Failsafe Air Heating | Dr.-Ing. Jürgen Prokop | April 2018

PTC finned resistor air heater designed for the fail-safe air heating in ventilation systems at low pressure loss.

The growing use of electrical energy in air duct heating applications poses new challenges to manufacturers of electrical heating systems – as many customers ask for example for space-saving designs and low pressure loss solutions for their systems. As of today, resistive type heating systems are in common use. Now, the PTC (Positive Temperature Coefficient) heating technology offers a new and safe alternative that combines high efficiency with of low pressure loss.

Typical applications areas for state-of-the-art electrical air heaters are the new generation ventilation systems for single and multi-family houses. Apart from being fail-safe and quiet, low pressure losses and a homogeneous heat distribution are important requirements that must be met when installing such units in air ducts and ventilation systems. A comparison of the commonly used heating systems - conventional tubular heaters, PTC finned resistor air heaters and open-coil heaters – shows that each system has its specific advantages:

Tubular heaters have the advantage of low pressure losses and low noise levels. They need, however, adequate protection to prevent fire hazards in case of failure. Depending on the circumstances, it may be difficult to obtain a homogeneous heat distribution.
Conventional PTC air heaters guarantee a homogeneous heat distribution and a high operating safety due to the PTC effect. If used in ventilation applications and large systems with extended distribution ducting, however, a bypass is needed to compensate for the higher pressure loss across the air heater. Which leads in turn to a less homogeneous heat distribution, making this type of heaters unsuitable for certain applications.
The open coil technology has the advantage of low pressure losses and an even heat distribution. It has, however, also several disadvantages: the need of electrical protection by additional controls, required adjustment to surrounding structures and adequate safety clearances to prevent overheating in case of failure. Any of the above described air heating solutions may be best suited to meet the needs of a specific application.

Figure 1: PTC finned air heater with significantly reduced pressure loss (Delta)

DBK David & Baader GmbH, expert for electrical heating systems and headquartered in Ruelzheim in the Southern Palatinate Region of Germany, has now developed an innovative solution to meet the demanding requirements of the AC and ventilation industry: A new generation of air heaters featuring an up to 50% reduced pressure loss (see figure 1). The biggest challenges in developing such systems are the long-term mechanical stability and the PTC behavior. The already mentioned the PTC effect prevents that a preset maximum temperature value of for example 200°C will be exceeded. This can play a fundamental role if the technical approval of ventilation systems depends on meeting high safety requirements, as is the case in railway applications. The PTC effect is generated by a hexagonal phase transformation of the doped base material barium titanate, superimposed by an interface effect, equivalent to a potential barrier, which can be preset to between 120 and 240 °C. Figure 2 shows an exemplary PTC curve with a maximum surface temperature of 200°C.

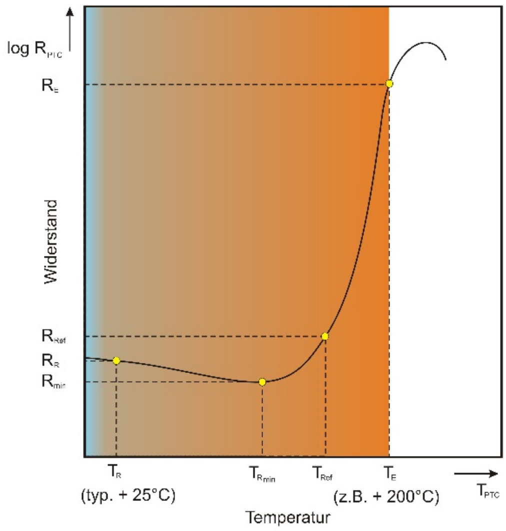

Figure 2: Exemplary PTC curve of a heating element with 200 °C max. temperature

In the development phase for the new air heaters, various phenomena had to be examined and new problem-solving paths to be found. Technical obstacles that had to be overcome were for example a raised third harmonic wave and variations in the PTC curve under specific loads. In the end, however, the mechanical design of the heating element plays the decisive role in building the unit and achieving a long-term stability for the air heaters. By means of mechanical calculations and diverse short and long run tests, DBK has succeeded in offering the user an optimal technical solution. The innovative concept of this product lies in the specific design and special processing techniques, in particular the patented glue process which is so far uniquely used in Europe for this type of application.

Figure 3: Installation of heating element in the air duct (Lab manager: Hr. Schaeffner)

A crucial step in the development of finned air heaters is the **air duct test**, shown in figure 3. With the aid of air duct tests, exact performance and pressure loss values can be determined for any application in the field. The air duct has a diameter of 30cm and can be temperature-regulated as required. Before starting any measurements, the pressure loss in the air duct including vane is determined at 20°C ambient, and deducted in the ensuing tests. The heating element used is a standard module sized 10cm x 10cm equipped with 240°C maximum temperature PTCs. The heat output in this setup is approx. 950Watt with an air volume of 200m³/h. Here, the obvious advantage of the heating element becomes apparent: due to the self-regulating effect of the PTCs a higher heat output can be obtained with higher air volumes. By increasing for example the air volume in the given setup by 100m³/h, the output will increase by approx. 20%. This effect can even be reinforced by reducing the temperature of the air to be heated. At 300m³/h and an air temperature of -20°C, the heat output increases by another 20 %, thus reaching an output of approx. 1380 Watts without needing any additional controls. Figure 4 shows the power values measured for different air volumes.

Figure 4: Performances and air velocity

By choosing the appropriate PTCs, either lower or higher performances can be obtained. By furthermore modifying the heater size, the new generation air heaters are perfectly suited for use in a wide field of applications. The heaters have even already been built in several custom-designed versions, as the **ready-to-install insert module** shown in figure 5.

Figure 5: Insert module ready for installation

Figure 6: Insulated circular resistor heater

The module is simply inserted into the air duct and complies with all legal requirements of the authorized test institutes. The integrated touch protection has been flow optimized. In a next step, we want to develop a smart air duct heater module satisfying complex requirements in terms of high pollution and humidity resistance and electrical insulation: **a circular, fully insulated air heater** for easy integration into the air duct system (see figure 6).

Further information

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