Residual (Tramp) Elements in Steel

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Residual elements (Cu, Ni, As, Pb, Sn, Sb, Mo, Cr, etc.) are defined as elements which are not added on purpose to steel and which cannot be removed by simple metallurgical processes. The presence of residual elements in steel can have strong effects on mechanical properties. There is therefore clearly the need to identify and to quantify the effects of residual elements in order to keep these effects within acceptable limits.

Residual elements, or at least some of them, have an influence on processing conditions and regimes, from casting to the final annealing, and possibly on all mechanical properties.

A clear distinction has to be made between those residual elements which have an effect due to their presence in solid solution, such as Mo, Cr, Ni, and Cu, and those which have an effect due to their segregation at interfaces (surface and grain boundaries), such as Sn, As, and Sb.

Hydrogen. Hydrogen gas is also a residual element in steel and can be very harmful. Hydrogen is soluble in liquid steel and somewhat soluble in austenite. It is very insoluble in ferrite and is rejected as atomic hydrogen(H+).If trapped inside steel usually in products such as thick plate, heavy forgings, a rail road, hydrogen will accumulate on the surfaces of manganese sulfite inclusions. When this accumulation takes place molecular hydrogen (H2) can form and develop sufficient pressure to create internal cracks which lead to scrap of products.

The following non exhaustive list gives some possible metallurgical effects of residual elements on processing conditions and properties of steel products.

Residuals may influence:

1. The processing conditions in terms of :

· Recrystallisation and rolling forces in the hot strip mill: Mo, Cr, Sn

· Austenite to ferrite transformation, hardenability: All

· Hot ductility during hot deformation: Zn, Sn,

· Recrystallisation during annealing: Mo, Cr, Sn

2. The surface aspect of the hot rolled and pickled strip: Cu, Ni, As, Sn

· Due to hot shortness

· Due to possible synergy of Cu an Sn in hot shortness

3. The embrittlement of grain boundaries: Sb, Sn, As

· During strip coiling

· During batch or continuous annealing of low C steels

4. The precipitate/matrix interface segregation phenomena: Sn

· Ostwald ripening, precipitate growth, texture control

· Sn on Fe4N, Sn on MnS, Sb on TiC

5. The mechanical properties of the final products: All

· Hot strips and cold rolled sheets

· Plates

· Long products

6. The coating by hot dip or electrodeposition

7. The weldability of HSS grades : Mo, Cr, Cu, Ni

Residual elements enter steel from impurities in ore, coke, flux and scrap; from these, scrap is considered to be the main source of residuals. The most commonly found residuals are Cu, Ni, Cr, Mo, and Sn. The acceptance limits of these residuals depend mainly on product requirements.

A major problem of the recycling process is to control the level of undesirable elements or residuals elements in order to ensure the steel cleanness required by the product performance. The most of steels used today are low carbon/low alloy and extra deep drawing grades of steel. The properties of these steels are very sensitive to the residual elements content and to the thermomechanical processing.

As far as flat products and reinforcing bars are concerned, Table 1 shows typical values of main residual elements for the EAF route, in wt%.

Although the effect of residuals on properties may be quite small, sometimes even a small change in some property can significantly increase the rejection rate of products with specified requirements. The general consensus about effects of residuals such as Cu, Ni, Cr, Mo, Sn and Sb on various steel properties is given in Table 2.

Table 1: Mean Residual Element Levels in EAF Produced Steels

	Cu	Ni	Cr	Mo	Sn
Flat products	0.050-0.2000	0.050-0.2000	0.025-0.1000	0.010-0.0300	0.010-0.0300
Reinforcing bar	max 0.48	max 0.08	max 0.24	max 0.06	max 0.08

(+) Indicates an increase

(-) Indicates a decrease

The strengthening mechanisms in steel include: solid solution strengthening, fine grain size, precipitation, amount of

Table 2: Effects of increase of residual elements content on various steel properties

Property	Cu	Ni	Cr	Mo	Sn	Sb
Strength and hardness	+	+	+,–	+	+	+
Ductility	–	+,–	+,–	–	–	
Strain hardening, n	–	–	0,–	–	–	
Strain ratio, r	+,–	0	0,–		0	
Impact resistance	+	+	0	–	0,–	
Hardenability	+	+	+		+,0	+,0
Weldability	–	–	–	–		
Corrosion resistance	+	+	+		+	
Temper embrittlement					+	+

pearlite, dislocations introduced by cold work, and bainitic and martensitic transformations.

The residuals affect the tensile properties through solid solution strengthening. At the low concentrations that the these residuals are present, the yield and tensile strength increment due to solid solution may taken as proportional to solute concentration. Some estimates of strength increments contributed by various residuals are given in Table 3.

References:

1. Residual and Unspecified Elements in Steel by Melilli AS,ASTM, 1989

2. The Steel Handbook by Alok Nayar, McGraw-Hill,1st edition,Dec. 2001.

3. Handbook of Materials Selection by By Myer Kutz, John Wiley and Sons,2002

4. Impurities in Engineering Materials: Impact by C. L. Briant,CRC Press,1999

Table 3: Effect of residuals on yield and tensile strength; strength increment per wt%

Base Material and Heat Treatment	Yield strength, MPa/ksi					Tensile strength, MPa/ksi				
	Cu	Ni	Cr	Mo	Sn	Cu	Ni	Cr	Mo	Sn
Low Carbon Steel normalized or annealed	41/6	0/0	-27/4	13/2	124/18	13/2	13/2	-34/5	-55/-8	
Low Carbon Steel normalized	76/11	41/6	55/8			55/8	34/5	69/10		
0.3 Carbon Steels normalized	82/12	55/8	62/9	13/2		62/9	34/34	89/89	69/10	
0.2 Carbon Steel as-rolled		55/8	89/13				69/10	131/19		

Report

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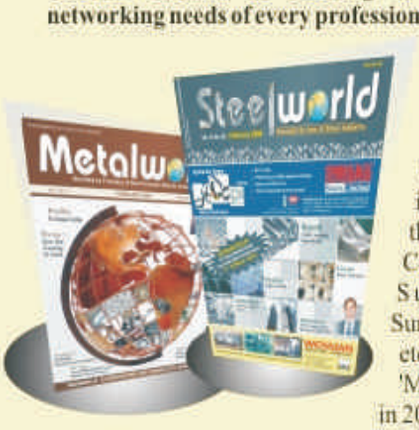

'Steelworld', a monthly magazine was launched in 1994 and started working on similar lines to serve iron & steel industry. After this came the events like 'Asian Steel Conference', 'Iron & Steel Summit', 'Extrusion Summit', 'Asian Metallurgy' etc. The second magazine 'Metalworld' was launched in 2001 to cater to non-ferrous metals and foundry industry. Meanwhile, the websites www.steelworld.com and www.metalworld.co.in were successfully designed and launched to reach out to global community and cater the information needs of the industry on a global level.

D.A.Chandekar, a Metallurgical Engineer from REC, Jamshedpur and having experience of working with few steel companies thought of entering into Print Media specially for Metal and Steel Sector in early 90's. Sustained efforts from him and his team supported well by the industry, Indian and overseas, have seen the company grow in terms of more industry penetration through publications, websites and trade events.

Today, the company has its HO in Mumbai and regional offices in Kolkata, Raipur and Chennai. Apart from Indian operations, internationally the group has its own companies and offices in Dubai and Bangkok and representatives in China, Germany and North America. While Indian events are being attended by global metal business community, the company has started organizing events outside India as well. Now, 'Steelworld' and 'Metalworld' are seen as the leading industry publications in Asian steel & metals sector. Also, CBMPL is recognized as the pioneering business media company in Asian industry and globally. With fast moving steel & metal business, CBMPL is expected to perform still better in coming years. "To grow further, we have to adopt internationally accepted working systems which are customer friendly and would create more confidence in the minds of the customer. Says Chandekar, CMD-CBMPL. "We selected BSI as they are one of the oldest and the most recognized certifying body all over the world. Also our consultants QRAS (Mr.Nimkar) helped us a lot in preparing for this certification." Management Representative Ms.Anita Chandekar motivated the team and led this journey very well. "We feel fortunate to get fullest co-operation from all the colleagues in the organization without which this certification would not have been possible." says Ms.Anita.