COURSE NAME: MME – 102

GROUP NO.: A1

EXPERIMENT NO.: 09

NAME OF THE EXPERIMENT:

Construction of a Pb-Sn phase diagram using cooling curve method.

DATE OF PERFORMANCE:

08. 12. 2024

DATE OF SUBMISSION:

12. 03. 2025

SUBMITTED TO:

Ahsiur Rahman Nirjhar

Lecturer

Department of MME, BUET

SUBMITTED BY:

Praggo Pabon

Roll: 2311002

Section: A- 1

Department of MME, BUET

Table of Contents

Introduction

A phase diagram is a graphical representation that illustrates the conditions under which distinct phases of a substance— such as solid, liquid and gas— exist in equilibrium. It typically plots temperature on the X-axis and pressure on the Y-axis or temperature on the Y-axis and composition in wt% on the X-axis. In our experiment, we used the second method to construct the phase diagram.

Phase diagrams are essential tools to predict how substances will behave under certain circumstances and varying conditions of temperature, pressure or an alloy composition — guiding processes like distillation, crystallisation and material synthesis. These diagrams are necessary to understand phase transitions and stability of different states.

In our experiment, we used a Pb-Sn alloy. The goal was to construct a phase diagram of Pb-Sn alloy in a range of certain compositions. In that range, we had an eutectic composition (in that composition, at the lowest of all other composition temperatures, the mixture remained in the liquid state before solidifying). As a result, the output phase diagram was an eutectic binary phase diagram.

Equipments

1. A container
2. Burner or heater
3. Thermocouple thermometer
4. 4 Alloys of particular compositions
5. Stopwatch

Procedure

We were given four different compositions of a Pb-Sn alloy, which were 30, 45, 62 (eutectic) and 80 [all in wt% Sn]. We were divided into four groups with one of the compositions. Then we followed the stated procedure:

1. Put our Sn-Pb alloy in a small container.
2. Connect a thermocouple thermometer.
3. Heat up the alloy sample until it fully melts.
4. After fully melting, stop the heating process.
5. As soon as we let the sample cool down in still air, we start taking the temperature reading of the thermocouple at 5 seconds duration.
6. We take around 200 pieces of data.
7. Then we plot them on the graph to generate a cooling curve.
8. From the cooling curve, we can observe the changing temperatures which are solidus and liquidus temperatures.
9. Using 4 sets of solidus and liquidus temperature, we generate our Sn-Pb eutectic binary phase diagram.

Analysis

Using Microsoft Excel, we plot the data from the experiment. We take temperature (on degree celsius) on the Y-axis and time (in seconds) on the X-axis. Different colors show the data of different groups.

Then we connected the dotted plotted points to generate the cooling curve. From the cooling curve we can deduce the solidus and liquidus temperatures of the Sn-Pb alloy of different compositions.

Composition (wt% Sn)	Liquidus Temperature (°C)	Solidus Temperature(°C)
30	196	182
45	186	181
62	179	179
80	183	178

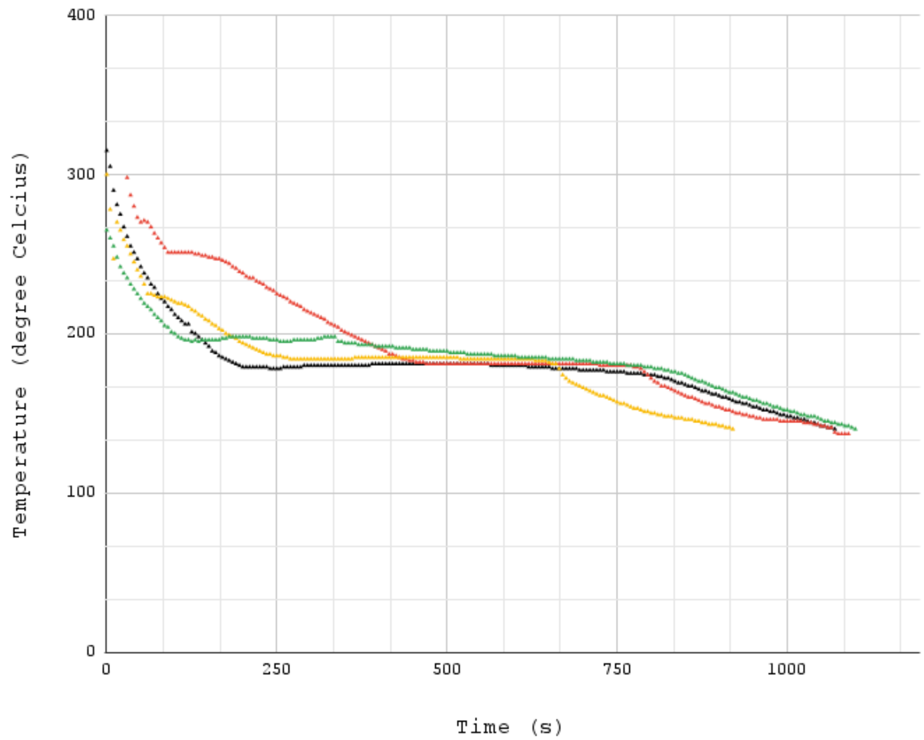

Fig: Graph of the plotted data

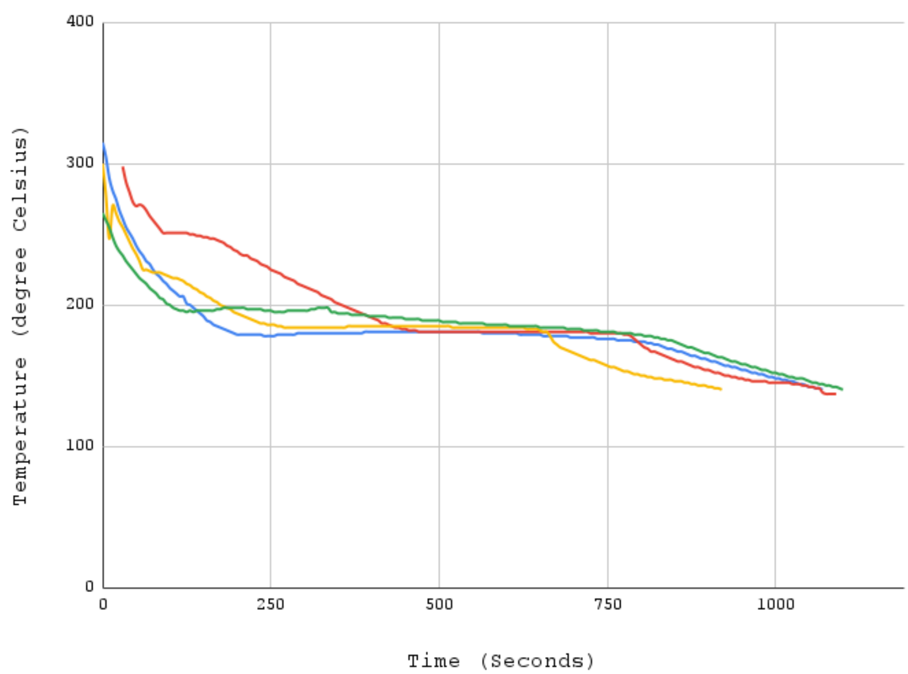

Fig: Cooling curves generated by four groups

Result

We can generate the phase diagram from the liquidus and solidus temperature:

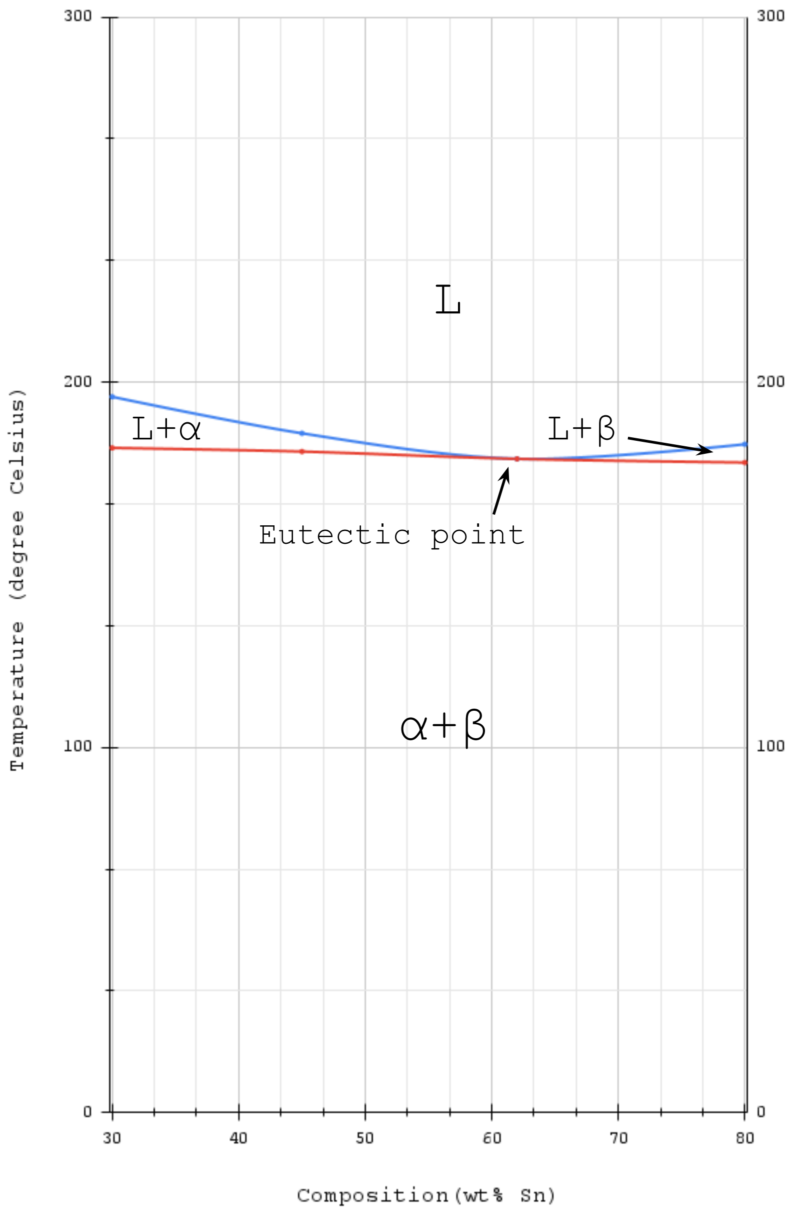

Fig: A partial phase diagram of Pb-Sn alloy

In the figure, the red continuous line represents the solidus line and the blue continuous line represents the liquidus line. L represents the liquid form, β and α are two solid-solution phases of the Pb-Sn alloy.

Discussion

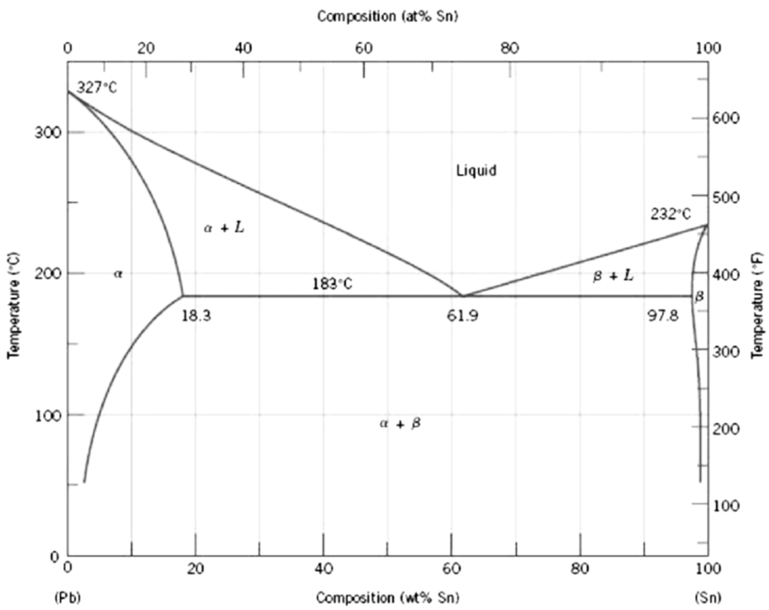

Fig: A binary eutectic complete phase diagram of Pb-Sn [1]

If we compare our phase diagram with a complete binary eutectic phase diagram shown in the figure, we will find out that our phase diagram is incomplete. It only shows the phase change from 30 wt% Sn to 80 wt% Sn. Moreover, our solidus line is not as horizontal as it should be. Even our liquidus line has a more concave shape from our literature findings.

The reason for this deviation can be predicted. We can conclude to 3 reasons for the errors:

1. Human Error: We were told to take temperature readings of the thermocouple with a 5s time gap. We assume that there were possible mistakes while taking the readings. For example: pausing more than or less than 5 seconds, taking the same reading twice or skipping one reading before taking the next one.
2. Mechanical Error: Our thermocouple thermometer might have shown some mechanical errors at measuring the temperature.
3. Graph analysis: If we take our solidus and liquidus temperature at slightly deviated points, our solidus and liquidus line will vary from our literature findings. We assume that there were some errors while choosing solidus and liquidus temperature from the cooling curve.

But we were still able to construct a partial eutectic phase diagram with minimal error. Thus, we can conclude that our experiment was a success.

Reference

[1] *Partial melting of a Pb-Sn mushy layer due to heating from above, and implications for regional melting of Earth's directionally solidified inner core - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Pb-Sn-phase-diagram_fig3_280576991 [accessed 12 Mar 2025]*