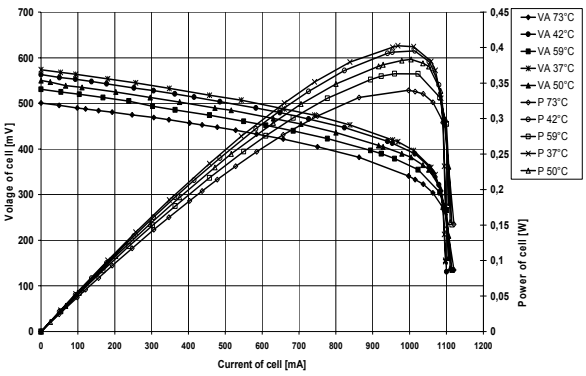

Fig. 1: *Influence of temperature on load and power characteristics of pv cell*

Here is important to think about cooling medium for practical applications which will be low-cost, generally accessible and hygienic unobjectionable.[2] We consider about *water* and *air*. If we now consider a specificity of pv. generator is air acceptable heat-transfer medium for ours devices.

3 CONSTRUCTION OF COMBINED PHOTOVOLTAIC AND PHOTOTHERMAL SOLAR CONVERTERS

3.1 AIR COOLING FOR PV GENERATOR OF TGM TYPE

Simplest variation was modification some of the industrially produced pv generators. First designed system was modification of pv generator TGM 750-12V (P_{MAX}= 13,5 W, VOC = 18 V, ISCMAX= 750 MA, see figure 2)(1). Cooling air inflow about aluminium rim (2) of generator into back area witch is covered by metal shield (3). Air is conducted away throw centre hole by force of axial fan (4). By using of cooling markedly increase quantity of energy conducted away by convection. This modification had direct influence on reduction of working temperature in result. Next efforts were direct on intensification of heat transfer by convection from back side of pv generator.

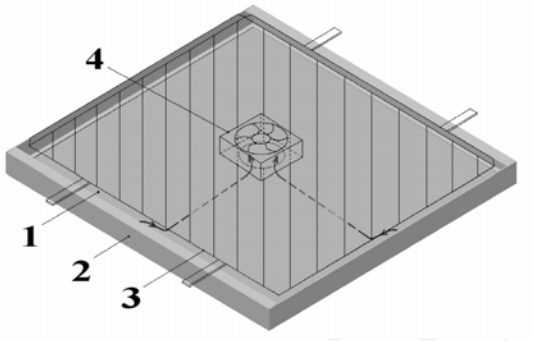

Fig. 2: *Modification of compound solar converter TGM (beck side view)*

3.2 OWN CONSTRUCTION OF PV GENERATOR

On the back of generator is covering insulative layer. This layer is a weak point of combined solar converter modified from industrially manufactured pv generator,

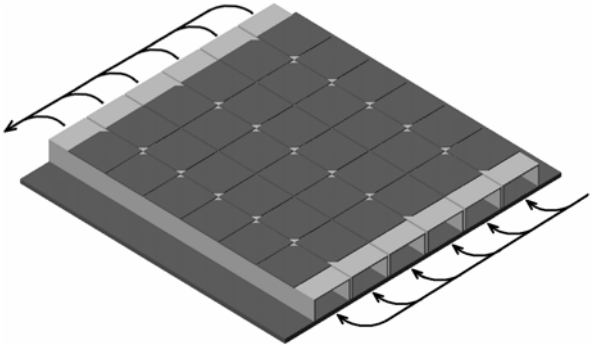

Fig. 3: *Model of own construction of pv generator*

because significantly raising heat resistance in the course of active cooling. So, in present time, is developed a new generation of pv generator in laboratory of unconventional conversion of DEPE. This generator has pv cells directly placed on duralumin cooler and thus linked parallel, in place of current serial connection. Parallel connnection is shown useful from working point of view for partially shaded generator.

4 CO-GENERATIVE SOLAR CONVERTERS UNDER WINTER CONDITIONS

Designed constructions of solar panel are identified for summer working conditions. [3] However no less than a half of the year are working conditions markedly different from proposal conditions. So therefore is very important knowledge of behaviour co-generative pv converters under these conditions.

4.1 RUNNING FORMATION OF SOLAR CONVERTERS BASED ON TGM

Here were measured three types of pv converters in the formation.

1. TGM generator without any modifications - P0
2. TGM generator with as is described in section 3.1 and with heat insulating frame – P1
3. This is the same as P1 more with Aluminium cooler on beck side of pv generator – P2.

First of all interest us a difference between running temperature of uncooled and cooled pv generator, improve of pv generator efficiency and heat gain from forced cooling from measured data. Here was chosen measuring from the day 1. 1. 2003 for demonstration. Working conditions of this day are stated on following figure (figure 4). G is solar irradiation for this day and T_{surr}. is surrounding temperature during the day (As T_{surr} for panel TGM are used data from www.meteo.cz). Irradiation during the day is answering to sunny weather with small afternoon cloudiness, because electric and heat gain is most significant for combined pv converter in this days. Situation is proportional with falling solar radiation in other days. They are surface running temperatures of solar converters on following figure (figure 5). The lowest running temperature has a pv generator P0. This is namely created with thanks to generator is not insert into insulating frame-base on TGM, witch decrease cooling by free convection to the surroundings. [6]

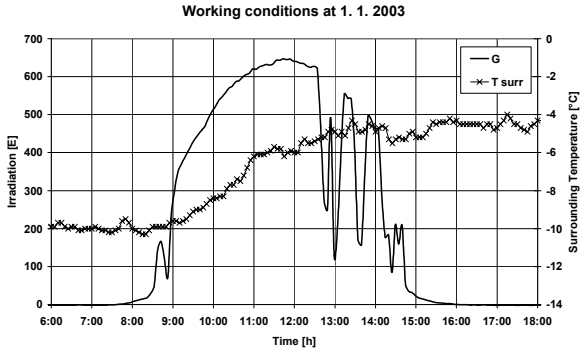

Fig. 4*: Working conditions at 1. 1. 2003*

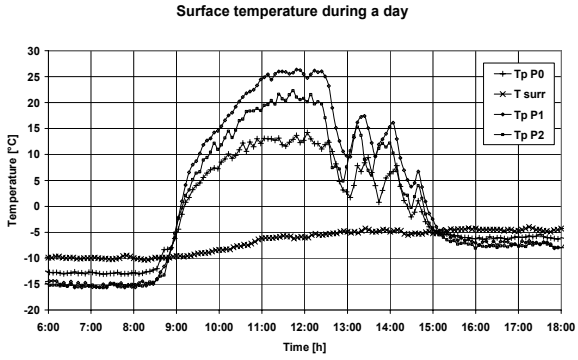

Fig. 5: *Surface temperatures of tested formation of solar converters TGM Own Construction of solar converter*

4.2 RUNNING FORMATION OF SOLAR CONVERTERS BASED ON OWN CONSTRUCTION

We have used two different types of duralumin cooler for its construction:

1. Ordinary U – profile cooled by air flow from beck side of cooler
2. Comb-shaped profile with five ribs, actually without forced coooling (H – profile)

Working conditions are for day 24. 12. 2003 on figure 6 and, also present clear sunny day as in previous case. Surface running temperatures are for pv generator own construction on following figure (figure 7). Curve $T_{pov.\,1}$ presents solar cells on Al cooler with U profile. Curve $T_{pov.\,2}$ answer to cooler with comb-shaped profile. This cooler (H) isn't cooled, but is situated to the same heat insulative frame-base as U-profille. Summary is in Tab. 1 for all shown pictures.

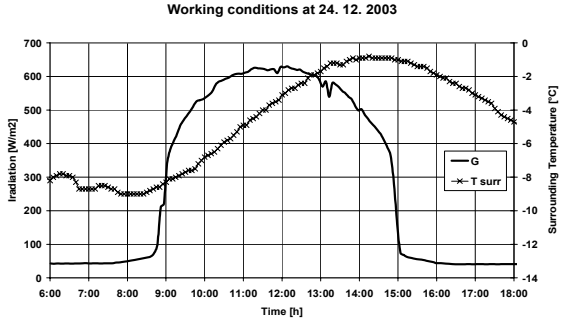

Fig. 6*: Working conditions at 24. 12. 2003*

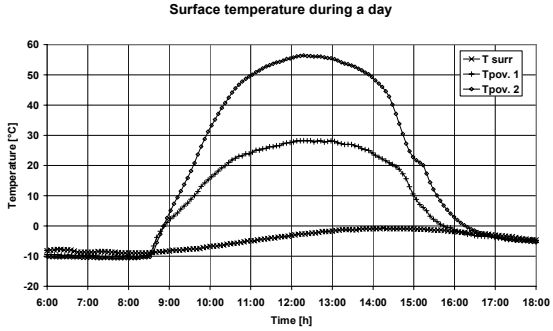

Fig. 7: *Surface temperatures during a day for own construction of solar converter*

Tab. 1: *Working temperatures for selected days*

Own 24.12.03				TGM 27.3.03			
G	627,18	T_p U	25,97	G	679,89	T_p P1	41,45
T_{in}	2,49	T_{out} U	11,11	T_{surr}	17,40	T_p P2	39,71
T_{out}	14,95	T_p H	54,45			T_p P0	32,63
ΔT	12,47	T_{out} H	-				

Note. T_{in} presents input temperature of cooling medium (and matches surrounding temperature), T_{out} output temperature (U or H means U – profile cooler resp. H – profile).

Lowest running temperature T_p has pv generator P0. It thanks that it isn't set in heat-insulating frame witch is decreasing his cooling by free convection into surroundings [5]. Measured data say us, that is optimal kept a pv generator absolutely without changes in winter period from running viewpoint. However, increasing of running temperature isn't so much significant, to wasn't balanced by benefits of heat gain in winter and decreasing of running temperature in the summer. Here is very markedly demonstrated a influence of cooling for own construction panel with U-profile cooler. Namely is significant to decrease of surface temperature (about 30°C) compared with uncooled section based on profile H (24. 12. 2003).

How to already was mentioned, we can decrease surface temperature by cooling and also we obtain source of low-potentional heat. Knowledge of its qualities and quantity is necessery for others utilization of conducted away heat too [4]. Here is cleary evident than heating up of cooling air is about 10°C for flow cooling air 1,6 l•s-1 for measured data mentioned on figure 8. Absorbing surface of panel is approximately 0,1225 m2

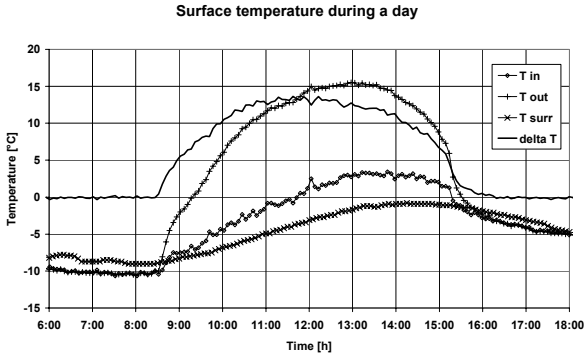

Fig. 8: *Input and output temperature of cooling medium*

5 CONCLUSIONS

If we inspect previously measured data, its says us, that is optimal to keep pv generator absolutely without modifications in winter season from running viewpoint. However, increasing of running temperature isn't so much significant, so that wasn't balanced by advantage of heat gain in winter [4] and decreasing of running temperature in the summer. The cooling of U-profile was very markedly demonstrate on solar panel of own construction. Namely by significant decreasing of surface temperature about 30°C at compared with uncooled profile.

REFERENCES

[1] Kleczek, J: Sluneční energie – úvod do helioenergetiky , SNTL Praha 1981

[2] Cihelka, J: Solární tepelná technika, Nakladatelství T. Malina Praha 1993

[3] Čambala, P., Gregor J.: Historie a současnost kombinovaných měničů sluneční energie na ÚEEN FEKT VUT v Brně, Sborník konference Současnost Elektroenergetiky 2003, Brno 2003

[4] Mastný, P.: Tepelná čerpadla v systémech využití tepla. Sborník konference EEICT, Brno 2003

[5] Čambala, P., Mastný P.: Power balance of photovoltaic generators. Sborník konference EEICT, Brno 2003

[6] Čambala, Petr: Using Air-Cooled Photovoltaic Generators. Sborník prací studentů a doktorandů, Student FEI 2001, Brno