Chemical Element Effects On The Steel

Sources : www.zknives.com

Aluminum (Al)
Primarily used as a deoxidizer. However, in small amounts also controls grain size growth.

Boron (B)
Typical range in steel alloys is 0.0005 to 0.003%. Added to steel to improve hardenability. Most effective in low carbon steels.

Carbon (C)
Present in all knife steels, it is the most important hardening element. Increases tensile strength and edge retention and improves resistance to wear and abrasion. Added in isolation, decreases toughness. Usually one would want knife-grade steel to have > 0.50% carbon, which makes it "high-carbon" steel. Low Carbon steels have up to 0.03% C, and there are mild steels with 0.03% or similar, obviously those aren't suited for knife blades.

Chromium (Cr)
Added for increased wear resistance, hardness, tensile strength, and (most importantly) for corrosion resistance. Cr forms large, complex carbides. A steel with at least 13% chromium is typically deemed "stainless", though another definition says the steel must have at least 11.5% free chromium (as opposed to being tied up in carbides) to be considered "stainless". Despite the name, all steel can rust if not maintained properly. Adding Chromium in high amounts decreases toughness. Chromium is a carbide-former, which is why it increases wear resistance. Unfortunately, the amount of free Chromium in the steels is almost never specified.

Cobalt (Co)
Increases hardness, also allows for higher quenching temperatures (during the heat treatment procedure). Intensifies the individual effects of other elements in more complex steels. Co is not a carbide former, however adding Cobalt to the alloy allows for higher attainable hardness and higher red hot hardness.

Copper (Cu)
In large amounts detrimental to steel performance. Between 0.20% and 1% helps with preventing surface oxidization.

Lead (Pb)
Added to steel in very small amounts to improve machinability.

Manganese (Mn)
An important element, Manganese improves grain structure and contributes to hardenability, strength, and wear resistance. Improves the steel, deoxidizes and degasifies during the steel's manufacturing (hot working and rolling). Present in most cutlery steels. In larger quantities, increases hardness and brittleness.

Molybdenum (Mo)
A carbide former, prevents brittleness, and maintains the steel's strength at high temperatures. Improves machinability and resistance to corrosion. Present in many steels, and air-hardening steels (e.g. A2, ATS-34) always have 1% or more Molybdenum.

Nitrogen (N)
Nitrogen acts very similar to Carbon in the alloy. N substitutes C in small amounts (or even large, with modern technologies) to increase hardness. Obviously, Nitrogen forms Nitrides, not Carbides. INFI has N, and there's few more, with Sandvik being the champion, having 3% N in the alloy, completely substituting C. Sadly, not available for knife makers. Because Nitrogen is less prone to form Chromium nitrides than Carbon is to form Chromium carbides, its presence improves corrosion resistance, leaving more free Chromium in the alloy. Since Nitrogen is less reactive in forming Nitrides, it can be used for added hardness without increasing carbide size and volume, e.g. Sandvik 14C28N steel.

Niobium (Nb)
Niobium is a strong carbide former and forms very hard, very small, simple carbides [NbC]. Improves ductility, hardness, wear and corrosion resistance. Also, refines grain structure. Formerly known as *Columbium*.

Nickel (Ni)
Adds toughness. Present in L6 and AUS6 and AUS8. Nickel is widely believed to play a role in corrosion resistance as well, but this is probably incorrect. One more reason Ni is added to an alloy is that it creates brighter portions in damascus steels.

Oxygen (O)
Another undesirable element in the steel. Oxides promote pitting in the steels. Essentially it is a contaminant.

Phosphorus (P)
Present in small amounts in most steels, phosphorus is essentially a contaminant, which reduces toughness. In very small amounts improves strength, machinability, and hardness.

Sulfur (S)
Typically not desirable in cutlery steel, sulfur increases machinability, but decreases toughness.

Selenium (Se)
Typically not desirable in cutlery steel. Added to improve machinability. Similar with Sulfur, in the same chalcogen group.

Silicon (Si)
Contributes to strength. Like Manganese, deoxidizes and degasifies to remove Oxygen from molten metal.

Tantalum (Ta)
Chemically very similar to Niobium (Nb), as such, has similar effect on the alloy - forms very hard, very small, simple carbides. Improves ductility, hardness, wear and corrosion resistance. Also, refines grain.

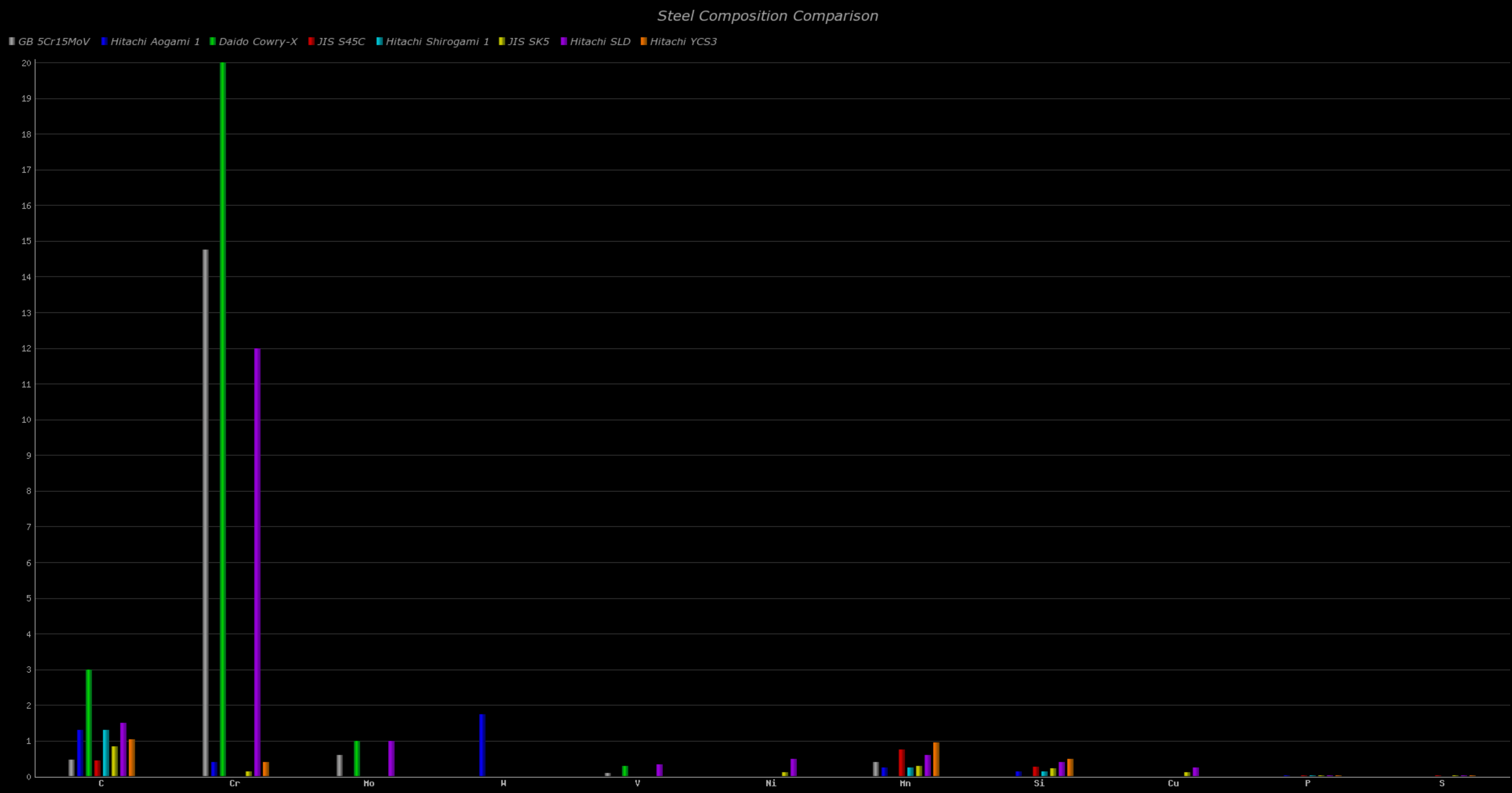
Titanium (Ti)
Used to control grain size growth, which improves toughness. Also transforms sulfide inclusions form elongated to globular, improving toughness and ductility.

Tungsten (W)
Scientific Wolfram. Strongest carbide former after Nb and then V. W increases wear resistance. When combined properly with Chromium or Molybdenum, Tungsten will turn a steel into a high-speed steel. The M2 high-speed steel has a high amount of tungsten.

Vanadium (V)
Contributes to wear resistance and hardenability, and as a carbide former (in fact, vanadium carbides are the hardest carbides) it contributes to wear resistance. It also refines the grain of the steel, which contributes to toughness and allows the blade to take a very sharp edge. A number of steels contain some Vanadium, where as M2, Vascowear, and CPM 10V, S90V, S125V (in order of increasing amounts) feature very high amounts of vanadium.

Zirconium (Zr)
Typically added to low alloy, low carbon steels, to improve inclusions characteristics (transforms shape from elongated to globular, improving toughness and ductility).

	Base	C	Cr	Mo	V	W	Co	Ni	Mn	Si	S	P	Cu	Nb	N
5Cr15MoV	Fe	0.475	14.75	0.60	0.10	0.00	0.00	0.00	0.40	Secret	Secret	Secret	0.00	0.00	0.00
Aogami 1	Fe	1.30	0.40	0.00	0.00	1.75	0.00	0.00	0.25	0.15	0.004	0.025	0.00	0.00	0.00
Cowry-X	Fe	3.00	20.00	1.00	0.30	0.00	0.00	0.00	Secret	Secret	Secret	Secret	0.00	0.00	0.00
S45C	Fe	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.275	0.04	0.030	0.00	0.00	0.00
Shirogami 1	Fe	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.15	0.004	0.025	0.00	0.00	0.00
SK5	Fe	0.85	0.15	0.00	0.00	0.00	0.00	0.125	0.30	0.225	0.030	0.030	0.125	0.00	0.00
SLD	Fe	1.50	12.00	1.00	0.35	0.00	0.00	0.50	0.60	0.40	0.030	0.030	0.25	0.00	0.00
YCS3	Fe	1.05	0.40	0.00	0.00	0.00	0.00	0.00	0.95	0.50	0.030	0.030	0.00	0.00	0.00


Steel Composition Comparison
GB 5Cr15MoV
Hitachi Aogami 1
Daido Cowry-X
JIS S45C
Hitachi Shirogami 1
JIS SK5
Hitachi SLD
Hitachi YCS3
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
C
Cr
Mo
W
V
Ni
Mn
Si
Cu
P
S