BIPM Capacity Building & Knowledge Transfer Programme

2024 BIPM - TÜBİTAK UME Project Placement

REPORT

Project Name	Characterization of the High Temperature Eutectic Fixed Points Cells Used for Contact Thermometry
Description	The Industrial needs for traceable calibration of thermocouples (TCs) at high temperatures (up to 1500 °C) with high accuracy and low uncertainty drive the improvement of the calibration facility at high temperatures. This project was focused on how to construct and characterize a new developed high temperature eutectic fixed-point cell (Fe-C) by advanced techniques for providing improved traceability to the thermocouple calibration to support its wider and simpler dissemination to the end users.
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Date	02-09-2024 to 02-12-2024

1. Motivation & Introduction

Thermocouples are the most common type of temperature sensors that are used for a wide range of temperatures above the 1500 ˚C in many different fields of science and industry. Because of this, the calibration methods and facilities should be improved to comply with the industrial needs. So, the purpose of this project is to learn how to construct and characterize high temperature eutectic fixed points (HTFPs) that are used for contact thermometry especially for calibrating thermocouples to improve their uncertainty. Fe-C eutectic point is one of the promising eutectic fixed points that can be used as a secondary standard for calibrating thermocouples. This HTFP of Fe-C is introduced to bridge the gap between Cu and Co-C fixed points according to the "CIPM Strategy 2030+". New eutectic fixed-point facilities will give precise tools for the measurements of thermocouples and avoid the errors due to the interpolation and extrapolation of the results which increase the uncertainty.

Manufacturing HTFPs, assigning their thermodynamic temperature values and evaluating their uncertainties, are one of the trending works in the field of thermometry nowadays in many National Metrology Institutes (NMIs) all over the world. This is because of the redefinition of Kelvin and the CCT recommendations with fabricating these types of HTFPs, comparing their results and estimating their uncertainties to ensure world-wide equivalence. So, my interest was focused on these HTFPs in which the new scale will be based on them, especially those related with contact thermometry. The objectives of this project were as follows:

1- Recognizing all the components that need to construct the eutectic cell effectively and training on how to construct it

2- learning how to measure and characterize it with noble thermocouples

3- Determining its point of inflection and calculating the uncertainty budget for it

The first aim of this project was to gain an understanding of the principles and the design of Fe-C cells which were already developed in TUBITAK UME Temperature Laboratory during this valuable training. During 3 months, I trained and learned from TUBITAK UME expert on the construction of the fixed-point cell during joint work consisted of several phases and parts. All the steps were done thoroughly during this project following TUBITAK UME's usual procedure for construction of fixed-point cells. The ultra-pure metal and graphite according to the design developed by UME expert together with TUBITAK UME facilities were employed to manufacture and assemble the Fe-C FP cell. These research activities had been performed at TUBITAK UME Temperature Laboratory for 3 months.

The biggest goal of this research was to facilitate knowledge transfer in high temperature measurements by the construction and validation of a new design of a HTFP cell operating at a temperature of nearly 1154 °C.

The knowledge transfer in high temperature measurements consisted of hands-on training during the joint work in the construction and validation for a Fe-C fixed point cells. In addition to this, I trained by the TUBITAK UME expert on all aspects on construction of Fe-C HTFP cell, collaborate during these activities with my mentor, receiving advice and support in the form of training and consultations in order to successfully complete all the technical tasks. This work not only contributes towards the assessment of thermocouple traceability but also contributes towards the improvement and further development of the NIS Temperature laboratory thus strengthening its metrological infrastructure. So, I will continue to work on the HTFP cells at my institute (NIS), using the knowledge obtained and experience gained from this activity. All the working procedures and results will be shown in the following sections.

2. Research

For implementing the objectives of this project, we used three noble metal thermocouples, two of them of type R (R01 & R02) belongs to UME and one (Pt/Pd) belongs to National Institute of Standards (NIS)-Egypt.

2.1 Experimental Procedures

The experimental work is divided into three steps. The first step was studying the homogeneity for each thermocouple. The second step was calibrating these thermocouples at Cu fixed point. The third step was manufacturing and characterizing the Fe-C eutectic cell. The detailed information about each of these steps will be in the following sections.

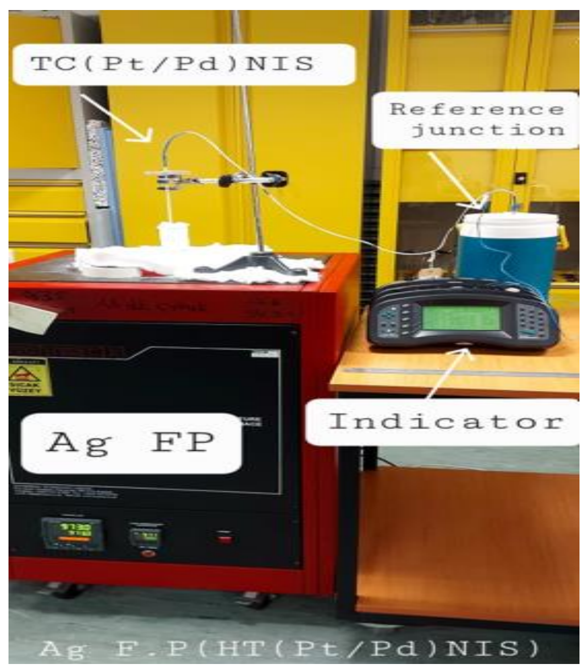
2.1.1 Homogeneity Test

As a preparation stage, we studied the homogeneity tests for the thermocouples used (R01, R02 & Pt/Pd) in two fixed points (FPs), Sn F.P (231.928 ˚C) and Ag F.P (961.780 ˚C) as shown in figure.1 (a, b). This test was carried out in the freezing plateau of Sn and melting plateau of Ag. This test is very important in thermocouples calibration because the high contribution in uncertainty budget comes from the homogeneity of thermocouple. In this test, the thermocouple withdrawn from the bottom of the cell at the rate of 5 minutes for 1cm until reaching 10 cm and immersing it again inside the cell with the same rate of 5 min/cm until reaching to the bottom of the cell. The full immersion of the thermocouple was about 0.5 cm from the bottom of the cell. In Sn F.P, ice point was used for thermocouple reference junction but in Ag F.P, thermocouple reference junction was immersed in water triple point bath at nearly 0.01 ˚C.

2.1.2 Copper Fixed Point Calibration

All these 3 TCs are calibrated at copper fixed point (Cu F.P) at the setting of 1085 ˚C for melting plateau and 1073 ˚C for freezing plateau (±5 ˚C of the freezing point) and the measurements were repeated 3 times for each one of them. The full melting and freezing plateaus were recorded using a software program (lab view program) recording the data each 30 seconds. Ice point was used as a reference point for the thermocouple reference junction. The ice point is made from a mixture of crushed ice with distilled water. The

(a) Homogeneity test for thermocouple type (R02) UME at Sn fixed point



(b) Homogeneity test for thermocouple (Pt/Pd) NIS at Ag fixed point

Fig.1 Homogeneity test for thermocouples at Sn F. P(a) and Ag F.P(b) measurements were taken by Keithley 2182A nanovoltmeter for recording the output of electromotive force (emf). This Cu F.P was open cell fixed point and Ar gas flow with the rate of 5 liter/min was used during the measurements. The Ar gas flow was opened after the furnace temperature reaches nearly 200 ˚C. This 5 L/min flow rate is fixed during the measurements, so should be checked all the time during the measurements. The pressure inside the open cell fixed points should be nearly one atmospheric pressure during the measurement. The Cu F. P. setup is shown on Fig.2.

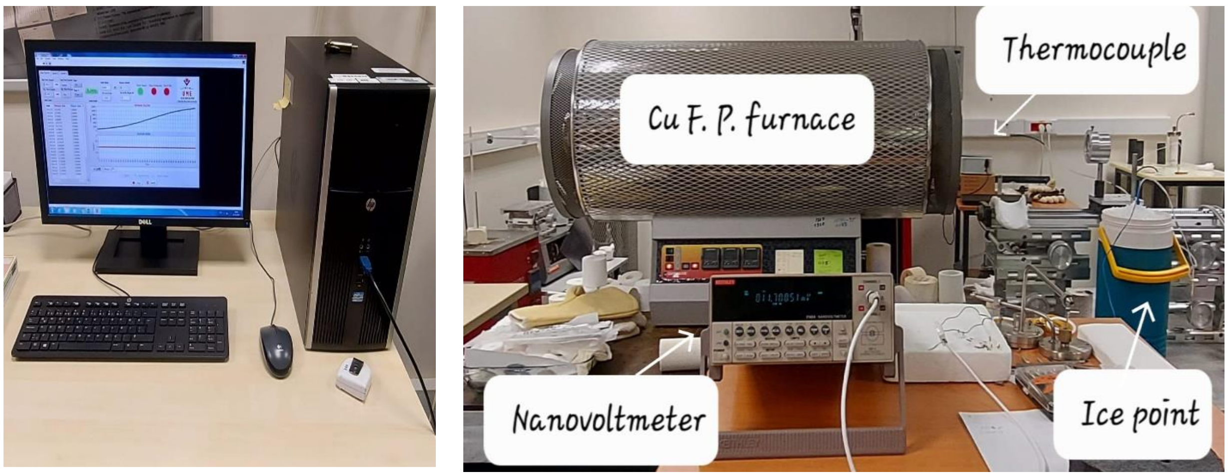


Fig.2 Setup for the calibration of Pt/Pd thermocouple (NIS) at the Cu fixed point

2.1.3 Fabrication of Fe-C Eutectic Cell

Simultaneously with the previous two steps of homogeneity test and Cu F.P calibration, the preparation and fabrication of the Fe-C eutectic cell was as follows:

1. ***Preparation stage***

- Recognizing all the components of Fe-C eutectic cell which consists of double wall graphite crucible, thermowell and cap all of them with purity greater than 99.9999% which supplied from Mersen, France.
- All graphite parts were put in a large alumina tube with a 100 cm length and diameter 60 mm and close it tightly using stainless steel cap which were cleaned with alcohol before using.
- This alumina tube was immersed inside the vertical furnace (manufactured by PROTHERM-Türkiye) and connected with the vacuum system - turbo molecular pump – PFEIFFER (Hi CUBE).
- The vacuum system consists of two stages of evacuation pumps, the first stage reaches to nearly (10^-1) mbar and the second stage reaches to nearly (10^-4 to 10^-6) mbar.

2. *Annealing stage*

- All the graphite parts were annealed in a vacuum at approximately 1200 ˚C for more than 2 h before the filling process as shown in Fig.3.

Fig.3 Setup of annealing and filling system

- The annealing process started after making three flashes of vacuum followed with passing Ar gas inside the system. The tank of a mixture of alcohol and dry ice was used to trap humidity and any other molecules found in the gas during the passage of the Ar gas inside the system.
- This flashing process was at an ambient temperature. Then we started to increase the temperature gradually from ambient to 200 ˚C, 600 ˚C, 900 ˚C, 1010 ˚C, 1050 ˚C, 1100 ˚C, 1150 ˚C and 1200 ˚C and the vacuum level was checked and recorded all the time during this process, and it was nearly 4.6 x 10^-4 mbar.
- After reaching the temperature to ~ 1200 ˚C, we waited ~ 2 hours for annealing at this temperature and the vacuum level was recorded all the time during this process.
- After finishing the annealing process, the furnace set to the ambient temperature and let to cool down over night and the vacuum system was left open also until the next day.

3. *Fe-C Mixture preparation stage*

- Before filling the crucible with the Fe-C mixture, we cleaned the working space with alcohol and measured the weight of all graphite parts that will be used during the preparation of the eutectic mixture. The weight of the graphite parts was recorded before putting the mixture as shown in Fig.4 (a).

- Fe of 54 g was added to 2.5 g of C, mixed well and put inside the inner crucible. The amount of C in this mixture was nearly 4.2%. The inner crucible filled with mixture was put inside the outer crucible as shown in Fig.4 (b), closed tightly with its graphite cap, put inside the long alumina tube, then put the alumina tube inside the furnace and connected with the vacuum system as shown in Fig.3.

(a) Weight all the graphite parts and the bottle used for filling

(b) Filling the crucible with the Fe-C mixture

(C) Putting the thermometer well inside the crucible after the first filling of the mixture

Fig.4 Filling process steps (a), (b) & (c)

- The double wall graphite crucible which was filled with mixture was arranged inside the alumina tube by putting another empty graphite crucible at the bottom of the tube to raise the filled graphite crucible in the tube.
- Based on the homogenous zone in the furnace, calculations were made to put the graphite crucible inside the alumina tube in the homogenous zone of the furnace.
- The top of the alumina tube was closed with stainless steel cap which contained a small hole fitted to the diameter of the thermocouple. An alumina tube with the same diameter as the thermocouple was inserted in this hole during the melting process.

4. The stage of filling and melting the Fe-C mixture

- First, we calculated the volume of the crucible that should be filled with the Fe-C eutectic mixture which was 28.08 cm^3.
- The filling process was done for 3 times, in each time the weight of the mixture was measured taking into consideration that the percentage of C in the mixture is not higher than 4.2%. The total weight of the mixture was 162.3 g (154.8 g of Fe and 7.5 g of C).

- Three flashes of evacuation of air and flashing with Ar gas were made before heating the furnace. Then the temperature was increased gradually and the value of pressure inside the system was recorded. After reaching ~ 500/600 ˚C, the vacuum pump was closed, and the Ar gas was added.
- After reaching ~ 1327 ˚C temperature above melting of the Fe-C, we started to push the alumina rod inside the large alumina tube to push the graphite thermometer well in its correct place inside the crucible (cell) and continue to increase the temperature with continuous pushing of the alumina rod inside the system. The melting process was in Ar gas environment.
- After pushing the alumina rod to the end of the graphite thermometer well, we adjusted the furnace to the ambient and after cooling down we closed the system.
- After finishing the melting process, we checked the mixture inside the crucible and found that the graphite thermowell is completely immersed in the crucible, so we closed the crucible with its cap and the cell was ready for measurement as shown in Fig.5 (a) and Fig.5 (b) show the first results of this Fe-C eutectic cell.

(a) Fe-C cell after finishing of its construction (b) The first melting plateau of the Fe-C cell

Fig.5 Fe-C cell after finishing its construction (a) and its first melting plateau (b)

5. The assembly stage of the Fe-C eutectic cell for measurement

Fig.6 exhibits all the components of the cell with their dimensions inside the furnace.

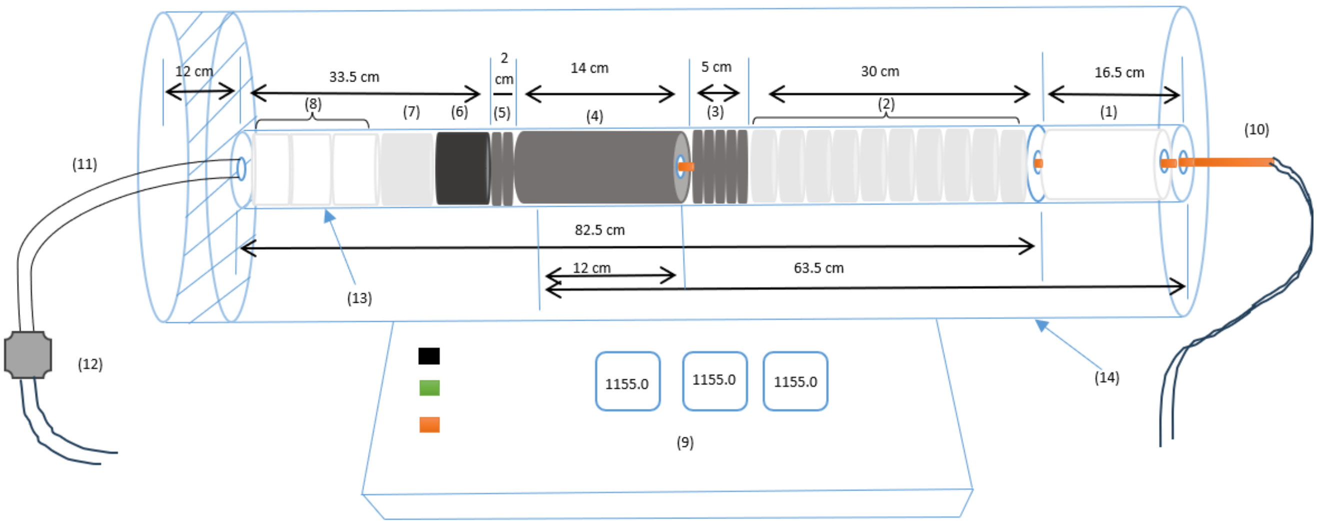


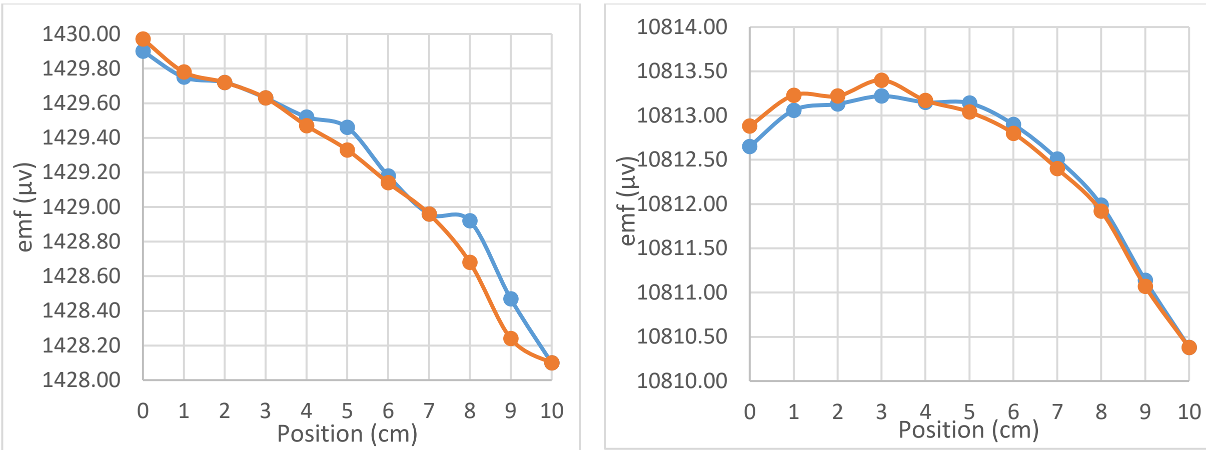
Fig.6 Schematic diagram for the assembly of Fe-C eutectic cell inside the furnace

(1) Co-wool
(2) White insulation of bricks
(3) Graphite rings
(4) Graphite crucible filled with the eutectic mixture Fe-C
(5) Graphite rings
(6) Black insulation of bricks
(7) White insulation of bricks
(8) Co-wool
(9) Indicators of the furnace
(10) Thermocouple for recording the measurements
(11) Plastic cable for passing the Ar gas inside the cell
(12) Valve for opening, closing and controlling the Ar gas
(13) Glass tube contains the cell
(14) Furnace tube

2.2 Results and Calculations

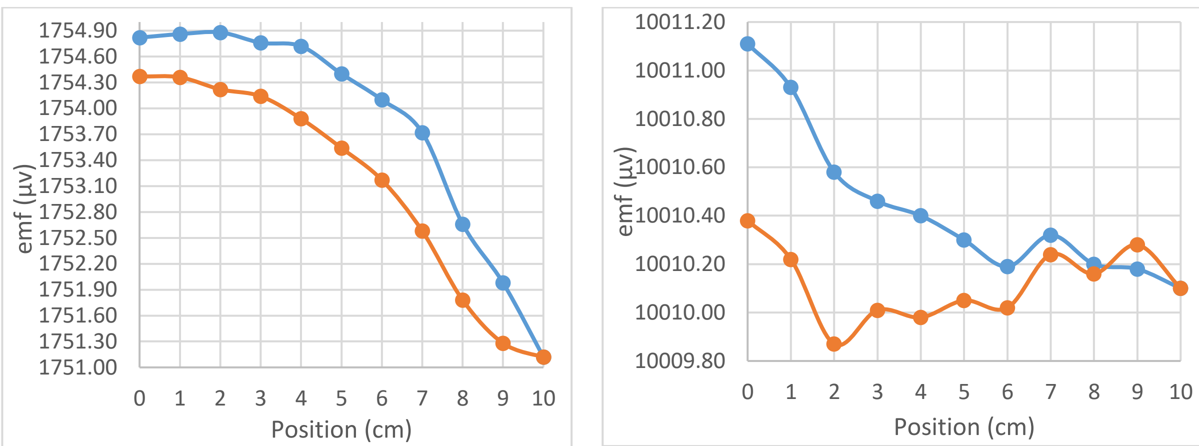
2.2.1 *Inhomogeneity results*

Figures 7, 8 & 9 represent the results of the homogeneity tests for all thermocouples at Sn F.P (a) and Ag F.P (b). The inhomogeneity value was taken as the biggest difference between withdraw and insertion of thermocouple at a specific distance. The results showed that the inhomogeneity value for Pt/Pd (NIS) was nearly the same (0.24 µv) at both fixed points with negligible difference. For TC (R01)-UME, there was a significant difference between the inhomogeneity values at Sn F.P and Ag F.P. It was 1.14 µv at Sn F.P and 0.73 µv at Ag F.P with difference of 0.41 µv, which means that the inhomogeneity at low temperature is higher than that one at high temperature. But for TC (R02)-UME, the situation is opposite to TC (R01)-UME where the inhomogeneity values at Sn F.P (0.22 µv) is lower than that one at Ag F.P (0.74 µv) with difference of 0.52 µv. This different behavior of the two thermocouples of the same type (R01 & R02) needs more measurements to know its root cause. But in general, all of these values do not exceed 0.1° C and may be lower. Tables.1, 2& 3 exhibit the data of Homogeneity tests at Sn F.P (a) and Ag F.P (b) for each thermocouple. Table.4 summaries the inhomogeneity results for all thermocouples.



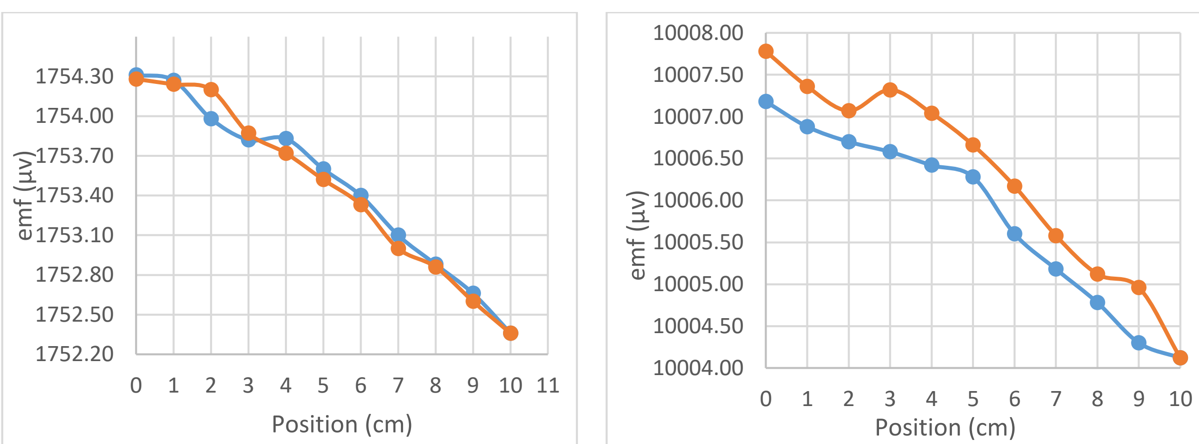
(a) (b)

Fig.7 Homogeneity test of Pt-Pd (NIS) at Sn F.P (a) and Ag F.P (b)



(a) (b)

Fig.8 Homogeneity test of R01 (UME) at Sn F.P P (a) and Ag F.P (b)



(a) (b)

Fig.9 Homogeneity test of R02 (UME) at Sn F.P P (a) and Ag F.P (b)

Table.1 The data of Homogeneity tests at Sn F.P (a) and Ag F.P (b) for Pt/Pd (NIS) thermocouple

Position	Withdraw Reading	Insertion Reading	Difference
cm	μv	μv	Δμv
0	1429.90	1429.97	-0.07
1	1429.75	1429.78	-0.03
2	1429.72	1429.72	0.00
3	1429.63	1429.63	0.00
4	1429.52	1429.47	0.05
5	1429.46	1429.33	0.13
6	1429.18	1429.14	0.04
7	1428.96	1428.96	0.00
8	1428.92	1428.68	0.24
9	1428.47	1428.24	0.23
10	1428.10	1428.10	0.00

(a)

Position	Withdraw Reading	Insertion Reading	Difference
cm	μv	μv	Δμv
0	10812.65	10812.88	-0.23
1	10813.06	10813.23	-0.17
2	10813.13	10813.22	-0.09
3	10813.22	10813.40	-0.18
4	10813.15	10813.17	-0.02
5	10813.14	10813.04	0.10
6	10812.90	10812.80	0.10
7	10812.51	10812.40	0.11
8	10811.99	10811.92	0.07
9	10811.14	10811.07	0.07
10	10810.38	10810.38	0.00

(b)

Table.2 The data of Homogeneity tests at Sn F.P (a) and Ag F.P (b) for R01 (UME) thermocouple

Position	Withdraw Reading	Insertion Reading	Difference
cm	μv	μv	Δμv
0	1754.82	1754.37	0.45
1	1754.86	1754.36	0.50
2	1754.88	1754.22	0.66
3	1754.76	1754.14	0.62
4	1754.72	1753.88	0.84
5	1754.40	1753.54	0.86
6	1754.10	1753.17	0.93
7	1753.72	1752.58	1.14
8	1752.66	1751.78	0.88
9	1751.98	1751.28	0.70
10	1751.12	1751.12	0.00

(a)

Position	Withdraw Reading	Insertion Reading	Difference
cm	μv	μv	Δμv
0	10011.11	10010.38	0.73
1	10010.93	10010.22	0.71
2	10010.58	10009.87	0.71
3	10010.46	10010.01	0.45
4	10010.40	10009.98	0.42
5	10010.30	10010.05	0.25
6	10010.19	10010.02	0.17
7	10010.32	10010.24	0.08
8	10010.20	10010.16	0.04
9	10010.18	10010.28	-0.10
10	10010.10	10010.10	0.00

(b)

Table.3 The data of Homogeneity tests at Sn F.P (a) and Ag F.P (b) for R02 (UME) thermocouple

Position	Withdraw Reading	Insertion Reading	Difference
cm	μv	μv	Δμv
0	1754.31	1754.28	0.03
1	1754.27	1754.24	0.03
2	1753.98	1754.20	-0.22
3	1753.82	1753.87	-0.05
4	1753.83	1753.72	0.11
5	1753.60	1753.52	0.08
6	1753.40	1753.33	0.07
7	1753.10	1753.00	0.10
8	1752.88	1752.86	0.02
9	1752.66	1752.60	0.06
10	1752.36	1752.36	0.00

(a)

Position	Withdraw Reading	Insertion Reading	Difference
cm	μv	μv	Δμv
0	10007.94	10007.76	0.18
1	10007.52	10007.12	0.40
2	10007.32	10006.86	0.46
3	10007.14	10006.67	0.47
4	10006.80	10006.44	0.36
5	10006.38	10006.10	0.28
6	10005.76	10005.57	0.19
7	10005.32	10005.16	0.16
8	10004.95	10004.69	0.26
9	10004.52	10004.50	0.02
10	10004.28	10004.28	0.00

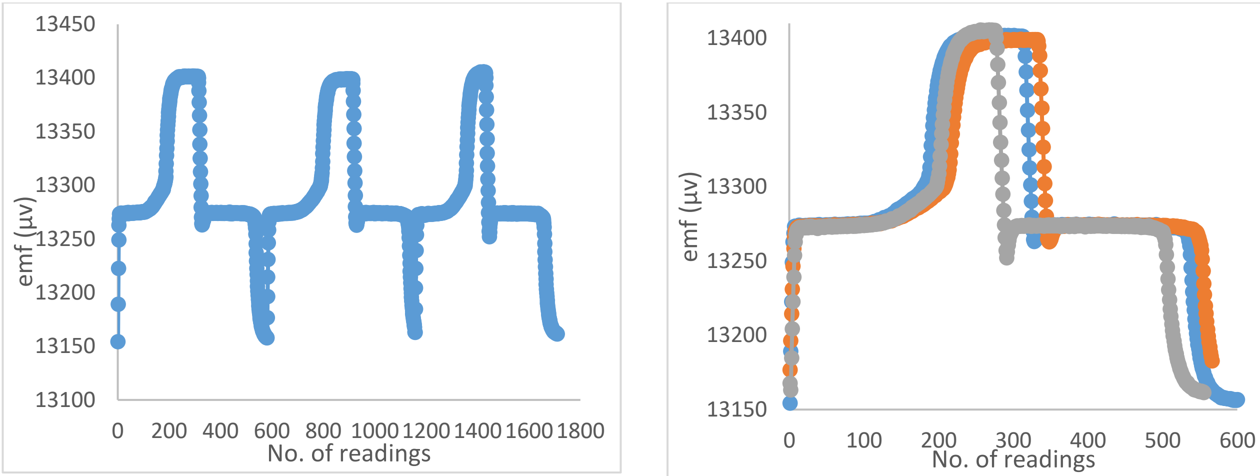
(b)

Table.4 The results of Homogeneity tests at Sn F.P and Ag F.P for each thermocouple

Thermocouple type	**Sn F. P**		**Ag F. P**	
	μv	**˚C**	**μv**	**˚C**
Pt/Pd (NIS)	0.24	0.01	0.23	0.01
R01 (UME)	1.14	0.13	0.73	0.06
R02 (UME)	0.22	0.03	0.47	0.04

2.2.2 Results of calibration at Cu fixed point

All of thermocouples Pt/Pd (NIS), R01 & R02 (UME) were measured at Cu fixed point at setting of (±5 ˚C of the freezing point). Figures 10, 12 & 13 (a), (b) show the output of these TCs at Cu F.P. The duration of melting and freezing plateaus at this setting (±5 ˚C) was 2 hours for melting (Pt/Pd & R02) and 2.5 hours for R01 and 3 hours for freezing for all of them. Fig.11 represent Six runs of melting and freezing plateaus for Pt/Pd (NIS) at Cu fixed point; the first 3 runs were at (±5 ˚C) and the second 3 runs were at (±10 ˚C) and the duration of melting and freezing plateaus decreased with increasing setting temperature to be 1 hours for melting and 1.5 hours for freezing. This means that when the setting increased by double, the duration of plateaus decreased by double also, so the temperature of the furnace can affect the shape of the plateau and its duration**.** Figures 10, 12 & 13 (a) present a good repeatability for TCs and (b) declare that the 3 plateaus are coincided and the shapes of the freezing plateaus are flat with sharp ends.



(a) (b)

Fig.10 Three runs of melting and freezing plateaus for Pt/Pd (NIS) at Cu fixed point (a), (b)

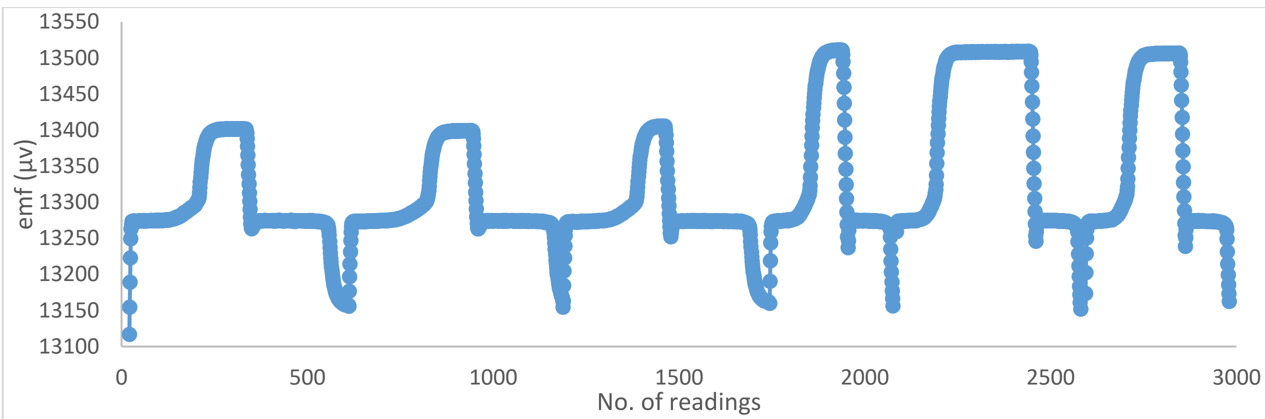
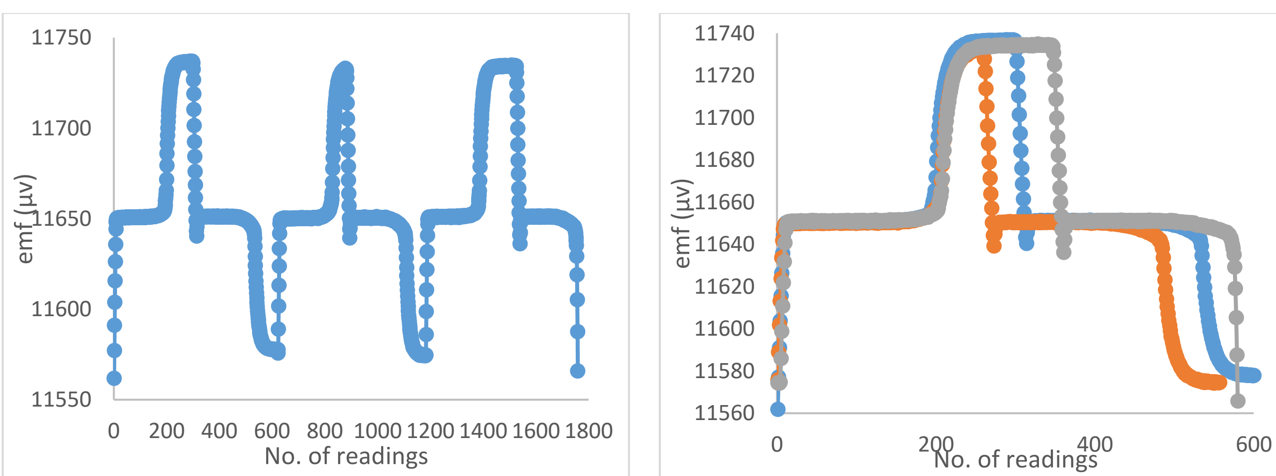
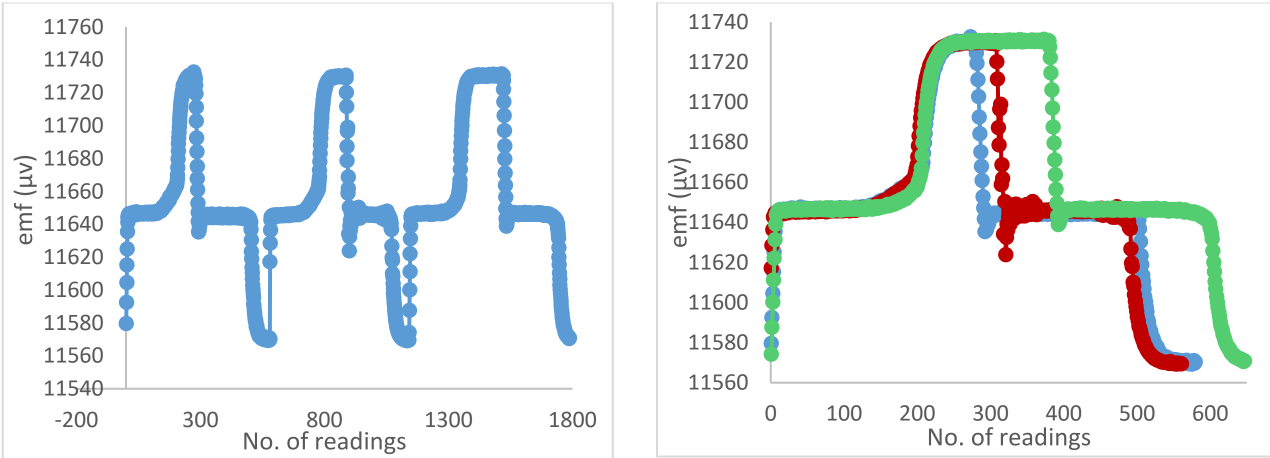


Fig.11 Six runs of melting and freezing plateaus for Pt/Pd (NIS) at Cu fixed point; the first 3 runs at (±5 ˚C) and the second 3 runs at (±10 ˚C)



(a) (b)

Fig.12 Three runs of melting and freezing plateaus for R01 (UME) at Cu fixed point (a), (b)



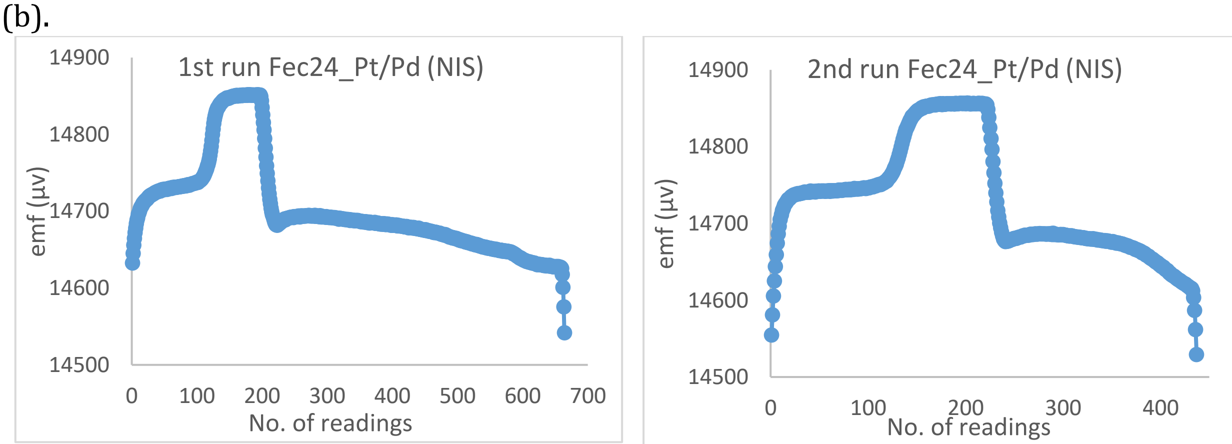
(a) (b)

Fig.13 Three runs of melting and freezing plateaus for R02 (UME) at Cu fixed point (a), (b)

In the second run of the R02 (UME) we noticed fluctuation in the freezing plateau, and we attributed this fluctuation to the change in the ice point and the duration of the freezing plateau was only 2 hours unlike 2 other runs which were nearly 3 hours. So, ice point plays a very important role in the measurement of thermocouples and should be checked from time to time during the measurements and repaired if there is need. The repeatability of these measurements was nearly 0.005 ˚C, 0.017 ˚C & 0.033 ˚C for Pt/Pd (NIS), R01 (UME) & R02 (UME) respectively.

2.2.3 Results of Fe-C eutectic cell

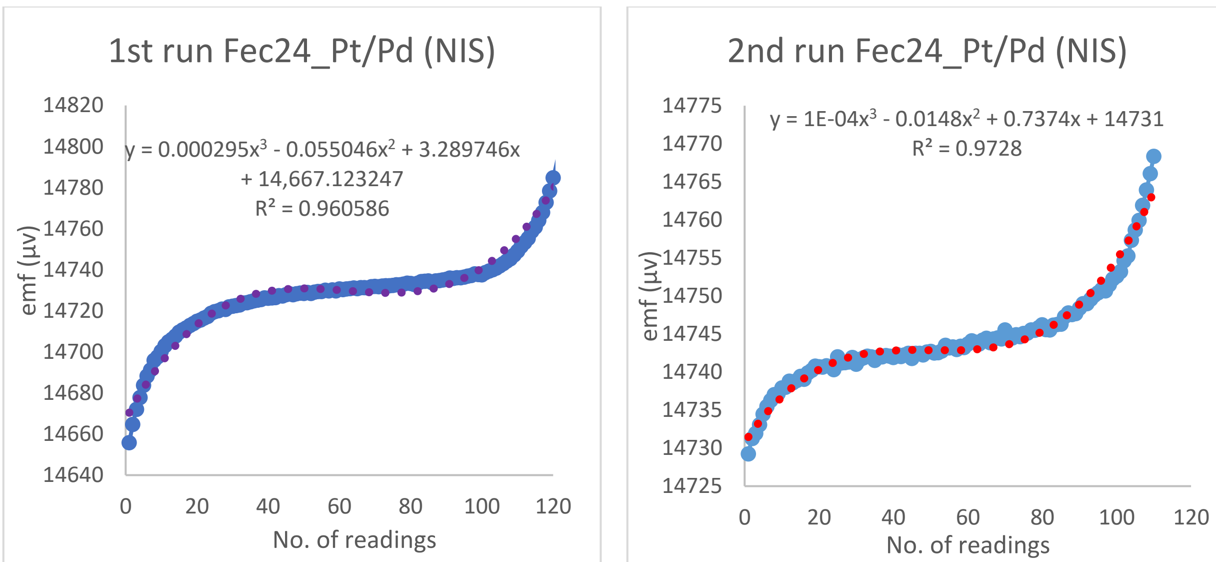
Before taking measurements for Fe-C cell we measured the offset of the furnace. The first melting plateau was measured by using Pt/Pd (NIS) at the setting of 1154 ˚C for melting and 1144 ˚C for freezing which corresponds to ±5 ˚C of the melting point. The complete run of melting and freezing is shown in Fig.14 (a). The second run was at setting of 1154 C for melting and 1142 ˚C for freezing, the complete run of melting and freezing is shown in Fig.14 (b).



(a) (b)

Fig.14 Melting and freezing plateaus of Fe-C eutectic cell (a) at setting of ±5 ˚C of the melting point and (b) at setting of ±5/3 ˚C of the melting point

In eutectic fixed points, our interest is based on melting plateau not freezing plateau as in the pure metal fixed points. The ideal plateau for melting or freezing should be completely flat at specific temperature. But for eutectic fixed points, the mixture melted over a range of temperature not at a well-defined temperature. So, the importance was for the point of inflection (POI) which can be determined from fitting the third order polynomial to the melting curve. This value (POI) can be determined by taking the second derivative of the third order polynomial and equating it to zero to get the time at which the POI is found. Substituting from this time in the equation, we can get the value of the inflection point. We applied this method and obtained the values of 14730.33 μv and 14731 μv for first and second runs respectively using Pt/Pd (NIS).



(a) (b)

Fig.15 Third order polynomial fitting for determining the Point of Inflection for Fe-C melting curve at setting of ±5 ˚C of the melting point (a) 1st run and (b) 2nd run using Pt/Pd (NIS)

2.2.4 Uncertainty Calculations

There are two types of uncertainty, type A uncertainty which is related to the repeatability of the measurements and type B uncertainty which related to all the devices used in the calibration. The combined uncertainty UC is expressed in the form of a 95% confidence level (k=2). Table.2 shows the uncertainty components and its contribution to the overall uncertainty of calibrating thermocouple at Fe-C eutectic fixed point. Table.3 exhibits the uncertainty budget for all thermocouples at Cu fixed point.

Table.2 Uncertainty budget of calibrating thermocouple at Fe-C eutectic fixed point

Sources of uncertainty	**Uncertainty contribution (µv)**
Statistical standard uncertainty (Repeatability)	0.75
Determination of the point of inflection (POI)	0.532
Voltmeter calibration	0.111
Voltmeter drift	0.033
Voltmeter resolution	0.0029
Homogeneity of thermocouple at Ag F.P.	0.24
Reference Junction	0.0029
Combined standard uncertainty UC, µv	1.239
Corresponding Combined Uncertainty UC, ˚C	**0.269**
Expanded uncertainty U (k=2), ˚C	**0.538**

Table.3 Uncertainty budget of calibrating thermocouples at Cu fixed point

Sources of uncertainty	**Uncertainty contribution (µv)**		
	Pt/Pd (NIS)	**R01 (UME)**	**R02 (UME)**
Statistical standard uncertainty (Repeatability)	0.0919	0.2137	0.4050
Furnace uniformity	3.617	2.36	2.36
Voltmeter calibration	0.087	0.087	0.087
Voltmeter drift	0.033	0.033	0.033
Voltmeter resolution	0.0029	0.0029	0.0029
Homogeneity of thermocouple wires	0.24	1,14	0.47
Reference Junction	0.024	0.024	0.024
Combined standard uncertainty UC, µv	1.984	1.745	1.745
Corresponding Combined Uncertainty UC, ˚C	**0.245**	**0.247**	**0.248**
Expanded uncertainty U (k=2), ˚C	**0.49**	**0.495**	**0.496**

Conclusions and Future Work

From my point of view, this program was a very good chance for me to learn, see and work in eutectic fixed points which is the first time for me to work on this topic. So, I can summarize the duration of my work in contact temperature laboratory at UME in some strong and weak points as the following:

1. *Strong Points*

- ✓ Gaining all information related to the system used for manufacturing eutectic fixed points and measurement equipment and procedures required for establishing such a system in my home laboratory in the future.
- ✓ Learning how to deal with the system and the precautions during work on it.
- ✓ Knowing how to assemble the fixed point inside the furnace after its manufacture.
- ✓ Preparing the furnace for measurement and calculating its offset.

- ✓ Participation in some calibration with the Staff of the lab. and know their procedures for calibration in fixed points.
- ✓ Seeing the procedures for preparing the triple point of water for measurement using the dry ice method.
- ✓ Opening communication channels not only with the members of the host laboratory but also with members from other laboratories for future scientific cooperation.
- ✓ Knowing new colleagues in different fields from different countries.

2. Weak Points

- ✓ The period for this project was not enough to take real measurements for the Fe-C cell after fabricating it to study sufficiently all the factors and parameters that may affect the cell results and to analyze the output results in a good way to get valuable data for publishing.

Finally, in the near future, I hope to have the opportunity to return again to UME to complete what we started in this project by taking real measurements and studying the effect of different factors which affect the measurements and to continue in endless cooperation in this field.

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