Class: 1st
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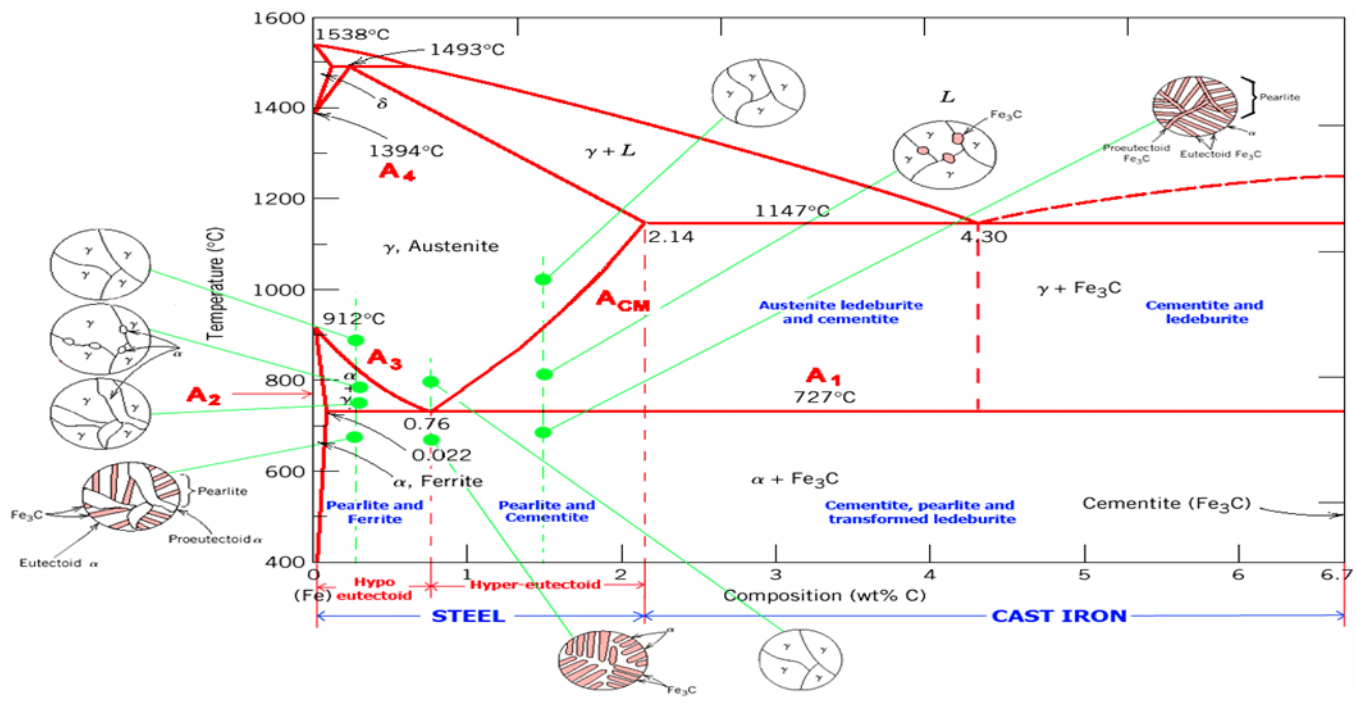
Engineering Materials

ASST .LEC. KAWTHER FALAH HASAN

Iron-Carbon Phase Diagram

The iron-carbon phase diagram is widely used to understand the different phases of steel and cast iron. Both steel and cast iron are a mix of iron and carbon. Also, both alloys contain a small amount of trace elements. The graph is quite complex but since we are limiting our exploration to Fe3C, we will only be focusing on up to 6.67 weight percent of carbon.

This iron-carbon phase diagram is plotted with the carbon concentrations by weight on the X-axis and the temperature scale on the Y-axis. The carbon in iron is an interstitial impurity. The alloy may form a face-centred cubic (FCC) lattice or a body-centred cubic (BCC) lattice. It will form a solid solution with α, γ, and δ phases of iron.



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Types of Ferrous Alloys on the Phase Diagram

The weight percentage scale on the X-axis of the iron-carbon phase diagram goes from 0% up to 6.67% Carbon. Up to a maximum carbon content of 0.008% weight of Carbon, the metal is simply called iron or pure iron. It exists in the α-ferrite form at room temperature.

From 0.008% up to 2.14% carbon content, the iron-carbon alloy is called steel. Within this range, there are different grades of steel known as low-carbon steel (or mild steel), medium-carbon steel, and high-carbon steel.

Eutectic Point

Eutectic point is a point where multiple phases meet. For the iron-carbon alloy diagram, the eutectic point is where the lines A1, A3 and ACM meet. The formation of these points is coincidental.

At these points, The alloys formed at this point are known as eutectic alloys. On the left and right side of this point, alloys are known as hypoeutectic and hypereutectic alloys respectively (‘hypo’ in Greek means less than, ‘hyper’ means greater than).

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Different Phases

α-ferrite

Existing at low temperatures and low carbon content, α-ferrite is a solid solution of carbon in BCC Fe. This phase is stable at room temperature. In the graph, it can be seen as a sliver on the left edge with Y-axis on the left side and A2 on the right. This phase is magnetic below 768°C.

It has a maximum carbon content of 0.022 % and it will transform to γ-austenite at 912°C as shown in the graph.

γ-austenite

This phase is a solid solution of carbon in FCC Fe with a maximum solubility of 2.14% C. On further heating, it converts into BCC δ-ferrite at 1395°C. γ-austenite is unstable at temperatures below eutectic temperature (727°C) unless cooled rapidly. This phase is non-magnetic.

Fe3C or cementite

Cementite is a metastable phase of this alloy with a fixed composition of Fe3C. It decomposes extremely slowly at room temperature into iron and carbon (graphite).

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Cementite is hard and brittle which makes it suitable for strengthening steels. Its mechanical properties are a function of its microstructure, which depends upon how it is mixed with ferrite.

Fe-C liquid solution

Marked on the diagram as 'L', it can be seen in the upper region in the diagram. As the name suggests, it is a liquid solution of carbon in iron. As we know that δ-ferrite melts at 1538°C, it is evident that the melting temperature of iron decreases with increasing carbon content

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