Goldens' Guide to Iron Alloys

Cast Iron is a ferrous alloy which has Carbon (C) and silicon (Si) as it's main alloying elements, with the amount ranging per weight from 2.1–4 wt% C and 1–3 wt% Si, respectively. Iron alloys with less carbon content are known as steel. The alloys are added to the molten iron and play a role during the solidification process influencing the way Carbon precipitates out of the molten solution and crystalizes in the final product.

C_6 Carbon	Carbon and Silicon are the most important of the Iron alloys because Carbon forms graphite which results in a softer iron, reduces shrinkage, lowers strength, and decreases density.
Si_{14} Silicon	Silicon helps by forcing Carbon out of the molten solution allowing it to form graphite. Silicon has an effect on carbon equivalent. It's a solid solution strengthening agent, so increasing silicon greatly effects the embrittlement of Ductile Iron, particularly at lower temperatures. For these reasons the overall amount must be controlled.
S_{16} Sulfur	Sulfur, when present, forms iron sulfide, which prevents the formation of graphite and increases hardness. The problem with sulfur is that it makes molten cast iron sluggish, which causes short run defects.
Mn_{25} Manganese	Manganese is added to counter the detrimental effects of sulfur, because the two form into manganese sulfide instead of iron sulfide. The manganese sulfide is lighter than the melt so it tends to float out of the melt and into the slag. The amount of manganese required to neutralize sulfur is 1.7 × sulfur content + 0.3%. If more than this amount of manganese is added, then manganese carbide forms, which increases hardness and chilling.
Ni_{28} Nickel	Nickel is one of the most common alloying elements because it improves toughness, and evens out hardness differences between section thicknesses. Nickel is also a graphitizing element and acts similar to silicon except that it does not embrittle, but rather increases the toughness of the matrix.
Cr_{24} Chromium	Chromium is added in small amounts to the ladle to reduce free graphite, produce chill, and because it is a powerful carbide stabilizer; nickel is often added in conjunction. A small amount of tin can be added as a substitute for 0.5% chromium.
Cu_{29} Copper	Copper is added in the ladle or in the furnace, on the order of 0.5–2.5%, to decrease chill, refine graphite, and increase fluidity. Copper is similar to nickel in many ways, except that is a much stronger pearlite promoter. At a 1% level, usually a 100% pearlitic matrix can be obtained. It is the most widely used alloy for pearlitic Ductile Iron production, because of its effectiveness and cost. It only gives a modest increase in hardenability.
Mo_{42} Molybdenum	Molybdenum is added on the order of 0.3–1% to increase chill and refine the graphite and pearlite structure; it is often added in conjunction with nickel, copper, and chromium to form high strength irons.
Ti_{22} Titanium	Titanium is added as a degasser and deoxidizer, but it also increases fluidity.

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