Methodology for the Use, Calibration and Application of Thermocouples Applied in High Energy Flux Dissipators

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Resumen

Actualmente en el laboratorio de termofluidos de Ingeniería Mecánica de la Universidad de Guanajuato se emplean termopares de marca registrada y por lo tanto no se fabrican. El propósito de la investigación presente es desarrollar una metodología para la construcción, calibración y aplicación de termopares. A través de esta práctica se enseñará a los alumnos de ingeniería mecánica a fabricar, construir y calibrar termopares. El objetivo es crear una seria de pasos para la construcción y calibración de los termopares para después ser aplicados en los Disipadores de Alto flujo Energético.

Abstract

Currently, in the Mechanical Engineering thermofluids laboratory of the University of Guanajuato, trademark thermocouples are used and therefore they are not manufactured. The purpose of this research is to develop a methodology for the construction, calibration and application of thermocouples. Through this practice, mechanical engineering students will be taught to make, build and calibrate thermocouples. The objective is to create a series of steps for the construction and calibration of thermocouples and afterwards be applied in High Energy Flux Dissipators.

Palabras Clave   Thermocouples, Temperature, Calibration, measurements

INTRODUCTION

THERMOCOUPLES

A thermocouple is a sensor which can measure the temperature [1].

A thermocouple is built with a junction between two different metal or alloy wires. There has to be a weld bead that bonds or covers the two different metals or alloys [1]. The purpose that the weld bead covers both wires means that this way there is only one contact point on both wires, therefore the temperature difference that the open end of the thermocouple wire registers will be correct.

The way one can know that the temperature measured with the thermocouple is correct is by calibrating it, checking the different temperatures registered and measuring the off-set given, so that one can add or sustract the off-set to the different temperatures that the thermocouple registers and finally having a more precise measurement of the temperatures desired.

The temperature range of the thermocouples may vary depending on the types of metals used and if the weld bead is well made [1].

There are many types of thermocouples (see Table 1), each one of them with their own characteristics such as temperature range, material, temperature in which oxidizes, etc. [1].

The thermocouples used in the thermofluids laboratory are type J and type K, because they work successfully with the experiments and the applications for the project.

Types of thermocouples

Table 1.Types of thermocouples depending on the types of metals used.

Thermo couple	Conductors	Temperature Range (°C)
E	Chromel (+) Constantan (-)	-270 to +1000
J	**Iron (+)** **Constantan (-)**	**-210 to +1200**
T	Copper (+) Constantan (-)	-270 to +400
K	**Chromel (+)** **Alumel (-)**	**-270 to +1370**
N	Nicrosil (+) Nisil (-)	-270 to +1300
B	Platinum (30% rhodium)(+) Platinum (6% rhodium)(-)	0 to +1820
S	Platinum (10% rhodium)(+) Platinum (-)	-50 to +1760
R	Platinum (13% rhodium)(+) Platinum (-)	-50 to +1760

- *TYPE J*

Type J thermocouple is a weld between iron and constantan. The Type J thermocouple has a range from – 210 °C to + 1200 °C and it oxidizes at high temperatures (see Figure 1) [2].
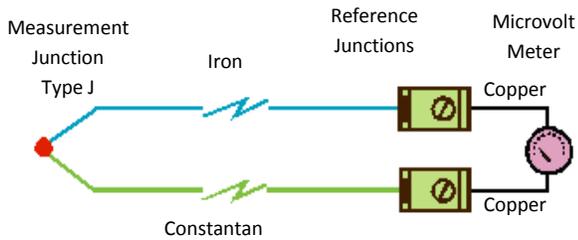
Figure 1: J-type thermocouple (iron-constantan) [3].

- *TYPE K*

Type K thermocouple is a weld between chromel and alumel. This type of thermocouple is the most common. Type K thermocouple has a range of − 200 °C to + 1350 °C and its best performance is in clean oxidizing atmospheres (see Figure 2) [2].
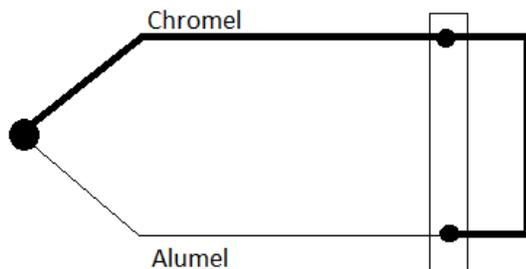

Figure 2: K-type thermocouple (chromel-alumel) [4].

MATERIALS Y METHODS

HOW TO BUILD A THERMOCOUPLE

The transformer (Variac) used to build a thermocouple has a current of 5A. Depending on the caliber of the thermocouple wires to be used, it is required to do tests at different voltages to see which is the best.

The procedure is as follows.

1. Have a transformer (Variac).

2. Peel perfectly all of the layers that cover the thermocouple cables, only on the ends used.

3. Only two alligator oppressor cables are going to be used, one will be a positive pole and the other will be a negative pole.

4. By plugging the two alligator oppressor cables on the side terminals, together there are 24 V. By plugging one alligator oppressor on the side terminal and one in the middle terminal, together there are 12 V. Put a coal on one alligator oppressor and on the other alligator oppressor connect an end of the thermocouple (see Figure 3).
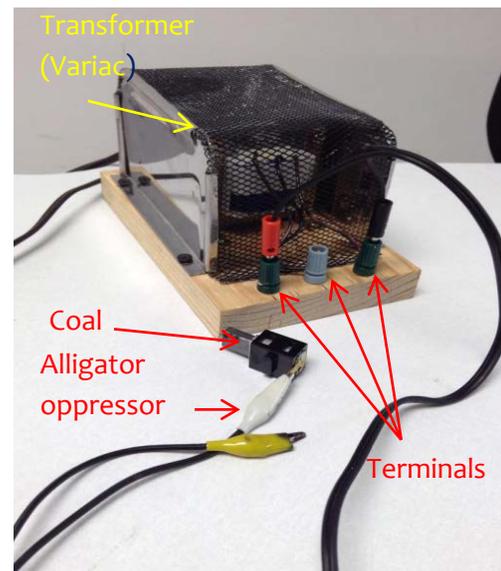

Figure 3: Connection between transformer and thermocouple cable.

5. Twist the thermocouple wires to the tip and cut so that only one twist of the wire remains, and has about the same size, preferably a short twist of about 5 mm.

6. Plug in the transformer to an AC plug.

7. Select the desired voltage (24 V or 12 V).

8. Once the wire is with one twist, touch the tip of the thermocouple twist with the coal tip (be careful with the glare on the eyes for this some special glasses have to be used, and also be careful with the heating of the wire).

9. After welding the cables, unplug the Variac transformer.

10. Check with an amplifying glass the uniformity of the welded part (see Figure 4), there must remain a sphere of constant radius but small deformations are accepted.

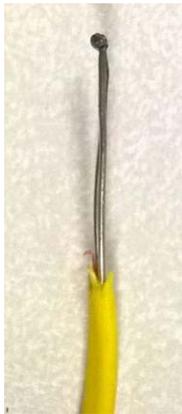11. Apply a layer of varnish to the finished thermocouple wire to prevent electrical shorts.

Figure 4: Thermocouple with both wires welded.

CALIBRATION

Calibration is the activity of comparing a result with a reference point [5].

Calibrating is very important because it can reduce the ranges of error [6].

- *THERMOCOUPLE CALIBRATION*

To calibrate a thermocouple first a calibration bath is needed (see Figure 5), in which the temperature inside that environment will be calculated through heating it until it reaches the temperature needed, for then measure it.

The procedure of calibration is as follows:

1. - On the screen of the device, set the wanted temperature with a little keyboard. The keyboard has numbers (to set the temperature), the asterisk is to return one step and to change settings, and the sharp (number sign) is to click ENTER.

2. - Once the temperature is constant, introduce the thermocouples and calibrate them. The smaller the range of error, the best the thermocouple will be.

3. - The temperatures that the sensors receive will be sent to a data acquisition card and these in turn will be sent to a Labview program, indicating the temperature that each thermocouple senses, then knowing the variation degrees of error between each thermocouple.
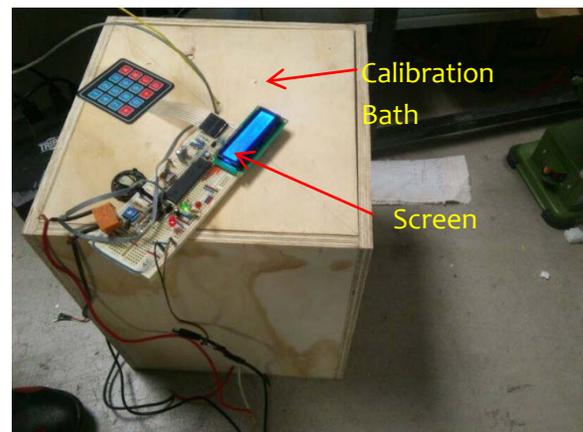

Figure 5: Calibration device.

After the calibration was done, 4 thermocouples were plugged into a heat dissipator to check if they give the right temperatures or to compare each one of them by connecting them to a Data Acquisition Card (DAC) for it to send the

temperature data to a program called Labview (see Figure 6).

Labview program consists in making a data matrix and save it in a format that can be exported to Matlab, this data matrix contains each of thermocouple temperatures like also the time of reception.

After finishing testing with Labview the data matrix is sent to the Matlab program.

Matlab will make a graph and an Excel file with the statistical data on each of the thermocouple's temperatures and thus calculate how much degree of error each of the thermocouples can have.

Figure 7: Ranges of error of the temperatures for thermocouple 4.

RESULTS AND DISCUSSION

The building of the thermocouples according to the steps mentioned in this report was successful such as the calibration and applications of the thermocouples in a High Energy Flux Dissipator.

The degree of error of 12 thermocouples was analyzed.

As seen on Figure 7, it can be appreciated the different ranges of error of thermocouple 4 in each of the different temperatures (20, 25, 30, 35 and 40 °C). Thermocouple 4 was the best of the 12 thermocouples tested.

With thermocouple 4, there is a range of error of 0.2 °C and an offset between 2.9 °C and 3.1 °C according to the tests made with Labview and Matlab.
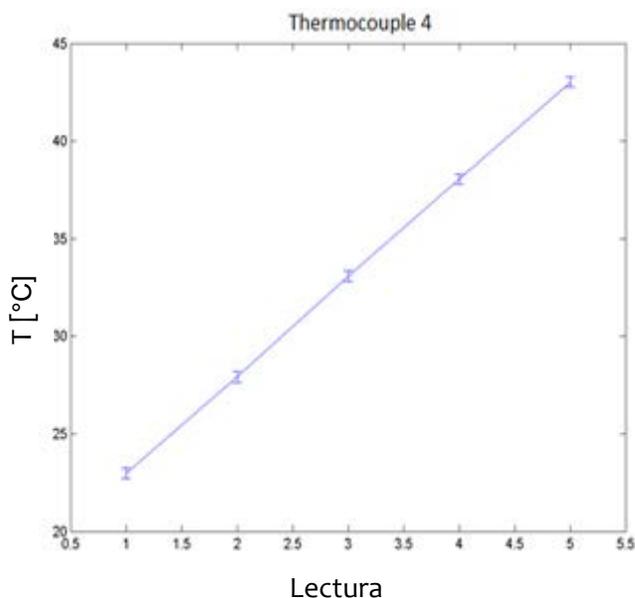

Figure 6: Thermocouples connected to the Data Acquisition card.

CONCLUSIONS

This project consists of a theoretical and practical base.

The building of the thermocouples according to the steps mentioned in this report was successful such as the tests with the calibration device by checking each one of the thermocouples' temperatures with the Labview and Matlab programs.

Once the building and calibration were finished, the thermocouples were applied on the Heat Dissipator measurements of the increasing temperatures.

SPECIAL THANKS

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