New Products

Ultra-thin Sheet-shaped Heatpipe “pera-flex®”

1. INTRODUCTION

Recently, the development of mobile electronic equipment including notebook PC, digital camera, PDA and mobile phone is truly remarkable. These electronic equipment are required to offer high performance as well as slim body brought about by high-density mounting. Thus the issue of heat dissipation in mobile electronic equipment, which was not viewed problematically, has come up to the surface.

Whereas conventional heatpipes and graphite sheets are known as an existing solution for heat dissipation, application of these devices to mobile electronic equipment has been considered to be difficult due to their mounting configurations.

Accordingly, applying the heatpipe technology that the company has long been studying, Furukawa Electric has embarked on the research of ultra-thin sheet-shaped heatpipe named “pera-flex®” that can efficiently transport and dissipate heat within an extremely limited space, and has succeeded in developing the new product. See Photo 1.

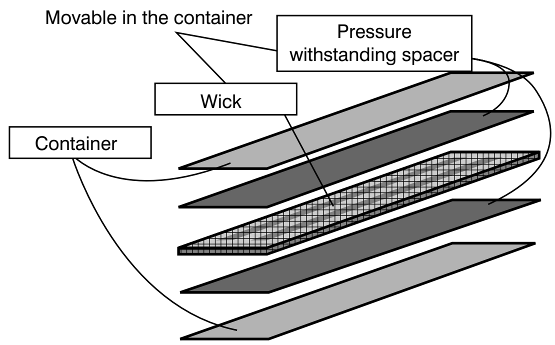

Figure 1 Structure of pera-flex.

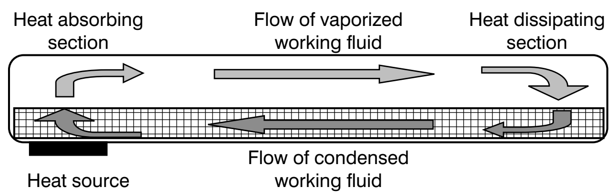

Figure 2 Circulation of working fluid in pera-flex.

2. STRUCTURE AND OPERATION OF PERA-FLEX

As shown in Figure 1, pera-flex has such a structure whereby a wick for capillary force generation and a pressure withstanding spacer are encapsulated together with a small amount of water into an envelope-shaped container made of thin metal foil, and subsequently the entire air is evacuated to seal the container hermetically. The inner pressure, which equals to the saturated vapor pressure of the working fluid at working temperature, is lower than the ambient pressure at room temperature, so that the wick and the pressure withstanding spacer are pressed together to become mechanically constrained thereby leaving fluid paths among the wicks.

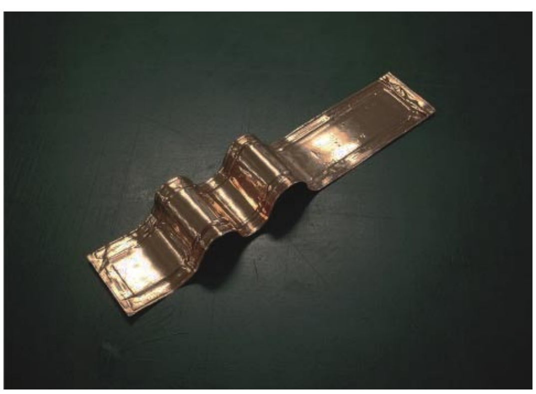

Photo 1 Appearance of pera-flex.

When heat is applied onto pera-flex, as illustrated in Figure 2, the saturated vapor pressure of the working fluid at the heat-absorbing section that is in contact with the heat source increases, and the working fluid vaporizes. Because the input heat is absorbed as latent heat of the working fluid, the temperature rise at the heat-absorbing section is suppressed extremely low. The vaporized working fluid diffuses thoroughly into the fluid paths provided in the wick, and condenses at sections of relatively low temperatures, thereby dissipating the latent heat. The condensed working fluid is absorbed into the wick to reflow back to the heat-absorbing section by gravity and capillary force. Because the working fluid within pera-flex circulates taking advantage of phase changes as described above, heat transportation between sections with a very small temperature difference becomes possible.

Photo 2 Pera-flex in asymmetrical shape.

The mechanism of pera-flex at the time of flexure is such that, since the wick and the pressure withstanding spacer can move inside, the strain is absorbed so as not to block the fluid paths in the wick due to buckling. Thanks to this flexibility, pera-flex can be installed easily without paying too much attention to the irregularities in height between the housing and the heat source, and this constitutes a significant advantage in upgrading ease of assembly.

Moreover pera-flex is provided with a high degree of freedom in planar shape as shown in Photo 2, and thus can deal with 2-dimensional heat transportation tasks involving bends and indents, which was difficult using conventional heatpipes.

What is more, the capillary force has been strengthened by the proprietary wick configuration and surface treatment, so that it become possible to operate pera-flex in the top-heat mode, which was difficult for conventional heatpipes, whereby the heat source is located on the upside. In terms of materials, copper with high heat conductivity is usually used together with water having high latent heat for the working fluid, resulting in such advantages as good thermal performance, low cost, safety and low environmental impact.

Pera-flex can be applied to an extremely limited space because of its exceptional small thickness in addition to flexibility and freedom in the shape. Moreover, it can be used in all inclination angles.

3. PERFORMANCE OF PERA-FLEX

Figure 3 shows an example of the measuring setup for thermal performance. One end of the pera-flex is heated with a heater and the heat dissipating section is provided with fins, and the remaining sections are thermally insulated. The results are plotted in Figure 4. It was shown that when heat amount of 4 W was input into a pera-flex 0.7 mm in thickness, under the condition of the insulating section temperature T3 kept at 50°C, the temperature difference ΔT and the thermal resistance could be suppressed within about 1°C and 1 °C/W, respectively, in all inclination angles and over the length from the heat insulating section to the end. The

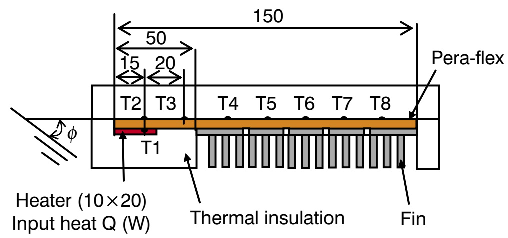

Figure 3 Setup for thermal performance measurement.

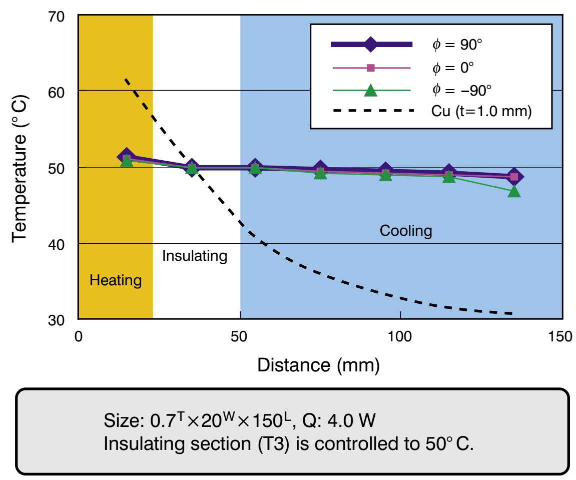

Figure 4 Typical temperature profile of pera-flex compared with copper sheet.

result of an experiment when the same amount of heat was input into a copper sheet 1.0 mm thick is shown for comparison, indicating that the ΔT and the thermal resistance reached 20°C and 7°C/W, respectively. In the meantime, the pera-flex 0.7 mm thick could control T3 to 50°C at room temperatures higher than 30°C using natural convection cooling, while the copper sheet 1.0 mm thick could not effect the same cooling unless at room temperatures lower than 30°C using forced convection cooling. Thus pera-flex was seen to have extremely higher heat transportation efficiency in comparison with copper sheet, being very effective in terms of heat transportation and heat dissipation.

Also like heatpipes, pera-flex has a limit in the amount of heat transfer rate. This phenomenon is called “dryout”, and Figure 5 shows the limiting value called “maximum heat transfer rate” usually represented by Q_{max}.

In the bottom-heat mode where the heat source is located on the downside, the maximum heat transfer rate reaches a relatively large value because gravity acts additively on the reflow of the working fluid. On the contrary, in the top-heat mode where the heat source is located on the upside, gravity acts subtractively reducing the maximum heat transfer rate to a relatively small value. Thus limiting the heat transfer rate according to working condition designs makes it possible to operate pera-flex at all inclination angles.

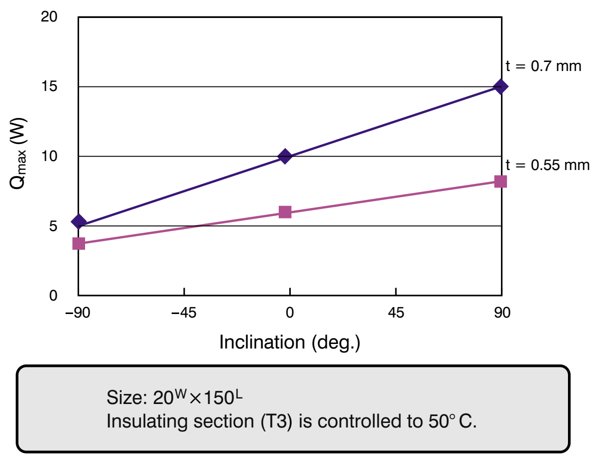

Figure 5 Relationship between maximum heat transfer rate and inclination angle.

4. CONCLUSION

Because pera-flex has such features as extreme thinness, flexibility and freedom in shape and configuration, it is capable of transporting and dissipating heat effectively, making itself a powerful solution to thermal problems in mobile electronic equipment of today. We would like to invite our customers in trouble with thermal problems to have a look at pera-flex.

REFERENCES

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