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COMPARISON OF A NON-PRESSURE CONTROLLED CAESIUM HEAT PIPE WITH A FLUIDISED BATH

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Abstract: In the paper comparison of a non-pressure controlled caesium heat pipe with a fluidised bath containing alumina powder is presented. Both the heat pipe and the fluidised bath are used for calibration by comparison of contact thermometers (resistance thermometers, thermocouples, indication thermometers). Emphasis of comparison was on temperature stability, homogeneity of temperature (axial and radial gradients), usable depth, operating temperature range, maintainability, commercial availability, price and possibility of using a particular device for other purposes than calibration by comparison.

Keywords: temperature, calibration, uncertainty

1 INTRODUCTION

In the calibration of the contact thermometers a dynamic range can be divided between baths, with different working liquids, and furnaces. The boundary is approximately at 300 °C, depending on the type of an oil used in the oil bath. In a lower range an alcohol bath is usually covering the range from –80 °C to 10 °C, then in the range from 10 °C to 80 °C a water bath is in use and finally above 80 °C different kinds of oil baths are used. The highest temperature that can be achieved with an oil bath depends on the flame point of the oil in use. A commercially available oil has the flame point of 315 °C. Above 300 °C, one can use a fluidised bath (with alumina powder up to 900 °C), a salt bath (depending on the used salt up to 600 °C) and a heat pipe (depending on the material used as a filling of the heat pipe, up to 1050 °C). In this paper, we are presenting the comparison between a non-pressure controlled caesium heat pipe and a fluidised bath. Emphasis of the comparison is on the technical characteristics of both calibration systems, used for calibration by the comparison of the contact thermometers, as well as on the practical consideration for the future use.

2 HEAT PIPE

The multi-tube caesium heat pipe is horizontally placed in a tubular furnace with a DC power supply. The power supply rectifies and filters the mains supply, and is short-circuit proof with rated outputs. Its features are minimal heat loss and the residual ripple less than 0,5%. The heat pipe itself is foreseen for an accurate horizontal operation. There is an orientation dependent wick structure installed inside. Furthermore, there is a certain surplus of a working fluid in the heat pipe, which increases with the increasing heat pipe temperature. The smaller a heat input to the heat pipe, the better isothermal state is achieved, which requires an uniform and moderate heat flux to the heat pipe by the furnace (which is water-cooled) and a good isolation. The heat pipe effect starts at about 280 °C but uniform temperature conditions for precision calibrations are available above 340 °C and up to 600 °C. The drawback is a very long stabilisation time of a few hours when the best homogeneity and stability of temperature of the heat pipe are required. The heat pipe enables better stability and homogeneity of temperature comparing to the fluidised bath although the heat pipe does not have a pressure control. Pressure controlled heat pipes are even better considering the temperature homogeneity and stability (see Figure 1).

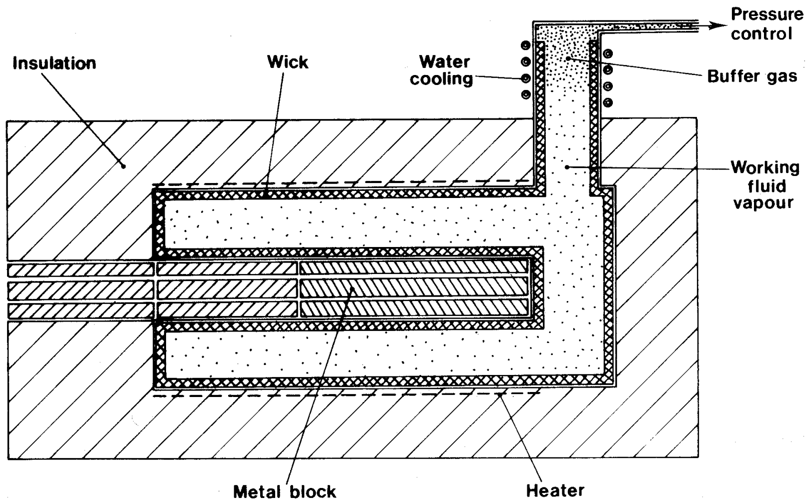

Figure 1. The scheme of a heat pipe

3 FLUIDISED BATH

The fluidised bath with alumina powder can be operated in the range from 100 °C up to 900 °C with slight problems of stabilisation at low temperatures, [1]. Our fluidised bath is operating from 100 °C up to 670 °C. The bath consists of a container of an alumina oxide powder with porous baseplate (see Figure 2). Sufficient air is passed through the baseplate to motivate the powder into a fluid-like state so that it will flow, display buoyancy effects and have good heat transfer characteristics. The airflow rate of 30 litres per minute at 0,5 bar allows using of either a pipe-compressed system or a small portable compressor. A disadvantage (also by other fluidised baths) is that good temperature stability and homogeneity can not be achieved by the fluidised medium itself but with the means of using a large metal equalising block. The fluidised bath with an alumina powder is designed to operate as a sealed system, thus eliminating the powder contamination of the surrounding ambient.

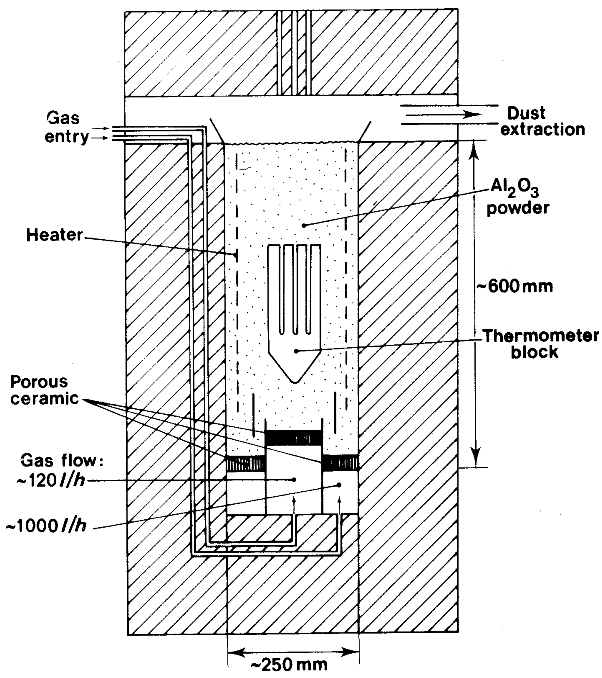

Figure 2. The scheme of a fluidised bath

4 COMPARISON

The main characteristics that we compared were: usable depth, stability, homogeneity, maintenance, price, possibility to use the bath for something else than calibration by comparison, and commercial availability.

The usable depth depends on the expected uncertainty. In the case of the caesium heat pipe, if we want to calibrate with the best possible uncertainty, the usable depth is 10 cm from the bottom and the axial gradient in that case is better than 0.01 °C (Figure 3). The radial gradient is better than 0.005 °C.

If we want to use the fluidised bath over the same usable depth, its axial gradient is 0.2 °C (Figure 4). The radial gradient is better than 0.01 °C.

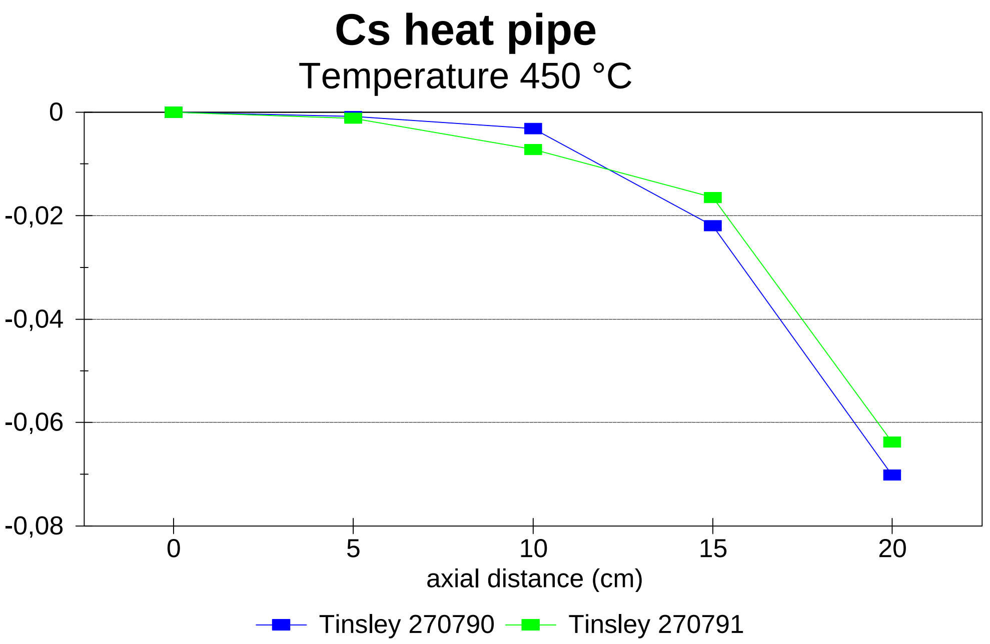

Figure 3. Axial gradients in a non-pressure controlled caesium heat pipe

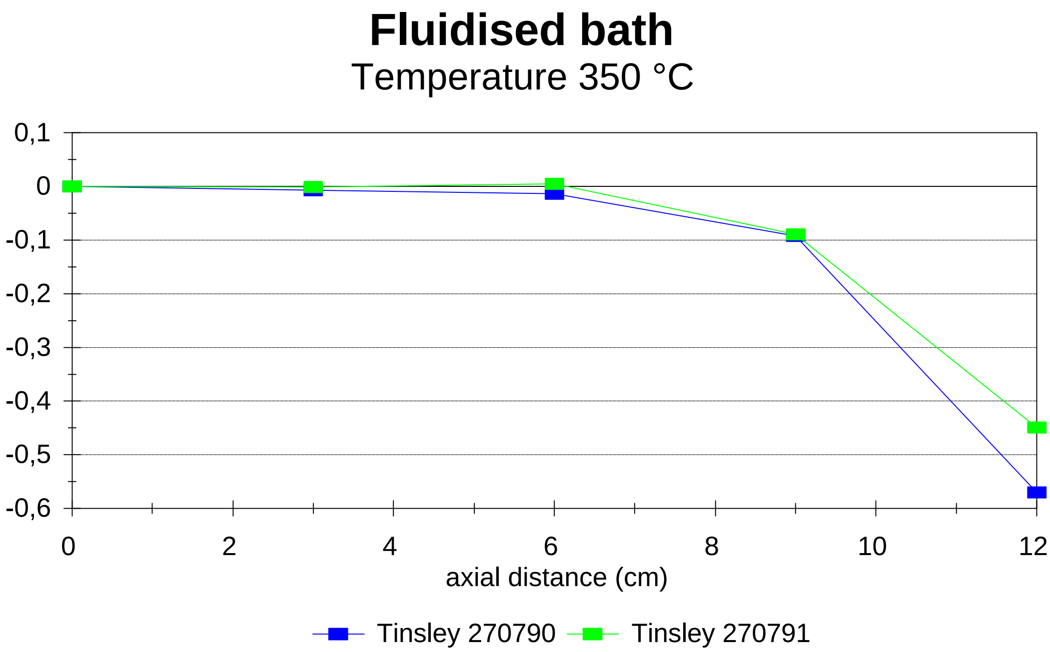

Figure 4. Axial gradients in a fluidised bath

Table 1. Characteristics of a non-pressure controlled heat and a fluidised bath

Characteristic	**Heat pipe**	**Fluidised bath**
Homogeneity (over the bottom 10 cm)	0.01 °C	0.2 °C
Stability (double standard deviation over 5 minutes)	0.005 °C	0.01 °C
Maintenance	Cleaning of the filter	Water supply for cooling
Price	Vary from a producer (in general more expensive than a fluidised bath)	
Other use	If it is made to be used for calibration by the comparison, it can't be used for any other purpose	Can be used, together with appropriate fixed points, for realisation of fixed points from the freezing point of Indium up to the freezing point of Aluminium
Commercial availability	To our knowledge, two commercial producers	To our knowledge, three commercial producers

Comparisson of all characteristics for the heat pipe and for the fluidised bath are presented in the Table 1. Both calibration devices are parts of the calibration equipment in the accredited calibration laboratory, [2]. Numerous calibrations of thermometers were performed in both devices in the past two years. The fluidised bath was successfully used also in the realisation of the freezing point of Indium and we expect the same result in the realisation of others fixed points (Tin, Zinc, Aluminium), [3].

5 CONCLUSIONS

Both calibration systems are covering the same range in the calibration of contact thermometers by comparison (300 °C to 650 °C). If a laboratory wants to achieve the ultimate results in calibration by the comparison, the heat pipe is a better solution, especially the pressure controlled, but also the non-pressure controlled is sufficient for the most applications. On the other hand, if the laboratory growth is expected in terms of a primary level, a kind of a bath for realisation of fixed points is required. In that case the right solution would be the fluidised bath, which is also adequate for calibration by comparison.

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