HALA

PULSATING HEAT PIPE (PHP) ASSEMBLIES

THERMAL MANAGEMENT

MAKING YOUR PULSATING HEAT PIPE ASSEMBLY MOST EFFICIENT AND THERMALLY BEST

PULSATING HEAT PIPE ASSEMBLIES
THERMAL MANAGEMENT

MAKING YOUR PULSATING HEAT PIPE ASSEMBLY MOST EFFICIENT AND THERMALLY BEST

BACKGROUND

The increase in power dissipation in electronic applications has made thermal management a growing challenge from year to year. In terms of sustainability to create more energy by means of thermally efficient cooling systems, passive cooling technologies and in particular Pulsating Heat Pipes (PHPs) have emerged as an advanced technology with high potential.

GENERAL

A PHP is a pulsation two-phase system capable of very efficient heat transfer with slim design and form factor. Heat can be transported multidirectionally, also against gravity.

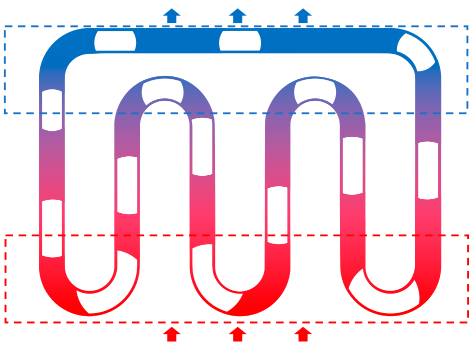
PHP DESIGN

PHPs usually consist of a continuous meander construction that can be adapted to the available space in the application. The channels can be narrow and e.g. formed into aluminum plates. The filling media of PHP can be deionized water, methanol or refrigerants such as ones with low global warming potential (GWP) refrigerants R1233zd(E) and R1234ze(E) or R1234yf depending on performance and operating temperature.

FUNCTIONALITY

A PHP basically consists of an evaporator section, an adiabatic section and a condenser section, as shown schematically in Fig. 1. In a PHP, the heat is transported from the evaporator to the condenser by self-excited oscillations between vapor bubbles and liquid blocks. When heat is applied, fluid partially evaporates in nucleation sites inside a serpentine. Small masses of liquid are converted to much lower density vapor bubbles that expands, exerting high positive pressure on adiacent fluid blocks. Inversely, contraction of vapor into liquid in the condenser section applies suction to neighboring fluid blocks. These frequent imbalances in pressure sustains the recirculating flow and gives this disruptive technology its name, removing the need to supply any mechanical work. Once in the colder condenser area, the vapor condenses back into the liquid working medium and its latent heat is released to air or liquid.

Fig. 1



ADVANTAGES

1. Heat transfer over long(er) distances.

In most applications, heat transfer for electronics cooling is usually up to 250/300 mm. Conventional heat pipes work efficiently up to one meter in a horizontal position. However, they must be shortened considerably if the evaporator is located directly above the condenser. PHPs with their vapor pressure-driven pulsating operation are ideal for applications such as aviation, aerospace, defense, 5G stations, portable electronics, or large-area applications.

2. Operate against gravity up to 1 meter and more

Like standard heat pipes, PHPs can operate against gravity, without being so dependent on capillary action as standard heat pipes. While a porous-wick heat pipe can works effectively against gravity up to about 200 mm. In addition, Qmax of a PHP decreases more slowly compared to standard heat pipes when transitioning from horizontal to counter-gravity orientation.

3. Offers more design freedom

PHPs enable effective heat transfer, even with complex geometries, offering more design freedom than conventional heat pipes. PHP channels can be integrated directly into a cooling solution or housing by forming a meander structure directly in the metal. Aluminum can also be used but not with water as working fluid. Their heat capacity (Qmax) exceeds that of conventional heat pipes, which have a a capillary limit.

4. Can be integrated directly into the thermal surface

PHPs offer the advantage that they can be integrated directly into the thermal surfaces in contrast to heat pipes, which are separate parts. This integration makes the assembly and connection technology effective without the high risks of mechanical failures at thermal interfaces. As a result, PHPs withstand shocks and vibrations better and thus form a very robust system.

5. Ability to transport larger amounts of heat

PHPs have a comparable heat flow and heat capacity to capillary limited high-performance heat pipes. A decisive advantage is their ability to transport larger amounts of heat up to several 100 W/cm² by acting as an oscillating heat pump. They are therefore suitable as a passive heat transfer solution for robust heat management systems.

PULSATING HEAT PIPE ASSEMBLIES
THERMAL MANAGEMENT

MAKING YOUR PULSATING HEAT PIPE ASSEMBLY MOST EFFICIENT AND THERMALLY BEST

FUNCTION START

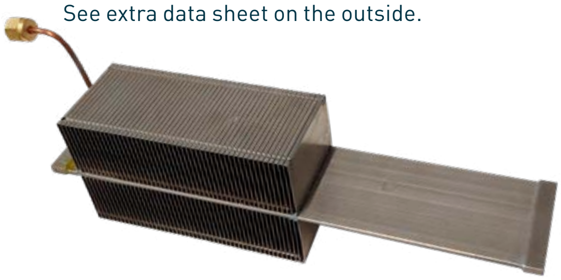
PHPs require a pressure difference in order to function. This leads to a slower start-up, which can cause thermal problems in the start-up phase. It is important to test and analyze during development and design as well as after filling. Uncovered die devices with very low thermal mass can be particularly susceptible. However, this start-up instability typically occurs at lower temperatures where there is a larger thermal margin. For most applications this is not a major problem, especially when using higher vapor pressure liquids, such as methanol.

DESIGN OPTIONS FOR SERIES PARTS

HALA and its PHP team offer 2 variants of standard PHPs assemblies.

1. FLAT PHP FINS increasing heat sink efficiencies
See extra data sheet on the outside.

2. PHP ASSEMBLIES as AL plates or blocks
See extra data sheet on the outside.



CONCLUSION

PHPs will surely become a relevant technology for thermal management in practice for their intrinsic properties mentioned above. In particular, they will take into account the increasing space, distance, performance and weight requirements, which is why they have great potential. However, experience and design knowledge are required to create integrated and fully operative thermal solutions.

MEET OUR EXPERTS

With our team of experts, we can help you establish a PHP as a new thermal management solution in your application.

CONTACT US NOW!

FON +49 7021 73141-0
CONTEC@HALA-TEC.DE

WATCH VIDEO ON YOUTUBE

www.youtube.com/watch?v=x9mwZTY84UI&t=7s

APPLICATION

PULSATING HEAT PIPE ASSEMBLIES
FIN PLATE ARRAYS

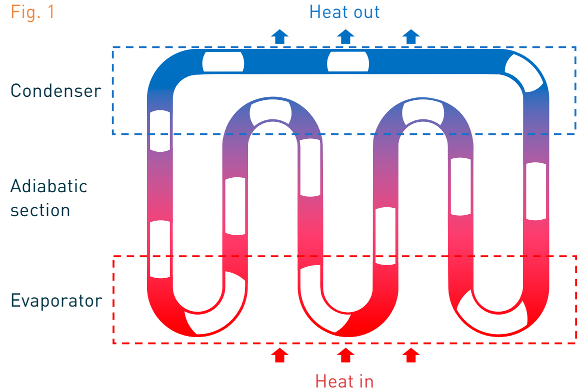
MAKING YOUR PULSATING HEAT PIPE ASSEMBLY MOST EFFICIENT AND THERMALLY BEST

This is an air-cooled coldplate incorporating a pulsating heat pipe (PHP) to increase the fin efficiency and thus power dissipation of the plate, which can be utilized individual or in an array of plates, with or without a fan, for reducing fan energy consumption.

PULSATING HEAT PIPE (PHP) THERMOSYPHON WORKING PRINCIPLES

In a PHP, heat is transported from the evaporator to the condenser by vapor bubble-liquid slug self-excited oscillations. These oscillations are driven by the nucleation and collapse of vapor bubbles in the evaporator and condenser, respectively. In the evaporator partial evaporation of the working fluid ensures cooling of the heat source. In the condenser the vapor bubbles condenses back to liquid by exchanging heat with a secondary coolant.

Fig. 1



PROPERTIES

- External dimensions: 46 mm length x 122 mm depth x 336.5 mm height; 4 fins per array
- Condenser boundary conditions: Natural and forced convection (4 CFM)
- Orientation: Vertical
- Material: 100% aluminum (795 g empty)

APPLICATION EXAMPLES

- 5G base station electronics
- Power electronics
- Medical devices
- X-ray machines (medical and security)
- etc.

THERMAL RESISTANCE [K/W]

	NATURAL CONVECTION			FORCED CONVECTION		
Watt	Aluminum plain fins array	PHP fins array	PHP with louver fins array	Aluminum plain fins array	PHP fins array	PHP with louver fins array
20 W	0.780	0.730	0.724	0.572	0.472	0.475
40 W	0.688	0.630	0.643	0.536	0.443	0.455
60 W	0.642	0.587	0.602	0.524	0.429	0.444
80 W	0.618	0.548	0.566	0.513	0.420	0.440
100 W	–	0.517	0.549	0.506	0.411	0.428
120 W	–	–	–	–	0.402	0.421
140 W	–	–	–	–	0.397	0.416

All data without warranty and subject to change. Please contact us for further data and information.

Technical Data Sheet Release 05 / 2024

HALA Contec GmbH & Co. KG / Hans-Böckler-Straße 15 / D-73230 Kirchheim u.T. / Fon +49 7021 73141-0 / Fax +49 7021 73141-99 / contec@hala-tec.de / www.hala-tec.de

PULSATING HEAT PIPE ASSEMBLIES
FIN PACK

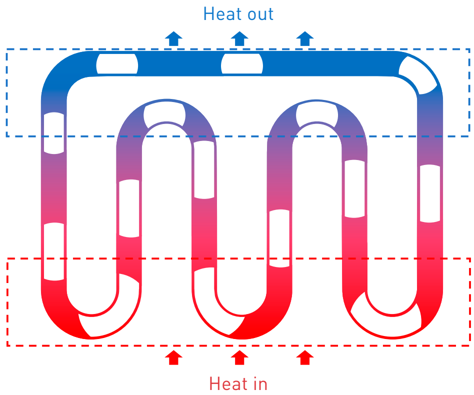
MAKING YOUR PULSATING HEAT PIPE ASSEMBLY MOST EFFICIENT AND THERMALLY BEST

This is an air-cooled pulsating heat pipe (PHP) used to dissipate power of the surface of a component, and which can be utilized with or without a fan.

PULSATING HEAT PIPE (PHP) THERMOSYPHON WORKING PRINCIPLES

In a PHP, heat is transported from the evaporator to the condenser by vapor bubble-liquid slug self-excited oscillations. These oscillations are driven by the nucleation and collapse of vapor bubbles in the evaporator and condenser, respectively. In the evaporator partial evaporation of the working fluid ensures cooling of the heat source. In the condenser the vapor bubbles condenses back to liquid by exchanging heat with a secondary coolant.

Fig. 1



PROPERTIES

- External dimensions: 243.5 mm long x 50.8 mm deep x 67 mm high, 2 mm thick
- Condenser boundary conditions: Natural or forced convection (100 CFM)
- Orientation: Vertical, horizontal, sideways
- Material: 100% aluminum (317 g empty)

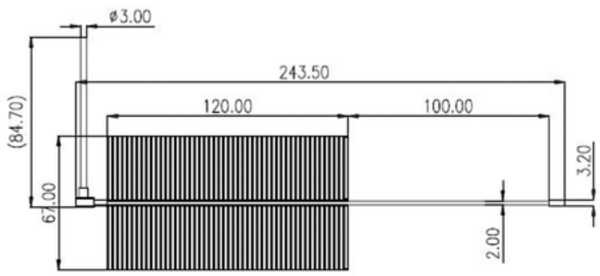
APPLICATION EXAMPLES

- Portable electronics
- Power electronics
- Computer & IT,
- Aerospace & Aircraft
- etc.

THERMAL RESISTANCE [K/W]

	NATURAL CONVECTION			FORCED CONVECTION		
Watt	Horizontal	Vertical	Sideways	Horizontal	Vertical	Sideways
50 W	0.696	0.479	0.564	0.231	0.165	0.242
80 W	0.643	0.455	0.512	–	–	–
100 W	–	0.523	–	0.241	0.167	0.250
150 W	–	–	–	0.236	0.168	0.240
200 W	–	–	–	0.238	0.168	0.237
225 W	–	–	–	–	0.162	–

All data without warranty and subject to change. Please contact us for further data and information.



Release 05 / 2024

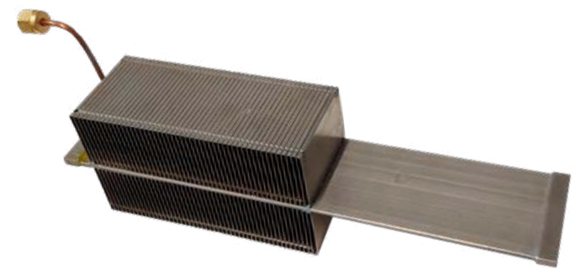
Technical Data Sheet

HALA Contec GmbH & Co. KG / Hans-Böckler-Straße 15 / D-73230 Kirchheim u.T. / Fon +49 7021 73141-0 / Fax +49 7021 73141-99 / contec@hala-tec.de / www.hala-tec.de

APPLICATION

PULSATING HEAT PIPE ASSEMBLIES CHECKLIST

FILL IN YOUR DATA AND SEND BACK TO US



1/ OPERATING POWER	.... Watts	Maximum total power demand
2/ OPERATING ORIENTATION	....	Angle from horizontal between evaporator and condensor sections
3/ MAX. COMPONENT TEMPERATURE	.... °C	Maximum temperature requirement for multiple components
4/ AMBIENT TEMPERATURE	.... °C to .... °C	Operating temperature range
5/ STORAGE TEMPERATURE	.... °C to .... °C	Storage temperature range
6/ COOLING	....	Heat sink with forced convection (flow rate), natural convection or liquid cooling
7/ SURFACE REQUIREMENTS	....	Evenesses, roughness, plated, unplated, sealed, etc.
8/ NOTES	....	Performance specifications, drawings, sketches, special requirements, etc.

HALA Contec GmbH & Co. KG / Hans-Böckler-Straße 15 / D-73230 Kirchheim u.T. / Fon +49 7021 73141-0 / Fax +49 7021 73141-99 / contec@hala-tec.de / www.hala-tec.de