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Preliminary communication

USING LOOP THERMOSYPHON TO WASTE HEAT REMOVAL FROM POWER ELECTRONIC COMPONENT

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Loop thermosyphon is a simple and reliable device providing several times higher heat transfer than convectional coolers used in cooling electronic. The paper deals with the cooling of power electronic component by means of this device. The main object of the paper is design and construction of the device to provide heat removal from the electronic component. Paper describes function principle of loop thermosyphon, testing of the function and measurement of cooling efficiency in dependence on input electric power of the electronic component. The findings from measurement of loop thermosyphon cooling efficiency are compared with natural convective alumina cooler on the end of paper.
Key words: loop thermosyphon**,** heat transfer, electronic component, temperature, measurement.

Korištenje toplinskog sifona u obliku petlje za uklanjanje otpadne topline elektroničkih strujnih komponenti. Toplinski sifon u obliku petlje je jednostavan i pouzdan uređaj koji pruža nekoliko puta veći prijenos topline nego konvekcijski hladnjaci koji se koriste pri hlađenju elektronike. Rad se bavi hlađenjem elektroničkih strujnih komponenti pomoću ovog uređaja. Glavni cilj ovog rada je projektiranje i izgradnja uređaja za omogućavanje uklanjanja topline iz elektroničkih strujnih komponenti. U radu se opisuje princip funkcioniranja toplinskog sifona u obliku petlje, ispitivanje funkcioniranja i mjerenje učinkovitosti hlađenja u ovisnosti o ulaznoj struji elektroničkih komponenti. Rezultati mjerenjaučinkovitosti hlađenja toplinskog sifona u obliku petlje uspoređeni su s prirodnom konvekcijom aluminatnog hladnjaka na kraju rada.
Ključne riječi: toplinski sifon u obliku petlje, prijenos topline,elektroničke komponente, temperatura, mjerenje.

INTRODUCTION

Given the rapid progress in the electronics industry, the thermal management of electronic components becomes an important and serious issue. Miniaturization of devices and increase their performance leads to increased heat flow. Natural and forced cooling for heat sink are often deficient and thus is limited to low and medium heat flux. One possibility for heat dissipation for high heat flux is using thermosyphon loop. A closed loop thermosyphon is an energy-transfer device capable of transferring heat from a heat source to a separate heat sink over a relatively long distance, without the use of active control instrumentation and any mechanically moving parts such as pumps. These devices are thus particularly suitable for cooling electronic components. The closed loop thermosyphon may be visualised as a long hollow pipe, bent and the ends joined to form a continuous loop, filled with working fluid and orientated in a vertical plane. If the one side of the loop is heated and the other side cooled, the average density of the fluid in the heated side is less than in the cooled side. An essentially hydrostatic pressure difference, as a result of the thermally induced temperature gradient between the hot and the cold sides, rives the fluid flows around the loop. The ‘buoyancy’ force, as it is often termed, driving the fluid is in turn counteracted by an opposing frictional force that tends to retard the flow [1]. A thermosyphon loop can transfer heat from the interior of a microelectronic system to a central location where space limitations are less stringent. The advantages that a thermosyphon system enjoys over a conventional refrigeration system include: (1) absence of moving parts leading to a more reliable system operation, (2) increased choices for selecting a working fluid compatible with microelectronics chips since it does not have to go through a refrigeration cycle, (3) reducing the decomposition rate of the working fluid as the higher temperatures at the compressor discharge in a vapour compression refrigeration system are not encountered, (4) clean operation as no oil is circulated through the system. In comparison to pool boiling systems employing vapour space condensation, a thermosyphon loop offers more flexibility in terms of providing a centralized condenser with different feed lines to individual evaporator stations. Further, with the addition of a liquid circulating pump in a thermosyphon loop, higher heat transfer coefficients associated with flow boiling systems could be realized [2].

EXPERIMENT

In the figure 1 is shown model of the closed loop thermsyphon. The evaporator body is made from aluminum block with parameters 116x80x30 mm. In to the block are drilled two 12 mm diameter horizontal holes and they are interconnected with ninth 6 mm diameter channels to liquid transport assurance from evaporator to the condenser part of loop thermosyphon [3]. The condenser is proposed so that to heat removal in to the surrounding was use natural convection. The length of condenser should be as long as the vapor of working medium can condensate and in liquid form return back to the evaporator. Achievement better heat transport transmitted by vapor of working medium in condensation section to the surrounding are on the pipeline fixed alumina fins with pitch 3 mm. The length of the condenser is 0.7 m. The transport section of the closed loop thermosyphon provides the circulation of vapor and liquid phases between the evaporator and condenser of the heat pipe. The whole transport section consists of 10 mm copper connecting tubes. Transient glass tubes were mounted on the evaporation and condensation sides of the transport section of the heat pipe to visualize and check the working fluid flow [4]. All connecting transient points of the whole heat pipe system are vacuum-tight. The intake and closing valves are located on the top of the evaporation transport section. As a working medium of closed loop thermosyphon was chosen Fluorinert FC 72, due to his compatibility with most metals, low freezing (- 90°C) and boiling (56°C) temperature and mainly due to excellent dielectric property [5].

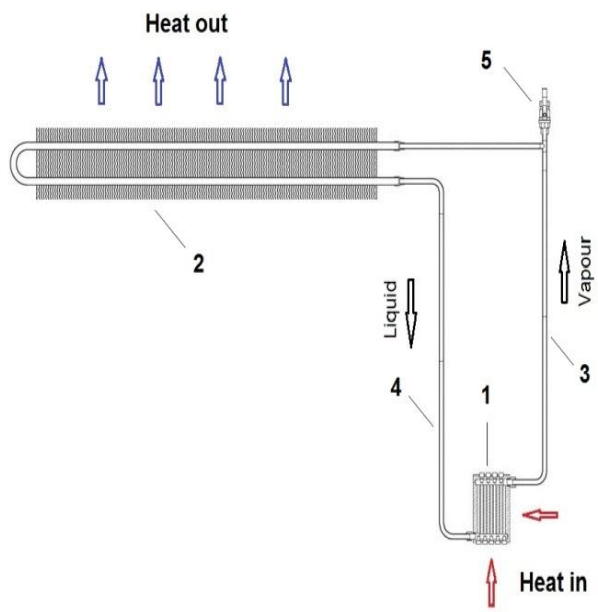

Figure 1. Loop thermosyphon scheme, 1 – evaporator, 2 – condenser, 3 – vapour pipeline, 4 – liquid pipeline, 5 – filling valve
Slika 1. Shema toplinskog sifona u obliku petlje, 1 – isparivač, 2 – kondenzator, 3 – cijevna linija s parom, 4 – cijevna linija s tekućinom, 5 – ventil za punjenje

In the Figure 2 is shown measuring unit of the electric components cooled by loop thermosyphon and alumina cooler. The electric components are plug-in DC power supply source and one is fixed on evaporator section of the loop thermosyphon and another is fixed on the alumina cooler. The electric current and voltage passing through the electronic components generate heat and cause the component temperature increasing. Because the highest admissible temperature of the electronic component is 100 °C, the thermocouple is inserted between surface of electronic component and surface of alumina cooler or evaporator of loop thermosyphon temperature to scanning its temperature. To the electronic component is connected volt-ampere meter to measuring electric current and voltage, too. So, all temperature and electric power data input to the measuring unit and are exported to the PC during the experiment measurement period [6]. The measurement heat removal efficiency from electronic component both variants starts at the input electric power 66 W. After electronic component temperature stabilization was the electric power increased step by step until the temperature of the electronic component connected to the alumina cooler reach the temperature 100 °C.

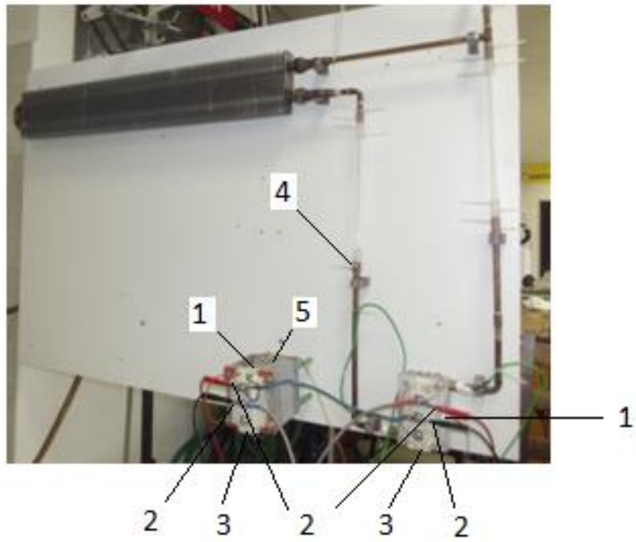

Figure 2. Measurement of electronic component cooling by loop thermosyphon and alumina cooler, 1 – temperature measuring, 2 – volt-ampere meter connection, 3 – electronic component, 4 – loop thermosyphon, 5 – alumina cooler
Slika 2. Mjerenje hlađenja elektroničkih komponenti pomoću toplinskog sifona u obliku petlje i aluminatnog hladnjaka, 1 – mjerenje temperature, 2 – priključak volt – amper metar, 3 – elektronička komponenta, 4 – toplinski sifon u obliku petlje, 5 – aluminatni hladnjak

RESULTS

Figure 3 show measured values course of the experimental measurement of heat removal efficiency from electronic component by loop thermosyphon and alumina cooler in to surrounding. Purple line represent input electric power of the electronic element, blue line represent temperature course of electronic element cooled by loop thermosyphon depending on input electric power in time and red line represent temperature course of electronic element cooled by alumina cooler depending on input electric power in time.
The steady values of electronic component temperature depending on input electric power from experimental measurement of the electric component cooling by loop thermosyphon and alumina cooler are listed in tab. 1.

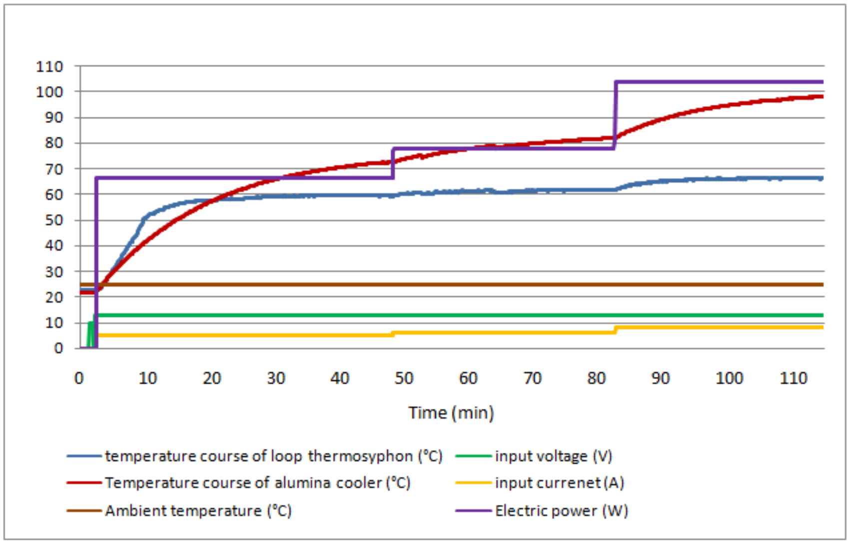

Figure 3. Temperature course of electronic component cooled by loop thermosyphon and alumina cooler
Slika 3. Temperatura hlađenja elektroničke komponente pomoću toplinskog sifona u obliku petlje i aluminatnog hladnjaka

The electronic component cooled by loop thermosyphon achieve temperature 66 °C and cooled by alumina cooler achieved temperature 98 °C at input electric power 104 W. According comparison of dependence electronic component temperature on input electric power and cooling method it is obvious, that the loop thermosyphon have better heat removal efficiency.

Table 1. Dependence of electronic component temperature on input electric power and cooling method
Tablica 1. Ovisnost temperature elektroničke komponente o ulaznoj električnoj snazi i metodi hlađenja

Input electric power of electronic component (W)	Temperature of electronic component cooled by alumina cooler (°C)	Temperature of electronic component cooled by loop thermosyphon (°C)
66	72	59
78	81	62
104	98	66

CONCLUSION

The objective of experiment was to design and construct a prototype of the closed loop thermosyphone and verify its functionality at the cooling of electronic component used in real applications at the highest admissible temperature on the contact area with the cooler 100 °C. Experimental measurement of heat removal from electronic component by loop thermo-syphon show very good efficiency, seeing that temperature on the contact area of electronic component with evaporator of loop thermosyphon not exceeds 70 °C. This experiment approves the cooling quality of the closed loop thermosyphon and justification of its use for the cooling of high efficiency electronic components and systems generating huge thermal flows of waste heat.

Acknowledgements

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