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Research Paper

CALIBRATION OF K TYPE THERMOCOUPLE FOR MEASUREMENT OF TEMPERATURE IN LABORATORY EQUIPMENT

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Thermocouples are widely use for measurement of temperature in laboratories and industries. The accuracy of measurement is affected by the procedure employed for calibrating the thermocouples. In this work laboratory equipment is developed for calibrating the thermocouples. A K type thermocouple is calibrated for the temperature range from 300 C to 1000 C and results are presented. It is observed that correction factor of 0.077 mV is needed for the results to match with the calibrating standards.

Keywords: Thermocouples, K-Type, Calibration, Laboratory Equipment

INTRODUCTION

When two conductors of dissimilar metals are joined together to form a loop and two unequal temperatures T1 and T2 are imposed at the two interface junctions, electro motive force is induced in the loop (Seebeck Effect) (T G Beckwith, 2009). The emf generated by the thermocouple is function of temperature of measuring and reference junction. More specifically it is result of temperature gradients which exits along the length of the conductors. Effective measurement and calibration is possible if the junctions are maintained in isothermal regions and at a depth sufficient to overcome heat losses (or gains), thereby ensuring that each junction actually reaches the temperature of its environment. The magnitude of the emf depends on the materials of the conductors used for the thermocouple and their metallurgical condition. Subsequent changes in the material composition and condition caused by contamination, mechanical strain, or thermal shock, also influence and modify the emf and an associated calibration. However, any such change is influential only if it is located within the region of a temperature gradient and is not necessarily detectable by recalibration if, for example, a degraded length of conductor is located within the isothermal region of a calibration bath.

Thermocouples are most widely used temperature measurement instrument in

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laboratories and industries. With longer use and with varying environmental conditions calibration of thermocouple becomes inevitable. This work focuses on the development of low cost equipment for recalibrating the thermocouple. In this paper results for K type thermocouples are presented but the work could be extended for other type of thermocouples also.

LABORATORY EQUIPMENT FOR CALIBRATION OF K TYPE THERMOCOUPLE

The K type thermocouple is made up of alumel (-ve) and cromel (+ve). The k type thermocouple is most widely used thermocouple and can be found is most of the laboratory equipments. This is due to its wide range of temperature sensing. The combination of alumel and cromel can be use to sense the temperature from -2700 C to 13700 C with an output of -6.9 to 54.9 mV over maximum temperature range.

Calibration is the process for maintaining the instrument accuracy. The process of calibration may also be used to display the result of the instrument in a user understandable format. For calibrating the thermocouple the instrument should posses following components viz. thermal source, millivoltmeter, and standard temperature measurement devices.

Thermal Source

For calibrating thermocouple it has to expose to varying temperatures. For this a thermal source is needed. The essential conditions for the thermal source are that it should be thermally stabilized and should not posses any thermal gradients within it [2]. For this thermal baths or furnaces are used]. In the equipment proposed in this work a liquid filled thermal bath is proposed as it is easy to construct and maintain and can be used for varying temperature ranges by changing the working liquid. A stirring arrangement is provided in the bath to maintain uniform temperature in the bath. Only precaution has to take with liquid bath is thermocouple under test and standards should be within protective covering. The thermocouple under test should be immersed in the thermal bath as it would be in normal working conditions. However it should be sufficiently immersed to minimized losses due to higher thermal gradients.

Voltage Measurement

The thermocouples generate the output which can be measured in millivoltmeter. The output generated by the K type thermocouple under test is measured by using high precision digital milivoltmeter. Digital voltmeters are generally sensitive for polarity and show different results if polarities are reversed. Also reading shown by the millivotmeter is sensitive for the emf generated by the junction of dissimilar metal. For minimizing effect of unwanted emf generation copper leads are used and the junctions are maintained at same temperatures.

Referance Standard

In calibration process reference standard is the measurement device with known accuracy. The accuracy of the reference standard should be at par or more than the instrument under test. For calibrating the thermocouple a high accuracy thermometers or another thermocouple may be used. In this work a handheld resistance thermometer is used with a known accuracy of 0.0020 K.

Referance Table

Thermocouple manufacturer provide the characteristic table with the thermocouple

showing relation between temperature and voltage generated by the thermocouple in millivolt. This reference table can be used to identify drift in the characteristics of the thermocouple under test and correction factor could be imparted.

MEASUREMENT PROCEDURE

In the process of calibration it is always advisable to record the readings in equal steps. It is also essential to test the measurement equipment for upscale and downscale readings so as to minimize effect of drift. In the work the readings are recorded by varying temperature in equal steps as

$$T_0, T_1, T_2, T_3, T_{n-1}, T_n, T_{n-1}, T_3, T_2, T_1, T_0$$

For this the thermal bath is filled with liquid (in this case water). With standard thermometer ambient temperature and initial temperature of thermal bath is recorded. The thermocouple under test is immersed in the thermal bath up to desired depth and emf generated by it is recorded by digital millivoltmeter. Now temperature of thermal bath is increased in the steps of five 0C and corresponding temperature shown by the standard thermometer is recorded and corresponding reading shown by the miliivoltmeter is recorded.

RESULTS

In the work a K type thermocouple used for measurement of temperature of exhaust at I.C. engine test rig is used for recalibration purpose. The instrument and thus thermocouple is in use from last 10 years and thus its accuracy is under scanner. Through the instrument developed following readings are recorded.

Table 1: Experimental Results for K Type Thermocouple Mounted on I.C. Engine

1 *S.N.*	*2* *Ambient Temperature (^{0}C)*	*3* *Temperature of Thermal Bath (^{0}C)*	*4* *Readings shown by Thermocouple under test in mV ($mV_{-0\text{-}Tatm}+mV_R$)*	*5* *Temperature shown by Thermocouple under test(^{0}C)*	*6* *Reading for Thermocouple under test in mV from characteristic table [3]*	*5-3* *Error (^{0}C)*	*4-6* *Error (mV)*
1	31	30	1.074	27.1	1.203	-2.9	-0.129
2	31	35	1.344	33.5	1.407	-1.5	-0.063
3	31	40	1.543	38.5	1.612	-1.5	-0.069
4	31	45	1.732	43	1.817	-2	-0.085
5	31	50	1.940	48.1	2.023	-1.9	-0.083
6	31	55	2.166	53.6	2.230	-1.4	-0.064
7	31	60	2.343	57.9	2.436	-2.1	-0.093
8	31	65	2.561	63	2.644	-2	-0.064
9	31	70	2.758	67.8	2.851	-2.2	-0.093
10	31	75	2.985	73.5	3.059	-1.5	-0.074
11	31	80	3.200	78.7	3.267	-1.3	-0.067
12	31	75	3.010	73.8	3.059	-1.2	-0.041
13	31	70	2.799	68.6	2.851	-1.4	-0.049
14	31	65	2.582	64.6	2.644	-0.4	-0.062
15	31	60	2.372	58.5	2.436	-1.5	-0.064
16	31	55	2.153	54.4	2.230	-0.6	-0.077
17	31	50	1.910	47.4	2.023	-2.6	-0.113
18	31	45	1.732	43	1.817	-2	-0.085
19	31	40	1.524	37.8	1.612	-2.2	-0.088
20	31	35	1.331	33.3	1.407	-1.7	-0.076
21	31	30	1.124	28.4	1.203	-1.6	-0.079

DISCUSSION

From the experimentation it is observed that the thermocouple under test shows average error of -1.69 0C and -0.077 mV. Thus a correction factor of 1.69 0C and 0.077 mV is needed to be incorporated to bring the results of thermocouple under acceptable range. The thermocouple under test is in use from last 10 years and being exposed to high temperature exhaust gases. Because of this there is considerable shifting in the characteristics of the thermocouple which ultimately results in the error in temperature readings. This may be because of contamination of the probe, thermal stresses etc. The result emphasizes that periodic recalibration of the thermocouple thermometers are essential to ascertain the accuracy of the readings shown by it. Furthermore recalibration of the thermocouples may be carried out with the in house equipment developed with proper incorporation of calibration procedure and working principles of thermocouple.

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