University of Jordan

School of Engineering

Industrial Engineering Department

Properties of Materials Laboratory

Instructor:

Prof. Issam Jalham

Group (G8)

Mohammad Awwad	0196871
Kamel Shaath	2191227
Nour Hamad	0197685
Hanadi Kidess	0197789
Abdelrahman Azzouqa	0199073

Introduction:

Equilibrium phase diagrams are graphical representations that can be used to indicate the phases of the alloy that present at any selected temperature, the composition of each phase, and the amount of each phase for the desired temperature and composition. As such it's very valuable to be able to construct a phase diagram and know how to use it to predict behavior of materials.

The Cooling Curve is a graphical plot of the changes in temperature with time for a material over the entire temperature range through which it cools, studying a particular cooling curve yields data related to a particular combination of two or more metals for the entire temperature range through which the alloy cools. And the cooling curves of all possible combinations and temperature constitute the equilibrium phase diagram.

Experimental Tools and Equipment's:

1) Lead (Pb) and Tin (Sn) metals

2) Scale

3) Laboratory oven

4) Mercury Thermometer

5) A ring stand

Experimental Procedure:

To obtain the willing Cooling Curve, we'll start the experiment by the following:

1) First, we must weigh varying proportions of Plumbum and Stannum.
2) Mixing the two proportions in the crucible (our sample included 70%Pb with 30%Sn).
3) Placing the crucible into the furnace.
4) Setting the furnace temperature at $350\text{-}400C^0$
5) Now, we wait the alloy to melt, then we start removing the crucible from the furnace and place it on the stand.
6) Fix the thermometer.
7) Record the temperature of the melt at intervals of 30 S.
8) Continue stirring of the melt until it solidifies.
9) Plot an inverse cooling curve, and indicate the arrest points
10) Construct the Pb-Sn phase diagram using the results of other groups

Discussion and Results:

At the beginning of this experiment, we used the cooling curves method of different proportions of elements (0-100%). This method based on the idea that if a hot system is allowed to cool freely in a constant environment, any marked change in its rate of cooling at some temperature indicates an evolution of hate due to change in the system itself.

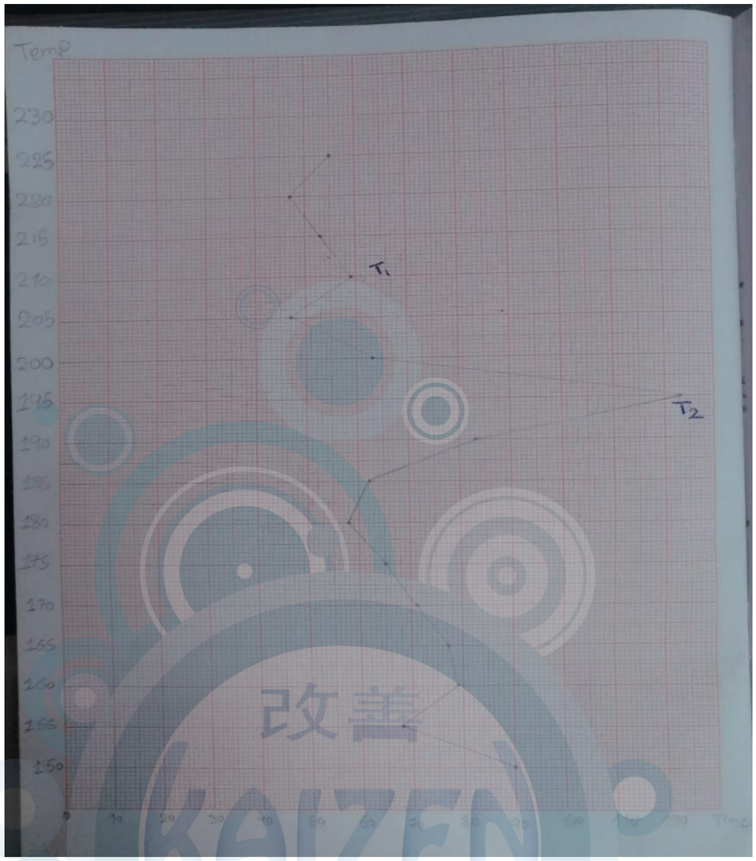
So, we built the inverse cooling curves by the data we obtained during the cooling process of alloy, we did these steps until we got the inverse of cooling curve:

1) We received a sample of alloy that contains a composition of Pb and Sn. (70% Pb) and (30% Sn) in crucible (after melting it in the furnace at temperate (350C-400C).
2) We placed it on the stand and fixed the thermometer in the closed crucible by rings clamp. (We must make sure not to touch the thermometer, so we do not get inaccurate readings)
3) We allowed the alloy to cool freely in a vacuum (at laboratory room temperature).
4) When the temperature of the thermometer reached to 230C we started to record the time in seconds it takes for the temperature to drop 5 degrees each time until the T is stabilized, which mean that cooling process has been completed.

THE RESULT FOR THIS PART OF EXPERIMENT: T

Temperature (c)	Time (second)
(230-225)	55
(225-220)	47
(220-215)	53
(215-210)	59
(210-205)	47
(205-200)	63
(200-195)	123
(195-190)	83
(190-185)	62
(185-180)	58
(180-175)	65
(175-170)	71
(170-165)	77
(165-160)	79
(160-155)	68
(155-150)	90

-The first shaded row represents T1.... (The temperature where solidification starts.
-The second shaded row represents T2… (The temperature where solidification has been completed.
The cooling process continues until the end of curve (stabilized temperature).

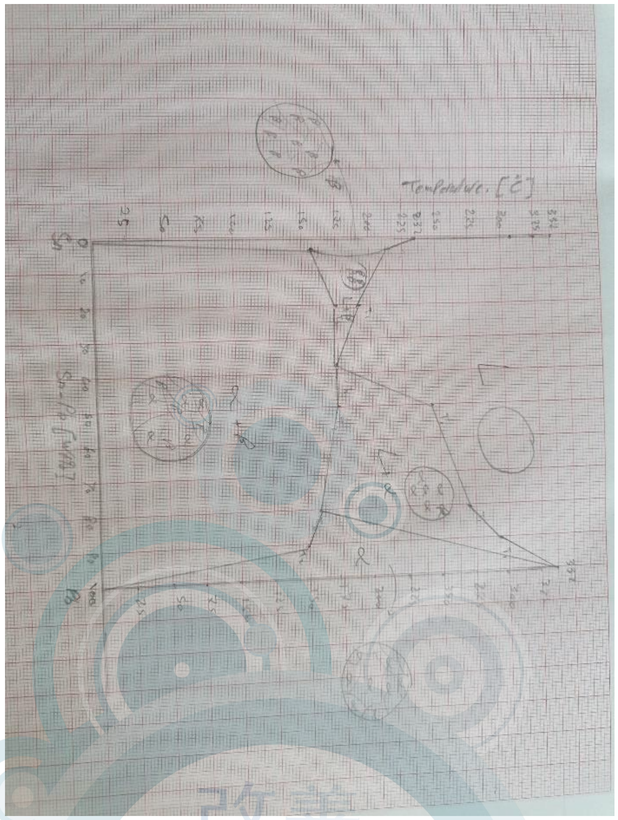


Part two of this experiment:
We construct the (Pb - Sn) phase diagram using the results that we obtained from cooling curve

This table shows us the results we obtained, we have the ratio of the composition Pb and Sn at the same time the temperature T1 AND T2.

	Pb wt%	Sn wt%	T1	T2
1	1.5	98.5	215	155
2	20	80	195	175
3	38.1	61.9	175	175
4	50	50	240	175
5	81	19	270	165
6	90	10	290	150

When T1 = T2 ... this point is called eutectic point. (A eutectic system is a system of a homogeneous mixture of substances that either melts or solidifies at a particular given temperature that is lower than the melting point of any of the mixture of any of the constituent elements. This temperature is known as the eutectic point).



1. Frist, we built tow axis (the vertical axis shows the temperature in the tow sided and between there we built horizontal axis shows us the ratios of Pb and Sn, where Pb ratios increase from left to right and ratios of Sn increase from right to left).
2. We selected the melting point of Pb and Sn (Pb= 327C, Sn=232C) on the diagram we built.
3. We selected the T1 and T2 with each ratio of Pb and Sn on the diagram as we see.
4. We marked the eutectic point on the diagram where it was the equilibrium point in the diagram and the intersection of curve T1 and T 2.
5. Selected the alpha and beta where:

Alpha: Solid solution rich in Pb … (Pb : solvent , Sn:solute).

-Max solubility of Sn in Pb ….19% Sn at 160C.

-Min solubility of Sn in Pb …...0.003 Sn at 50C.

Beta: Solid solution rich is Sn … (Pb : solute , Sn: solute).

-Max solubility of Pb in Sn …. 2.5% Pb at 175C.

-Min solubility of Pb in Sn …. 0.02% Pb at 50C.

6) We marked the max point and the min point for each other on the diagram.

7)T1 values connected to each other with the melting point of Pb and Sn and T2 values connected to each other with melting point of Pb and Sn. Max and Min points of alpha connected with melting point of Pb in the one side and in the other with eutectic point, the same thing we did with points of beta but we connected there points with melting point pf Sn, as we see.

Finally, we distributed the phases and we drew the structure of the composition as we see in the phase equilibrium diagram.

Conclusions:

To wrap up, in this experiment the cooling curves are used to construct the phase diagram. The aim of constructing this phase diagram is to indicate the phase of the alloy at any selected temperature, the composition of each phase and the amount of each phase for the desired temperature and composition.

References:

Experimental Laboratory Manual in Materials Science and Engineering

YouTube videos

Notes from the experiment