INFLUENCE OF ALLOYS

Aluminium **Al** Melting point 658°C	* Considerable hardening in the solid state * Deoxidises effectively, casting percentage 0,020 – 0,040% or > 0,015 for soluble Al * Obstructs grain enlargement and this helps to prevent cracks during grinding * It is the alloy in nitriding steel. It forms extremely hard aluminium nitrides with nitrogen * Enables regulation of the depth of the nitriding layer * Prevents aging of the steel * Does not tend to form carbides but tends to increase the abrasive strength * Harms the machinability of free cutting steels * An Al / N ratio > 2 is recommended to have a good deoxidation
Arsenic **As** Melting point 817°C	* Has a great tendency to segregate * Worsens the tempering embrittlement * Considerably reduces the toughness
Bismuth **Bi** Melting point 270°C	* Used in an alloy with lead (~ 0.1%) it increases the machinability of free cutting steels by 20-30% * It may not be identified metallographically since it is linked with lead even if it is added separately during the production process * In hot rolling is more difficult, giving more possibility of surface defects.
Boron **B** Melting point 2300°C	* With contents of 0,003-0,005 it considerably increases the hardening in carbon and low alloy steels. Higher contents causes brittleness when hot. If boron is allowed to combine with oxygen and nitrogen then its effect on hardenability is lost. Therefore, the steel must be deoxidised prior to the addition of boron and a strong nitride forming element such as titanium also has to be added. * Avoid temperatures of between 200°C and 400°C for boron steels as the material becomes fragile in this range. If tempering is to be carried out, use temperatures of 180°C or 420°C * Harmful to ends of the welding, employed also like deoxidizing * Increases the transition curve
Calcium **Ca** Melting point 850°C	* Even minimum quantities form non-metallic inclusions which improve machinability and resist abrasion * Does not worsen the mechanical characteristics and does not cause problems during heat treatment * Alkaline earth metal, which is white/silver in colour and very soft * Deoxidizer for varius ferrous alloy * Increase impact strength * Refines the grain and in this way holds the depht of hardening up. The quenching will be preferably made into water
Carbon **C** Melting point 3540°C	* It is the most important element during hardening and tempering to obtain the desired hardness * Mild carbon steel (C < 0,15) or extra mild carbon steel (C< 0.08), without special additives, is too ductile and is too soft during cutting which results in poor finishes * With a C% greater than 0,15 there is an increase in shear strength and wear of the tools due to the increased abrasiveness of the structures richer in carbons * Graphite form of carbon is a black, odourless, slippery solid. Graphite sublimes at 3825°C. Diamond form is a clear or colored; an extremely hard solid
Chromium **Cr** Melting point 1920°C	* Provides a good resistance against wear and abrasion with a high carbon content * Increases hardening * Prevents corrosion, oxidisation and decarburising * Helps maintain mechanical strength at high temperatures * Slight tendency towards formation of carbons * Increases surface hardness which can be achieved by nitruration
Cobalt **Co** Melting point 1492°C	* Maintains hardness at high temperatures * Prevents overheating of machine tools *Together with tungsten and molybdenum, cobalt is used to form the super high speed steels. It improves the red hardness value of the steel, that is, it
Copper **Cu** Melting point 1084°C	* Increases resistance to atmospheric corrosion * Undesired in steel as it causes hot-shortness when hot when content exceeds 0,40% * Negative effects on welding * Enables the steel to resist softening at a high temperature or in the case of a cutting tool to hold its edge under severe conditions

Hydrogen **H** Melting point -262°C	* A very harmful impurity, especially if it exceeds 2 ppm * Produces micro-cracks, known as flakes, which can occur even after long periods of time or after hardening heat treatment
Lead **Pb** Melting point 327.4°C	* Together with sulphur, it considerably increase the machinability of steels (0,15-0,35%) * Slight tendency to thin the austenitic grain * Negatively effects the mechanical characteristics *Harmful for welding. If welding is carried out, use UTP 63 electrodes or equivalent R 700 N/mm2 and A% 40 * Tool interphase, thereby reducing friction.
Manganese **Mn** Melting point 1221°C	* Helps increase hardening * Provides impact wear resistance * Prevents brittleness in the presence of sulphur * It is considered an alloy if it exceeds 1% * Mn/C ratio must be > 3 in order to have a satisfactory toughness at low temperatures (e.g. Kv –50°C)
Molybdenum **Mo** Melting point 2622°C	* During heating it increases the temperature at which the austenitic grain starts to increase in size * It opposes brittleness with tempering * Increases hot creep limit * Increase depth of hardening, as it reduces the critical cooling speed
Nickel **Ni** Melting point 1453°C	* Increases hardening * Useful for increasing impact strength at low temperatures with a percentage of approximately 2% and excellent influence on lowering the transition curve. * Increases strength of annealed and untreated steels
Niobium **Nb** Melting point 1950°C	* Forms very hard abrasive carbons and causes an increase in the wear of machine tools. * Used in self-hardening steels * It is also the metal used in arc welding rods for some stabilized grades of stainless steel. * Used to make special steels and strong welded joints. * Niobium becomes a superconductor when lowered to cryogenic temperatures
Nitrogen **N** Melting point -210°C	* Increases hardening, tensile strength and yield stress * Used in nitruration processes to obtain extremely hard surface layers * A content of approximately 0,012% favours the cutting of the chips, thereby improving machinability * Recommended max. 90 ppm * Generally considered to have negative effects on the toughness (Kv) at low temperatures
Oxygen **O** Melting point -218.7°C	* Generally considered an impurity, as it has a negative effect on the mechanical characteristics * The greater the degree of deoxidization, the higher the quality of the steel is considered to be * Recommended max. 30 ppm * Oxygen is one of the chief constituents of the atmosphere of which it forms approximately one fifth. It is odourless and invisible. Although oxygen itself does not burn it is extremely efficient in supporting combustion, nearly all other chemical elements combine with it under evolution of heat. It has many uses in industry and is essential to the BOS (Basic Oxygen Steelmaking Process)
Phosphorous **P** Melting point 44°C	* Reduces ductility but improves cutting in free cutting steels (0,040 - 0,11%). * With a content > 0.20 the impact strength is nil. * A maximum content of 0,015% is recommended for galvanising treatment, or otherwise the formula Si + 2,5P < 0,15%
Selenium **Se** Melting point 217°C	* 0,20% of this element is more suitable than an equal quantity of sulphur for the improvement of the cutting of carbon, low alloy and austenitic steels * It is a better substitute for sulphur and tellurium in stainless steels * Forms manganese sulphides into globules and is used to improve the mechanical properties of resulferized steels in a transversal direction * Improves machinability in difficult deep drilling operations
Silicon **Si** Melting point 1414°C	* Used as an alloy in sheets for electromagnetic applications as it increases the electrical resistance * Slight influence on the deoxidation * Increase wear resistance of low alloy steels * Reduces cold deformability * Seriously damages machinability of the tool * A maximum content of 0,25% is recommended for galvanising treatment

Sulphur **S** Melting point 118°C	* It is added to steel in various quantities depending on the classes and the technological needs to improve the machinability * Undesired from the point of view of the mechanical characteristics why it cause embrittlement * It is considered the simplest, most economic and effective additive to be added to steel to improve the machinability * It lowers the temperature of malting point of the steel
Tellurium **Te** Melting point 449.5°C	* Makes the sulphurs less plastic enabling an increased cutting speed and facilitating drilling operations * Improves machining by up to 50% when combined with lead * Reduces hot deformability * Reduces hot machinability like lead, when present in steel with a S% : Te% content of ~ 10 * Tends to form sulphurs into globules
Tin **Sn** Melting point 231.8°C	* Contents of greater than 0,05% may make the steel brittle in hot machining, just like copper * It is silvery-white, soft, malleable and ductile metal. Exposed surfaces form oxide film. Resists oxygen and water * When present in steel it is an undesirable impurity which gives rise to temper brittleness
Titanium **Ti** Melting point 1727°C	* Prevents formation of austenite in steels with a high chromium content * Reduces hardness and hardening in steels with an average chromium content * Prevents inter-granular corrosion in stainless steels * Deoxidising, denitriding and refining of austenitic grain * Reduces machinability of tool as it forms abrasive carbons
Tungsten **W** Melting point 3380°C	* Provides abrasion resistance for tool steels, reduces sensitivity to overheating * Produces mechanical strength in parts for hot-working * Improves toughness and prevents enlargement of grain size * Used particularly in high-speed steels for cold cutting and shearing components
Vanadium **V** Melting point 1726°C	* Produces fine grains * Increases hardening * Increase impact strength just like nickel * Increase elastic limit * Provides considerable wear resistance
Zirconium **Zr** Melting point 1860°C	* Fixing nitrogen eliminates the tendency to aging * Tends to form oxides and nitrides which are harmful for mechanical processing * Has the power to absorb gases and is therefore also used as a “getter” or metallic absorbent * Since it cannot be altered by atmospheric agents it is used to produce corrosion resistant metal alloys
Iron **Fe** Melting point 1536°C	* This is the most common metal 90% of all the metal refined worldwide is ferrous. * It is used in steels and in other alloys and the pure metal is obtained by the liquefaction of ferrous minerals. * The first findings were meteorites made of iron-carbon alloy, nickel, cobalt, chromium alloys. * On the earth in the magnetite seams you can find hematite, limonite and siderite. * It's a grey and magnetic hard solid . Whether exposed to humid air, it becomes rust (iron oxide). * Pure iron Ac3 = 911°C