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Suggestions for Ductile Iron Production

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NEW HIGH PERFORMANCE STEELS: A RISKY CHARGE MATERIAL FOR DUCTILE IRON FOUNDRIES

by
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During the last thirty years, a number of "drivers" have prompted the development of new grades of steel in order to maintain its position as a design material in the automotive industry. These "drivers" were fuel consumption and environmental requirements, safety requisite and corrosion resistance. In order to meet the targets, novel steel grades were developed to exhibit higher strength, improved impact resistance and better formability, while the use of corrosion resistant coatings, mainly zinc based, was generalized. Figure 1 illustrates the increasing utilization of coated steels in the auto industry since 1980, while Figure 2 pictures the change in steel composition in a North American vehicle up to 2010. It clearly demonstrates that the steel used in the automotive industry, which is a major source of steel scrap for foundries, is moving from unalloyed low carbon steel to steels containing significant concentrations of alloying elements. Table 1 compares the composition of some of these "new" steels to that of traditional low carbon steel. This change in steel composition begins to have a growing impact on Ductile Iron foundries, since automotive steel scrap remains a major constituent of a typical Ductile Iron furnace charge.

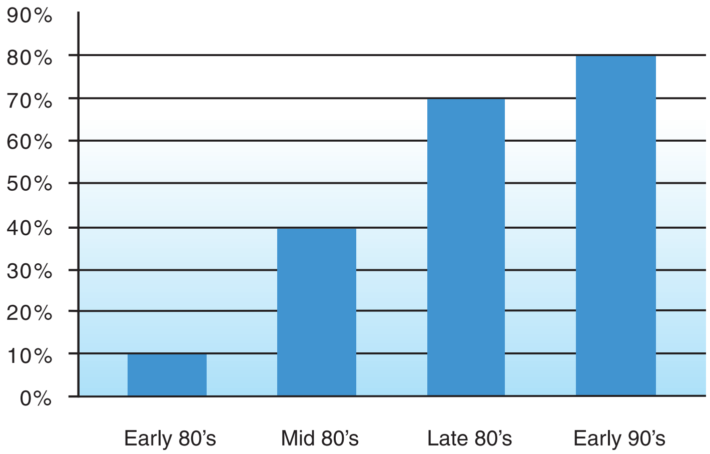

Figure 1. Coated Steel Usage in North American Auto Industry.

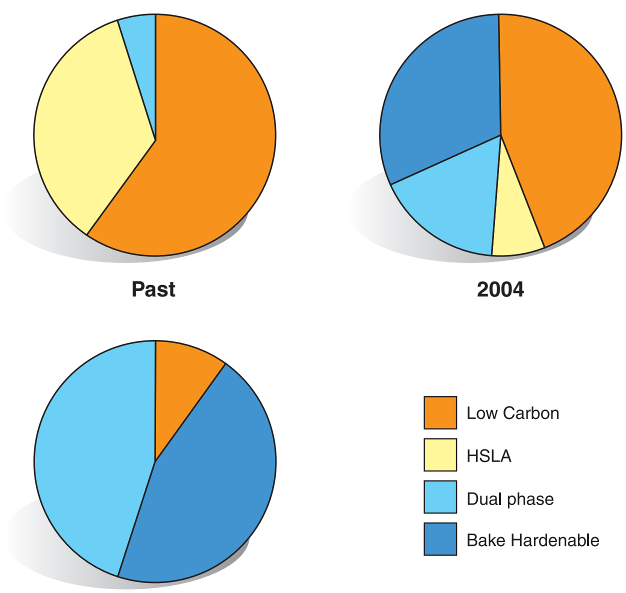

Figure 2. Trends in Major Steel Grades Used in North American Auto Industry.

TABLE 1

CHEMICAL COMPOSITION OF ALLOYED STEEL GRADES

Element wt %	Low C Steel	IF* Steel	Re-P IF*	Bake-Hardenable	HSLA	Dual-Phase	TRIP	Martensitic	Heat-Treatable
C	0.03 – 0.06	0.001 – 0.005	0.002 – 0.005	0.002 – 0.003	0.05 – 0.10	0.08 – 0.015	0.15 – 0.25	0.10 – 0.25	0.20 – 0.26
Mn	0.20 – 0.30	0.10 – 0.20	0.10 – 0.50	0.10 – 0.30	0.3 – 1.0	1.50 – 2.20	1.5	0.20 – 0.60	1.00 – 1.35
Ti		0.03 – 0.05	0.01 – 0.02	0 – 0.02				0.03 – 0.05	
Nb		0 – 0.04	0.02 – 0.04	0.01 – 0.02					
P			0.02 – 0.08	0.02 – 0.08					
V				0.005 – 0.08					
Mo						0.15 – 0.35			
Cr						0.15 – 0.50			
B						0.0010 – 0.0015		0.001 – 0.002	0.0005 – 0.0030
Al							1.0 – 1.5		
Si							0.20 – 0.50		

* IF: Intersticial Free Steel

One of these effects is the presence of coatings on steel. Zinc or zinc/aluminium coatings evaporate/oxidize during melting; most of the resulting oxide is captured in the furnace slag, but a significant portion dissipates as effluent, and becomes an environmental concern. Moreover, a detectable deterioration of graphite particle roundness has been related to the use of zinc coated steel in the charge by some foundries.

More importantly, many of the elements used to improve specific characteristics of steel are poison for Ductile Iron. Table 2 lists such elements with their upper acceptable limit in Ductile Iron castings. It is seen that many of these deleterious elements are those found in the new generation of steels, increasing significantly the risk of contamination of the Ductile Iron charge. As seen in Table 2, many of the alloying elements listed in Table 1 are carbide promoters (Mn, V, Nb, Mo, Cr, Ti) and their presence, even at low concentration, may dramatically reduce the mechanical properties and the machinability of the Ductile Iron castings. Other elements may have other detrimental effects. For example, lead would strongly affect graphite particles shape while boron softens the parts by limiting pearlite formation. The reader is referred to *"The Sorelmetal Book of Ductile Iron"* for a more detailed review on the effect of residual elements in Ductile Iron.

Steel scrap dealers and processors source their scrap from multiple generating facilities. Each facility may process and generate several different grades of steel scrap. It is difficult and risky for a foundry to rely on an average composition that may be documented by the scrap supplier. Therefore, foundries must exert a very close control of their steel scrap supply by developing a partnership philosophy with the suppliers. However, whatever the measures taken it cannot fully guarantee the chemical consistency of the steel scrap delivered. Therefore, it is advisable to include in the furnace charge high purity iron units that attenuate the inherent, and growing, fluctuation of steel scrap composition. **Sorelmetal**, unlike other pig irons, offers the purity and consistency levels required to play such a role, and has been the prime choice of Ductile Iron foundries for more than 50 years! Ductile Iron foundries can count on the security of supply of **Sorelmetal** to face the challenge of the deteriorating steel scrap quality for the coming years.

For more information, ask your **Sorelmetal** Technical Services metallurgist, or your **Sorelmetal** agent or contact us via our website **www.sorelmetal.com**.

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TABLE 2

SUMMARY OF THE EFFECTS OF RESIDUAL ELEMENTS ON DUCTILE IRON PROPERTIES AND MICROSTRUCTURE

	Pearlite Promoters		Carbide Promoters		Degenerated Graphite Promoters	Effects
	Ferritic Iron	Pearlitic Iron	Ferritic Iron	Pearlitic Iron		
Aluminium					0.03	Vermicular graphite former, aggravates hydrogen pinholes, flake formation can be controlled by Ce addition.
Antimony	0.003	0.02			0.003	Accumulates at surface of spheroids. Reacts with Mg thus reduces Mg efficiency; effect can be controlled by Ce addition. Suppresses the formation of ferrite shell. Controls chunk in heavy section casting.
Arsenic	0.01	0.05			0.01	Flake formation can be controlled by Ce addition.
Bismuth					0.002	Mesh graphite former, effect can be controlled by Ce addition.
Boron		0.0006	0.002	0.002		Borocarbides resistant to anneal; segregates to intercellular regions. Interact with pearlite promoting effect of copper.
Cadmium					0.002	Intercellular flakes former.
Chromium			0.05	0.05		Pearlite promoter in intercellular regions. Retards anneal. Reduces range between stable and metastable eutectic temperatures.
Copper	0.03	1.0				Strong pearlite promoter that must be well controlled for as-cast ferritic irons. Promotes intercellular flake graphite.
Lead					0.002	Deteriorates graphite (Widmanstätten graphite, sooty or spiky graphite when H+Pb), effect can be controlled by Ce addition.
Manganese	0.15	0.35	0.15	0.35		Segregates to cell boundaries to form intercellular carbides at concentration > 0.4%. May promote eutectic carbides.
Phosphorus	0.025	0.030	0.025	0.030		Strongly segregates to cell boundaries to form steadite. Even in absence of steadite, embrittles ferritic irons. Stabilizes pearlite.
Tellurium			0.002	0.003		Minimizes pinholes; reacts with Mg; white iron former. Deteriorates graphite shape.
Tin	0.01	0.08			0.08	Accumulates at surface of spheroids and suppresses the formation of ferrite shells. Retards C diffusion. Lowers eutectic temperatures.
Titanium	0.035	0.06			0.07	Compacted and vermicular graphite former. Small quantity (<0.001%) reduces the susceptibility to spiking (nodule alignment). Reduces range between stable and metastable eutectic temperatures. Promotes hydrogen pinholes when Al is present.
Vanadium			0.03	0.04		Carbides resist to annealing. Reduces range between stable and metastable eutectic temperatures.
Zirconium					0.1	Vermicular graphite former.