Phase Diagram

The understanding of phase diagrams for alloy systems is extremely important because there is a strong correlation between microstructure and mechanical properties, and the development of microstructure of an alloy is related to the characteristics of its phase diagram. In addition, phase diagrams provide valuable information about melting, casting, crystallization, and other phenomena.

solid solution

A solid solution occurs when we alloy two metals and they are completely soluble in each other. and no new structures are formed. If two liquids, soluble in each other (such as water and alcohol) are combined, a liquid solution is produced as the molecules intermix. A solid solution is also compositionally homogeneous.

Impurity point defects are found in solid solutions, of which there are two types: substitutional and interstitial.

A. Substitutional Solid Solution

atoms of the parent metal (or solvent metal) are replaced or substituted by atoms of the alloying metal (solute metal). In this case, the atoms of the two metals in the alloy, are of similar size. Here we see the black atoms have been replaced or substituted by the white atoms in figure below.

E-mail: hiba.mohsin.abd@uomus.edu.iq

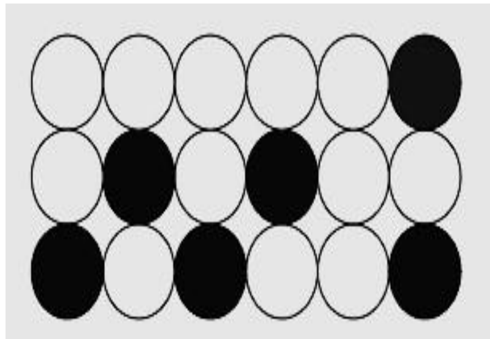

Figure . Substitutional Solid Solution.

B. Interstitial Solid Solution

atoms of the (parent or solvent metal) are bigger than the atoms of the (alloying or solute metal). In this case, the smaller atoms fit (sit) into interstices (i.e. spaces between the larger atoms). The smaller atoms are small enough to fit into the spaces between the larger solvent atoms. Shown in figure below.

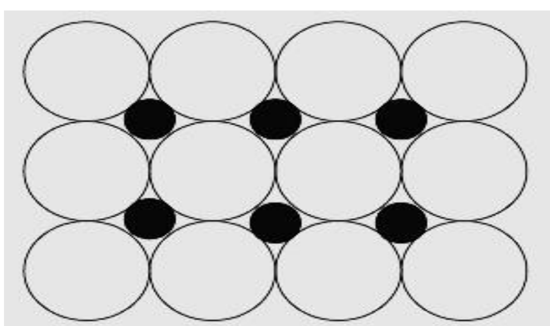

Figure . Interstitial solid solution.

Thermal Equilibrium Diagrams (Phase Diagrams)

Equilibrium may be defined as a state of balance of stability. When a metal solidifies, equilibrium will occur under conditions of **slow cooling** where the reduction in temperature is small in relation to the time elapsed (gone). To achieve equilibrium, it would be necessary, at every stage of cooling, to give the alloy elements **time to diffuse** (mix through on another) which would lead to a state that each grain of metal would have the same composition throughout. Complete diffusion seldom takes place in casting because solidification usually takes place before diffusion is complete.

There are a number of different types of thermal equilibrium diagrams

1. Two metals completely soluble in each other in both liquid and solid states.
2. Two metals completely soluble in each other in the liquid but not in the solid state (**Eutectic alloy**).
3. Two metals completely soluble in each other in the liquid and partially soluble in the solid state.
4. Iron / Carbon equilibrium diagram.

Two metals completely soluble in each other in both liquid and solid states

Instead of dealing with several different cooling curves for any alloy, a quicker graph has been created using the various arrest points of all the alloys. As you can see there are three areas the **liquid state**, the **solid state** and the **pasty state** (consists of a solid phase and a liquid phase). A very important point to note is that the line joining all the points where the liquid begins to solidify is known as the **Liquidus line** while the line joining all the points where solidification is just complete is known as the **Solidus line**. If we want to find out what temperature **60%** Copper is fully solidifying at in an alloy of Copper and Nickel. Firstly, we need the thermal equilibrium diagram for the alloy of Copper and Tin. This is the thermal equilibrium diagram for the alloy of Copper and Nickel. In order to find what temperature **60%** copper solidifies at we simply draw a vertical line from **60%** copper until it hits the solidus line and at this is the point where **60%** Copper has fully solidified.

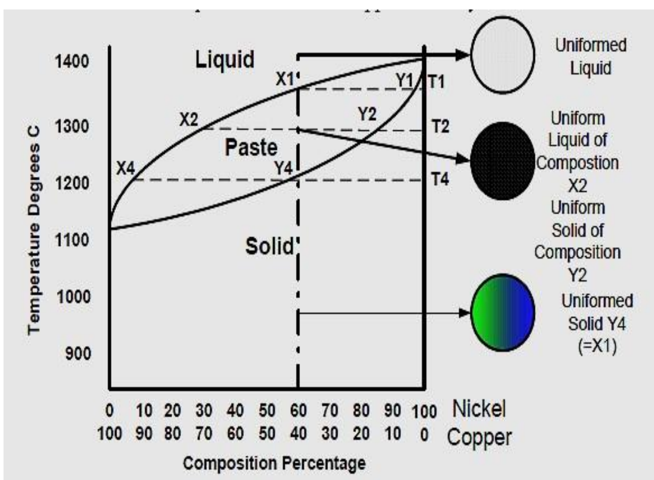

Figure . Nickel-Copper thermal equilibrium diagram.

E-mail: hiba.mohsin.abd@uomus.edu.iq

Two metals completely soluble in each other in the liquid but not in the solid state

(Eutectic alloy)

A eutectic is an alloy of lowest melting point in that alloy system and is formed when two different solid phases separate at constant temperature from a single liquid phase (i.e. changing from a solid to a liquid at a constant temperature).

A Eutectic equilibrium diagram results when the two metals are soluble in the liquid state but insoluble in the solid state. In the liquid state the two metals are soluble in each other but when cooling is complete, the grain of the solid alloy consists of two distinguishable metals which can be seen under a microscope to be like a layer of one metal on top of a layer of the other metal. This state is completely different where the cooled solid grains look just like one metal when viewed under a microscope. In order to fully understand this type of alloy combination we will look at the (Cadmium Bismuth) eutectic thermal equilibrium diagram. Cadmium and Bismuth are completely soluble in the liquid state, but are completely insoluble in the solid state.

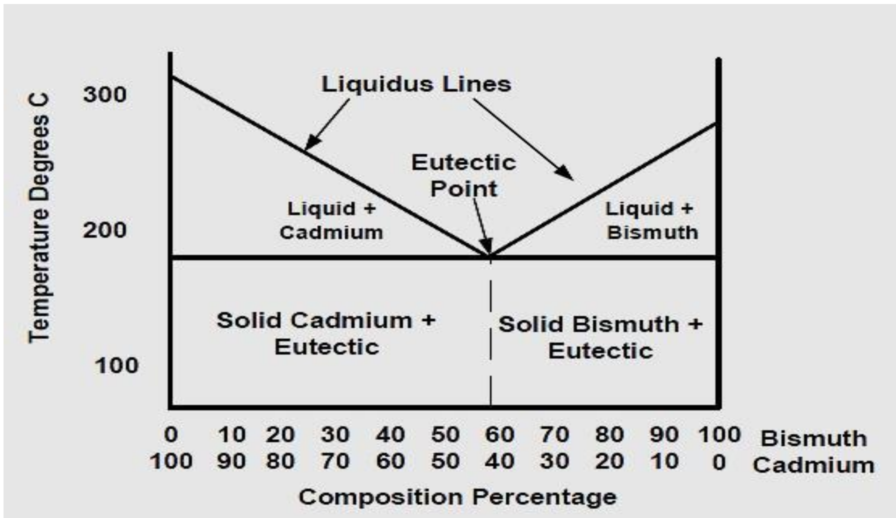

Figure . Bismuth-Cadmium (Eutectic Alloy).

The first and most noticeable point on this diagram is the **Eutectic point**. The eutectic point as can be seen above is a point in the diagram where the liquid alloy changes to a solid without going through a pasty state.