Technical Note

Curve fitting
For: {T} type thermocouple {Copper-Constantine}

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ABSTRACT

An empirical formula has been obtained mathematically to be used in determination of temperature, which is determined from the thermocouple output for (T) type (Copper – Constantan) .

INTRODUCTION

Graph is the main view for value determination of any chemical, physical variables,and for mathematical representation of those relations.
In verifying of any lab. Results, it is essential that they are plotted on a graph paper.
To verify the graph, the energy conservation in that experiment should be first observed, since if heat is applied to a thermocouple * hot junction, then it's output potential increases according to the peltier effect [1] since there is always energy conservation balance in the experiments.
In electrical measurements and measuring instruments [2] it is stated that the e(mv) output of the said thermocouple (60 Cu 40 Ni) alloy , cold-junction at 0 ^{0}C is .

Copper $+2.76 + 0.8 * 10^{-2} t \ \mu V / {}^0C$
Constantine $- 38.1 - 7.3 * 10^{-2} t \ \mu V / {}^0C$

Then, the thermos – electric power of the thermocouple is:

$$de / dt = 40.86 + 8.1 * 10^{-2} t$$

and $e1 = 40.86t + 0.0405 t^2 \ \mu V$

The national Bureau of standard [3] has approved the results of different authors in Circular No.561, and with (I.S.A) [3a] as partner for 10^0 Tables, Extension and errors range.
German Bureau of standard [4] has approved the results of different authors in (DIN 43710) for 10^0c (T) type , Also the measurement of temperature by thermocouple done by ASEA [5]
B.S.[6] 1041 : 1943 states the code for temperature measurements and with (H.M.S.O.)[7] .AS partner for the international temp. Scale, Honeywell [8] automation division carried out the conversion tables I PTS 48 and I PTS 68 for (T) type as well for other types.

THE PROPOSED SYSTEM AND WORK

In accordance with the mentioned references an empirical formula for the copper Constantine (T) type thermocouple has been derived, and can be used for quick resolution in processes as well as in the lab. , Instead of using charts. The error is in the range of

approved code described in (N.B.S) circular No.561, it can also be used for the determination of those values not given in the approved lists. This is instead of doing an experiment for the particular value. This method even more precise than interpolation procedure between two values adjacent to the required value. it is economical and academical method. An access to new research papers in kurdistan during 1990-97 was very limited, therefor this method is suggested to add to the previous efforts in this subject.

In addition the graph No. 1 is plotted for (N.B.S) No.561 values and e_1 (mv)=40.86t ± 0.0405t^2 Vis t ^{0}C reference junction at 0^0C and graph No. 2 on which our calculations are based.

The suggested method for determination of Lad Experiment relations is as follow.

1- plot (N.B.S) No. 561 values and (DIN 43710) values V is t ^{0}C reference at 0^0C on a graph paper .
(Graph No.2).
2- Draw a graph curve in between the above standard values.
3- Derive a mathematical formula for computing relation between e_2 (mv) Vis t ^{0}C for the said graph.
4- The method for determination of the graph constants is as follows.
a- Transferring the graph location from original position to positive position of (X,Y).
b- Determination of constants
c- Rearranging values to original

MATERIAILS AND METHOD

Graph repositioning values .
Let $\bar{e}$=e+5.379 and $\bar{t}$ =t+190

Temperature Values relocations	X	e_2(vm) Values relocation	Y	Relocated values X,Y
1) –190+190 =	0	-5.379+5.379 =	0	0,0
2) –180+190 =	10	-5.205+5.379 =	0.174	10,0.174
3) 0+190 =	190	0 +5.379 =	5.379	190,5.379
4) 300 +190 =	490	14.864+5.379 =	20.243	490,20.243

$$\text{Let } \bar{e} = a + b(\bar{t})^n$$

Then ,

1. $0.174 = a + b10^n$
2. $5.379 = a + b190^n$
3. $20.243 = a + b490^n$

From the above three formula , the values of 3 constants can be derived as.

n=1.412217456 b=0.0032 a=0.091322602

The formula is valid for the range of (-189to500)^{0}C for which the experiments are carried out. Then repositioning the graph values to the original position.

Since $e_2 = \bar{e} - 5.379$ and $\bar{t} = t + 190$

And since $\bar{e} = a + b(t)^n$ or $\bar{e} = a + b(t+190)^n$

Then $e_2 = a + b(t+190)^n - 5.379$

Or $e_2 = b(t+190)^n - 5.287 * 677398$

$a - 5.379 = 5.287677397$

*For approximating the calculation

From the derived formula it is possible to derive the temperature value for given thermocouple output potential value e_2 (mv) as .

$$t^0C = \left[\frac{e_2\,(mv) + 5.287677398}{b}\right]^{1/n} - 190$$

RESULTS

List of calculated values of thermocouple output by e_1 , e_2 formulas and the corresponding values approved by (N.B.S.No.561 and DIN 423710) and the % error of each one shown below .

Table –1- standard and e1,e2 values

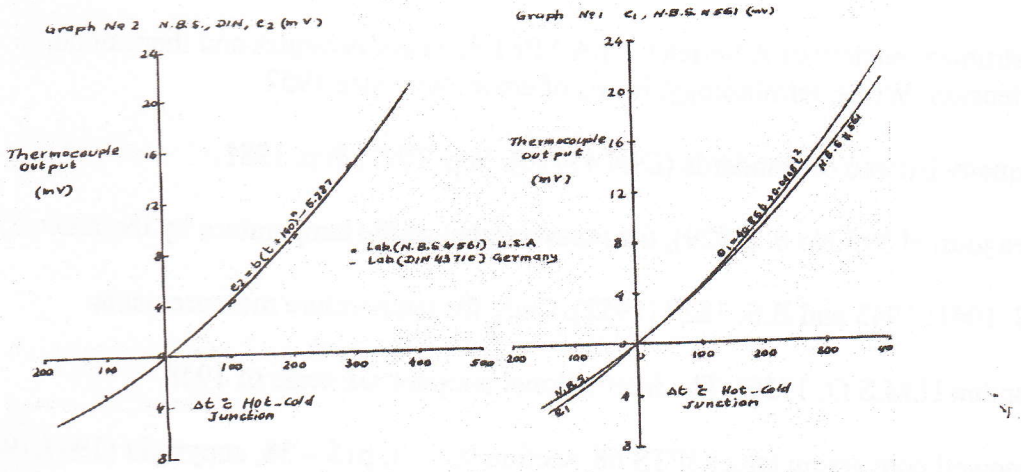
t^0C	200	180	100	0	100	200	300	400	500	600
NBS mv	-	5.205	3.349	0	4.277	9.288	14.864	20.874	-	-
DIN mv	5.7	-	3.4	0	4.25	9.2	14.9	21	27.41	34.31
e_1 mv	6.55	6.04	3.681	0	4.491	9.792	15.903	22.824	30.555	39.096
e_2 mv	-	5.205	3.447	0	4.319	9.31	14.863	20.906	27.39	34.27

Table2 ± %errors

$e_{1\pm}$ NBS	-	- 13.8	- 9	0	+4.7	+5.15	+6.5	+8.5	-	-
$e_{1\pm}$ Din	- 13	-	- 7.6	0	+5.4	+6	+6.3	+8	+10.3	+12.24
$E_{2\pm}$ Din	-	0	- 2.8	0	+0.97	+0.24	0	+0.15	-	-
$E_{2\pm}$ Din	-	-	+1.36	0	-1.6	+1.18	- 0.25	- 0.45	- 0.07	- 0.1

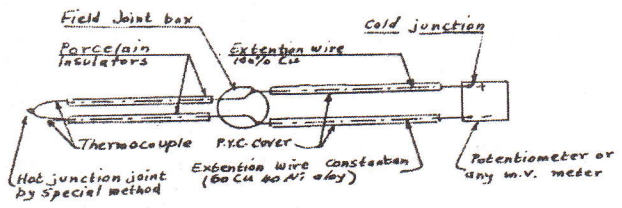
RESULT AND DISCUSSION

In verifying the results of proposed empirical formula, it was possible to determine the values of the thermocouple output potential corresponding to the given temperatures of its hot junction and vice versa as shown in table (1), they are contain less error than the error limits indicated in the standards as in the table (2) .



THERMOCOUPLE

Consists of two wire made of different pure metal or alloy. One side must be joint together and called the (Hot) junction, the other end is open for joining + and – of mV port of potentiometer , for measurement of its output and this is called the cold junction . This is correct even if the hot junction is located is located in cooler temperature . In this case the polarity output Leeds must bee reversed, if not, then the potentiometer will read negative.



Thermocouple construction

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حساب منحني (گراف) لأجل ثرمو كبل نوع (T) كوبر كونستنتن

سردار زيوه ر

رسم (گراف) طريقة عامة في علوم الرضيات و ذلك لتقديم قيم المتغيرات الواردة عند إجراء تجارب كيمياوية و فيزيائية . والعمل المقترح طريقة رياضية لأجل إيجاد علاقة المتغيرات الگراف . (منحني البياني) لمادة ثرمو كبل (كوبر كونستنتن) نوع T .

پێوەری گراف بۆ ثرمو کێڵ جۆری (T) کوپر کونستنتن

سەردار زێوەر

(گراف) ڕێبازێکی سەرەکیە بۆ خستنەڕووی گۆڕانکاریەکانی تاقیکردنەوەی کیمیاوی و فیزیاوی ، وە کاری پێشکەشکراو ڕێبازێکی گشتییە لە زانستە بیرکاریەکاندا بۆ دۆزینی بەهای گۆڕانکاریەکانی پرموکبل جۆری (T) کوپر کونستنتن .