Alloying Elements and Properties of Steel

Illustration

- Here are a few major alloying elements for steel and some informatioen about what they can do.
  - This list is based on the "Materials in Action Series; Structural Materials"

Element	Influence on Ferrite	Influence on Hardenability	Tendency to form hard Carbides	Major Functions
Manganese **Mn**	Powerful solution strengthener	Moderate increase	Middle	**1.** Takes care of *Sulphur* (**S**). **2.** *Cheap* increase of hardenability.
Silicon **Si**	Hardens, but *reduces ductility*	Moderate increase	-	**1.** Deoxidation of *liquid steel*. **2.** Improves oxidation resistance. **3.** Strengthens low alloy steel. **4.** Increases *electrical resistivity* (important for transformer cores).
Chromium **Cr**	Strengthens a little Provides corrosion resistance	Moderate increase	Strong	**1.** Corrosion resistance. **2.** Hardenability. **3.** *Abrasion resistance* (needs high **C**, too). **4.** Strength + oxidation resistance at *high **T***.
Titanium **Ti**	Age hardening possible	Very strong increase	Extremely strong	**1.** Forms hard carbides. **2.** Prevents *local depletion* of **C** carbon in stainless steels due to **Cr**-carbide formation
Vanadium **V**	Moderate solid solution hardening	Very strong increase	Very strong	**1.** *Restricts grain coarsening* of austenite. **2.** Increases hardenability. **3.** Delays softening during tempering.
Nickel **Ni**	Strengthens	Mild improvement stabilizes austenite	-	**1.** Improves strength and toughness at *subzero **T***. **2.** Together with **Cr** provides austenitic steel.
Molybdenum **Mo**	Age hardening possible	Strong increase	Very strong	**1.** Increase hardenability. **2.** Prevent *embrittlement* of certain **Ni/Cr** steels. **3.** Keeps strength at higher **T**. **4.** Restricts austenite *grain growth*. **5.** Improves *corrosion resistance of stainless steels*. **6.** Provides carbides with high *abrasion resistance*.
Cobalt **Co**	Strengthens in solid solution	*Decreases* slightly	Like **Fe**	**1.** Contributes hardness at *moderately high **T***.

- The list could go on for a while, of course. It includes some properties not much discussed before, for example:
  - Behavior at low and/or high temperatures.
  - Properties like wear (or abrasion) resistance or corrosion resistance (note that stainless steel, while oxidation resistant, might nevertheless corrode in some other chemical environment.
  - Making steel in the first place (look for "liquid").
  - Counteracting the effects of other elements.
  - Keeping the structure from unwanted changes ("grain growth")