Stainless Steels Alloying Elements

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Introduction

Stainless steels contain several alloying elements that are in line with the specific composition and grade. The following sections describe the alloying additions and the reasons they are present, and a summary table of each alloying element.

Carbon

Carbon and iron are alloyed together to form steel. This process boosts the strength and hardness of iron. Heat treatment is not adequate to strengthen and harden pure iron, but when carbon is added, a wide range of strength and hardness is realized.

High carbon content is not preferred in Ferritic and Austenitic stainless steels, specifically for welding purposes, due to the risk of carbide precipitation.

Manganese

The addition of manganese to steel improves hot working properties and boosts toughness, strength, and hardenability. Just like nickel, manganese is an Austenite forming element and has been traditionally used as a replacement for nickel in the AISI200 range of Austenitic stainless steels, for example AISI 202 as a replacement for AISI 304.

Chromium

Chromium is combined with steel to improve it's resistance to oxidation. When more chromium is added, the resistance is improved further.

Stainless steels have at least 10.5% chromium (usually 11 or 12%), which imparts a considerable level of corrosion resistance, compared to steels with a relatively lower percentage of chromium.

The resistance to corrosion is attributed to the formation of a passive, self-repairing layer of chromium oxide on the stainless steel surface.

Nickel

Large amounts of nickel - more than 8% - is added to high chromium stainless steels to produce the most important group of steels that are resistant to both heat and corrosion.

These include the Austenitic stainless steels that are characterized by 18-8 (304/1.4301), where nickel’s tendency to form Austenite contributes to high strength and excellent toughness or impact strength, at both low and high temperatures. Nickel also significantly improves resistance to corrosion and oxidation.

Molybdenum

When mixed with chromium-nickel austenitic steels, molybdenum enhances resistance to crevice and pitting corrosion, particularly in sulphur and chlorides-containing environments.

Nitrogen

Similar to nickel, nitrogen is an Austenite forming element and increases the Austenite stability of stainless steels. When nitrogen is mixed with stainless steels, yield strength is

considerably enhanced along with increased resistance to pitting corrosion.

Copper

In stainless steel, copper is often present as a residual element. This element is added to several alloys to create precipitation hardening characteristics or to improve corrosion resistance, predominantly in sulphuric acid and sea water conditions.

Titanium

Titanium is often added to stabilize carbide, particularly when the material has to be welded. Titanium merges with carbon to form titanium carbides that are relatively stable and cannot be easily dissolved in steel, which is likely to reduce the occurrence of inter-granular corrosion.

When around 0.25 / 0.60% titanium is added, it causes the carbon to merge with titanium as opposed to chromium, avoiding a tie-up of corrosion-resistant chromium as inter-granular carbides and the associated loss of corrosion resistance at the grain boundaries.

In the past several years, the use of titanium has considerably reduced because of the ability of steelmakers to supply stainless steels that have extremely low carbon contents. Such steels can be readily welded without any need for stabilization.

Phosphorus

In order to improve machinability, phosphorus is often added with sulphur. While the presence of phosphorus in Austenitic stainless steels boosts strength, it has a detrimental effect on corrosion resistance and increases the material's tendency to break during welding.

Sulphur

Sulphur improves machinability when it is added in small quantities, but just like phosphorous, it has a negative effect on corrosion resistance and the subsequent weldability.

Selenium

Selenium was previously employed as an addition to enhance machinability.

Niobium/Colombium

Carbon stabilization is achieved by adding niobium to steel, and performs in the same manner as titanium. In addition, niobium strengthens alloys and steels for increased temperature service.

Silicon

Silicon is typically employed as a deoxidizing (killing) agent in the steel melting process, and a small amount of silicon is used in most steels.

Cobalt

When subjected to strong radiation of nuclear reactors, cobalt becomes highly radioactive and hence, all stainless steels deployed in nuclear service will have certain cobalt limitation, often 0.2% at the most.

This issue is important as some amount of the remaining cobalt will be present in the nickel used to make Austenitic stainless steels.

Calcium

Calcium is added in small amounts to enhance machiniability, without having any detrimental effect on other properties induced by selenium, phosphorus and. sulphur.

The following table shows the effect of alloying elements on properties of stainless steel.

Effect of alloying elements on properties of stainless steel

Property	C	Cr	Ni	S	Mn	Si	P	Cu	Mo	Se	Ti or Nb
Corrosion Resistance	-	√	√	X	-	-	√	-	√	-	-
Mechanical Properties	√	√	-	-	√	√	√	√	√	-	√
High Temperature Resistance	-	√	√	X	-	-	-	-	√	-	√
Machinability	X	X	-	√	-	-	√	-	-	√	-
Weldability	X	X	-	X	√	-	X	-	√	-	√
Cold Workability	X	X	√	X	-	-	-	√	-	-	-

Key

√ = Beneficial

X = Detrimental

This information has been sourced, reviewed and adapted from materials provided by Aalco - Ferrous and Non-Ferrous Metals Stockist.

For more information on this source, please visit Aalco - Ferrous and Non-Ferrous Metals Stockist.

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The Company

Aalco is the UK's largest independent multi-metals stockholder, with an extensive inventory spanning aluminium, stainless steel, copper, brass, bronze and nickel alloys in all semi-finished forms.

Aalco provides customers with a cost-effective single source for all their metals requirements, together with a comprehensive processing service offering all stock in standard sizes or cut to customer’s instructions as well as finishing and coating.

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With seventeen service centres nationwide, plus ongoing investments in technology and logistics, Aalco delivers on-time to every corner of the UK. Every Aalco service centre holds stocks to meet the immediate needs of customers in their local area, backed up by bulk stocks held at a central warehouse.

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Standard Stock & "Specials"

In providing customers with a cost-effective single source for all their metals requirements, over 50% of Aalco sales comprise non-standard products.

Thus, as well as the 10,000 item standard stock range, Aalco also holds a significant range of non-standard products as well as special items for particular industries and

individual customers. In fact, around 40% of the stock at individual service centres falls into this category.

This combines with a comprehensive processing service offering items cut to customer's instructions as well as finishing and coating. In addition, Aalco regularly arranges sub-contract processing using a range of approved suppliers.

People

Exceptional customer service starts with people. Flexible people, whom customers can trust and reply upon to provide quality advice and informed product knowledge in a friendly manner.

Aalco attracts, develops and retains high quality people. Continuous development of their skills includes an in-house product training programme giving them a complete understanding of the full range. This enables customers to benefit from assistance in materials selection and choice of the most cost effective processing options.

In addition, Aalco regularly arranges other services for customers on a sub-contract basis.

Quality

Aalco takes great care when selecting manufacturing sources for its products. Every mill is subjected to careful scrutiny and must meet a schedule of quality control requirements. All products supplied by Aalco conform to the relevant BS or international standard and a certificate of conformity or analysis can be supplied on request.

Aalco service centres operate a quality manual designed to ISO9000/2000 requirements. Many vendor approvals and bespoke quality control systems are operated through individual Aalco service centres, including aerospace release materials from Southampton and Hull.

Primary Activity

Material Manufacturer

Services

Processing Services

Processed metals save time and money and so many customers have a need for cutting services. Understanding this, Aalco is committed to providing an effective response and thus made major investments in a wide range of advanced processing equipment at both local service centres and central facilities.

Most service centres have on-site bar sawing, protective PVC coating of sheet and a guillotine. Central facilities include plate saws, polishing of sheet and coil, and plasma profiling, as well as coil processing, spanning, decoiling, levelling, slitting and blanking.

Service

The most comprehensive stock range; the highest investment in processing equipment; local service centres nationwide; helpful, friendly, knowledgeable staff and the industry's biggest fleet of delivery vehicles - it all adds up to unbeatable service.

Aalco has maintained market leadership over many years through an absolute dedication to flexible, responsive customer service - a service level that is continuously monitored and improved through key performance indicators.

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Aalco has a selection of product literature including a 72 page brochure and a handy stocklist. These are all available for Download as pdf files on the Aalco web site. Hard copies can be obtained by contacting the local branch.