The most frequently asked questions about Peltier Elements

What does the Peltier Element do?

In a Peltier Element, different materials are arranged between two surfaces in such a way that thermal energy (heat) is transported from one surface to the other during a current flow. Here it can be observed that the side from which the energy is dissipated cools down, while the other side becomes warmer. The lake basin effect and the Peltier effect always occur simultaneously and interfere with each other. This obstacle prevents an increase in energy from producing a proportional increase in transport performance.

What is the Peltier effect used for?

The Peltier effect keeps objects at a constant temperature. Cooling systems are set up with Peltier Elements. Peltier Elements are able to bring certain places to "any" temperature. Pel-tier Elements are often used where conventional compressor cooling systems cannot be used. For example, when leaking coolant should be a danger, or where regular maintenan-ce cannot be carried out.

What can a Peltier Element do?

A Peltier Element is able to locally shift thermal energy (heat) contrary to the natural physi-cal heat aspiration. Just as an object on an inclined surface is anxious to slide down this slope, so thermal energy is anxious to migrate to cooler places. If you need a motor to move the body up the mountain, a Peltier Element can be used to transport heat from a cold level to a warm environment.

When is the use of Peltier Elements recommended?

Peltier Elements are excellent for keeping various objects at a constant temperature or bringing them to the desired temperature.

Peltier Elements are suitable for cooling down areas to temperatures below the ambient temperature.

Peltier Elements are suitable for heating. Due to their ability to transport heat, heating effi-ciencies of well over 100% can be achieved, as with conventional heat pumps. In this context, the term efficiency is not correct, since no energy is converted here, but is shifted. Better is the expression coefficient of performance COP. (Coefficient of Performance)

With Peltier technology, objects or areas can be maintained at temperatures between ap-prox. -40°C and + 200°C or changed cyclically.

Peltier Elements do not need a start-up time to unfold their effect, apart from the tempera-ture time due to the materials. Thus very dynamic temperature changes can be achieved. Temperature jumps of 10 Kelvin per second are possible depending on the dimensioning.

In order to achieve the temperature in a targeted manner, it is necessary to use control technology. For this purpose, a sensor must be used to detect the object temperature.

What power supply does a Peltier Element need?

A Peltier Element must be supplied with direct current. The maximum supply voltage is given in the data sheet of the Peltier Element. The more thermocouples a Peltier Element has, the higher the maximum supply voltage. For example, the Peltier Element QC-127-1.4-6.0 is composed of 127 thermocouples. The maximum voltage per thermocouple is approx. 0.12 Volt. This results in a voltage of approx. 15 volts for this type of Peltier Elements. Swit-ching power supplies with sufficient smoothing are suitable as a supply source. For de-manding tasks a direct current supply with toroidal transformer is necessary.

Can a Peltier Element also be supplied with low voltages?

A Peltier Element can be operated with any low voltage. With decreasing voltage the power consumption of the Peltier Element decreases. At half the voltage, for example, approx. one quarter of the power of the Peltier Element is called up.

Is it always possible to achieve better cooling with a lot of electricity?

A Peltier Element can only function as well as the cooling element (or heat sink) on which the Peltier Element is mounted. If (due to structural conditions or for other reasons) the he-at sink cannot exceed a certain size, it makes sense in many cases to feed the Peltier Element with a lower voltage and correspondingly less current. Then one can achieve a lower tem-perature on the cold side. Here applies: Less can be more!

How can the internal resistance of a Peltier Element be measured?

The ohmic resistance of a Peltier Element is measured with an LCR measuring instrument at a frequency of 1000 Hertz. With a standard multimeter, on the other hand, a direct current is induced which leads to false results due to the thermoelectric reaction of the Peltier Ele-ment. When performing the measurement, it is important that both sides of the Peltier Element have the same temperature. Otherwise, the thermogenerative effect also causes a falsification. The measurement does not provide meaningful results.

Which side gets cold with the Peltier Element?

First of all it must be put in front that one side of a Peltier Element can become cold only if the other has a heat-locking contact to a heat sink or another heat sink. With a Peltier Ele-ment there is in most cases a red and a black connection cable. If the red cable is properly connected to the positive terminal of the DC power source, the printed side is the one that gets cold. Other features to identify the cold side are as follows: If a Peltier Element has ce-ramic surfaces of different sizes, the cold side is always the smaller one. The connecting cables are always soldered to the warm side of the Peltier Element. If you place a Peltier Element in front of you in such a way that the connecting cables are directed towards the observer (the observer looks at the cable connections on the ceramic of the element) and the right cable is red, the cold surface looks upwards.

How can you heat with a Peltier Element?

By reversing the current direction (black cable to the positive pole of the direct current source) the cold side becomes the warm side. This does not harm a Peltier Element. It is designed for this. However, if the temperature changes constantly, it is absolutely necessary to ensure that a high cycling Peltier Element is used.

In which cases should a sealed Peltier element be selected?

Whenever a temperature below the ambient temperature is to be reached with the Peltier element, the occurrence of condensate is to be expected. This can strongly impair the cooling function and leads to corrosion in the Peltier element after a short time. With a silicone or epoxy resin seal, the occurrence of condensa-te and the associated harmful consequences can be largely suppressed. A seal is also required if the Peltier element is exposed to the risk of contamination.

Which control method is used for the Peltier element?

The common method for controlling Peltier elements in a control loop is pulse width modulation. Here the current strength is controlled over the length of a pul-se. Circuit breakers with only two states are used: Full blocking (hardly any cur-rent, almost no voltage drop) or full through switching (almost no current, hardly any voltage drop). The mean value of the voltage is changed by the ratio on/off time. The re-sulting current profile is smoothed by inductances and converted into a quasi-constant profile. The frequency whose pulse width is changed is approxi-mately 100 - 200 kHz. The higher the frequency, the smaller are the inductances for smoothing. On/Off control is also possible. However, this does not allow high-quality and precise control. In addition, the Peltier element is subjected to a hig-her load.

What material is a Peltier element made of?

A Peltier element consists of the p- and n-doped semiconductor bismuth telluride (Bi2lTe3). This starting material is formed into a cuboid and soldered between electrically insulating surfaces. In most cases this is aluminium oxide (Al3O2). A pair of an n-doped and a p-doped parallelepiped is called a thermocouple. A Pel-tier element can consist of a few to several hundred thermocouples. The number of thermocouples used is in most cases part of the article number.

Is it possible to connect several Peltier elements to one voltage source?

It is no problem to connect several Peltier elements to one voltage source.

In which cases should a sealed Peltier Element be chosen?

Whenever a temperature below the ambient temperature is to be reached with the Peltier Element, the occurrence of condensate is to be expected. This can strongly impair the coo-ling function and leads to corrosion within the Peltier Element after a short time. With a si-licone or epoxy resin sealant, the occurrence of condensate and the associated harmful consequences can be largely suppressed. Sealing is also required if the Peltier Element is ex-posed to the risk of contamination.

Which control method is used for the Peltier Element?

The usual method for controlling Peltier Elements in a control loop is pulse width modulati-on. Here the current strength is controlled over the length of a pulse. Circuit breakers with only two states are used: Full blocking (hardly any current, almost no voltage drop) or full through switching (almost no current, hardly any voltage drop). The mean value of the vol-tage is changed by the ratio switch-on time/switch-off time. The resulting current profile is smoothed by inductances and converted into a quasi-constant profile. The frequency who-se pulse width is changed is some 100 - 200 kHz. The higher the frequency, the smaller are the inductances for smoothing. An on/off control is also possible. However, this does not allow high-quality and precise control. In addition, the Peltier Element is stressed more strongly.

What material is a Peltier Element made of?

A Peltier Element consists of the p- and n-doped semiconductor bismuth telluride (Bi2lTe3). This starting material is shaped into a parallelepiped and soldered between electrically insu-lating surfaces. In most cases this is aluminium oxide (Al3O2). A pair of an n-doped and a p-doped parallelepiped is called a thermocouple. A Peltier Element can consist of a few to se-veral hundred thermocouples. The number of thermocouples used is in most cases part of the article number.

Is it possible to connect several Peltier Elements to one voltage source?

It is no problem to connect several Peltier Elements to one voltage source.

How can several Peltier Elements be electrically connected to each other?

The Peltier Elements can be connected either in parallel or in series. With parallel connec-tion you need the maximum voltage for one Peltier Element and a current intensity corres-ponding to the number of Peltier Elements multiplied by their maximum current intensity.

(e.g. 4 Peltier Elements with 15.5 Volt and 8.5 Amp. require a voltage source of max. 15.5 Volt at 34 Amp).

With series connection, however, only the current strength corresponding to a Peltier Ele-ment and a corresponding multiple of the voltage are required. (e.g. 4 Peltier Elements with 15.5 Volt and 8.5 Amp. require a voltage source of max. 62 Volt at 8.5 Amp.). Since it is ea-sier to obtain a high voltage than a high current for the direct current supply, this type of circuit is much cheaper. It has to be considered that the Peltier Elements influence each other. With strongly different temperatures it can come to under- or oversupply of indivi-dual elements in the chain.

A combination of series and parallel connection is also possible.

The electrical contact can be made, for example, by means of a luster terminal or by sol-dering covered with shrink tubing.

What happens if you take a Peltier Element between your fingers and feed it with electricity?

If you take a Peltier Element between your fingers and feed it with current, you will feel a temperature difference on both sides of the Peltier Element for a short time (depending on the Peltier Element and the selected current strength for a few seconds). A few seconds la-ter, the Peltier Element is so hot on the warm side that the pain threshold is exceeded, so that it is involuntarily dropped. The heating can take place so quickly that an injury can oc-cur before the pain reaction sets in. Once again a few seconds later, the Peltier Element is so hot that the soldering points on the thermocouples melt and as a result it is irretrievably de-stroyed. Therefore a Peltier Element must never be operated without a heat sink or without contact to a surface with a large thermal mass.

How can you check whether a Peltier Element works?

The Peltier Element is connected on the warm side (not printed side) with a heat sink. Power (+) is fed into the red connecting cable, whereby the voltage must not exceed the voltage defined for the Peltier Element. The cold side must then cool down very quickly. A further test possibility is the measurement of the ohmic resistance of the element. This must not deviate by more than 10% from the specification.

Is it possible to reverse the current direction when supplying the Pel-tier Element?

It is possible to reverse the direction of current supplied to the Peltier Element without any problems. The positive pole of the DC voltage supply is connected to the black connecting cable of the Peltier Element. The side that has previously cooled becomes the heating side. It must be ensured that it does not become too hot. The previously warm side becomes the cooling side. The minimum achievable temperature, however, is not as low during operati-on in reverse current direction as with normal current direction.

What does Qcmax mean?

Qcmax is the maximum cooling capacity that the Peltier Element can provide when it is dri-ven with full voltage and the Peltier Element "feels" a temperature difference of 0°C. Qcmax is the maximum cooling capacity that the Peltier Element can provide when it is driven with full voltage and the Peltier Element "feels" a temperature difference of 0°C. If the Peltier Element is to build up a temperature difference, the cooling capacity is reduced approxi-mately proportionally to the temperature difference. At a temperature difference of ap-prox. 70°C the cooling capacity is zero.

What possibilities are there to install a Peltier Element with the best possible thermal contact?

In order to achieve the best possible cooling effect, it is of elementary importance to cool the Peltier Element as efficiently as possible on the warm side. The physical property of the heat sink of the heat transfer is important and the best possible thermal connection of the Peltier Element to the heat sink.

The more planarity the connecting surfaces of the heat transfer have, the better the initial situation.

The following options are available to reduce the heat transfer resistance at the mounting surfaces:

- Heat conducting paste

- thermal adhesive

- thermal conducting foil

With proper handling there are hardly any differences with regard to the achievable heat transfer resistance.

What has to be considered if several Peltier Elements are installed si-multaneously?

If several Peltier Elements are installed simultaneously in a system, it must be ensured that their height, flatness and parallelism are within narrow tolerances (< 0.05 mm) and that they are installed with the required contact pressure of approx. 140 N/cm².

If the Peltier Elements are electrically connected in series, which leads to a reduction of the required current strength, care must be taken to ensure that the internal electrical re-sistance is as uniform as possible.

How can the temperature dependence of the electrical resistance of a Peltier Element be described?

The electrical resistance Rel(t) of a Peltier Element increases with increasing temperature.

The dependency can be described with good accuracy as follows:

Rel(t) = Rel(25°C) * (1 + α*ΔT) with ΔT = t[C] - 25°[C] and α = 0,0049 1/K Rel(25°C) = the electrical resistance of the Peltier Element at 25°C

What are typical damage patterns when using Peltier Elements?

The most common damage patterns are melted thermocouples in the Peltier Element. This can often be detected by fluoroscopy with a very bright light source. A further indication is the internal resistance, which is infinitely high in these cases.

In most cases the cause is the operation of the Peltier Element without heat sink. Further damages are broken or cracked ceramics.

A Peltier Element is relatively sensitive to shocks and blows. If it falls on a hard under-ground, it can already come to such damages. Even if a Peltier Element is installed tilted, the corners of the ceramic plates can easily break off. Therefore it is to be paid attention with the assembly always to the fact that the screws are tightened evenly.

How can Peltier Elements and Heat Pipes be connected?

Heat Pipes are suitable for transferring heat from the warm side of a Peltier Element. This is always very helpful if there is not enough space for a sufficiently powerful heat sink at the installation location of the Peltier Element. The connection between both components is made with a heat coupling element. This consists of a cuboid made of copper or aluminium with a hole for the Heat Pipe. The cuboid covers the Peltier Element. The Heat Pipe can be glued, clamped or soldered into the heat coupling element.

How low is the lowest temperature that can be reached with a Peltier Element?

The achievable lowest temperature is essentially influenced by the temperature on the "warm" side of the Peltier Element. The lower it can be kept, the lower the temperature on the cold side.

A single-stage Peltier Element in combination with a very good heat sink can produce about -30°C with ambient air. At this temperature, however, the amount of heat that can be shif-ted is infinitesimally small. You can precool the "warm" side so that in technical applications you can reach approx. -50 to -60°C depending on the degree of precooling.

If the pre-cooling is done with a Peltier Element, it is called a two-stage element. With a mul-ti-stage pre-cooling the achievable temperature can be further reduced.

A limitation in principle must not be ignored: The efficiency of the thermoelectric semi-conductor material bismuth telluride changes proportionally to the absolute temperature. The lower the target temperature, the lower the efficiency and the lower the transferable power.

Practically achieved laboratory values are in the range of and -100°C, but this can only be achieved with extreme effort and almost perfect isolation of the target area.