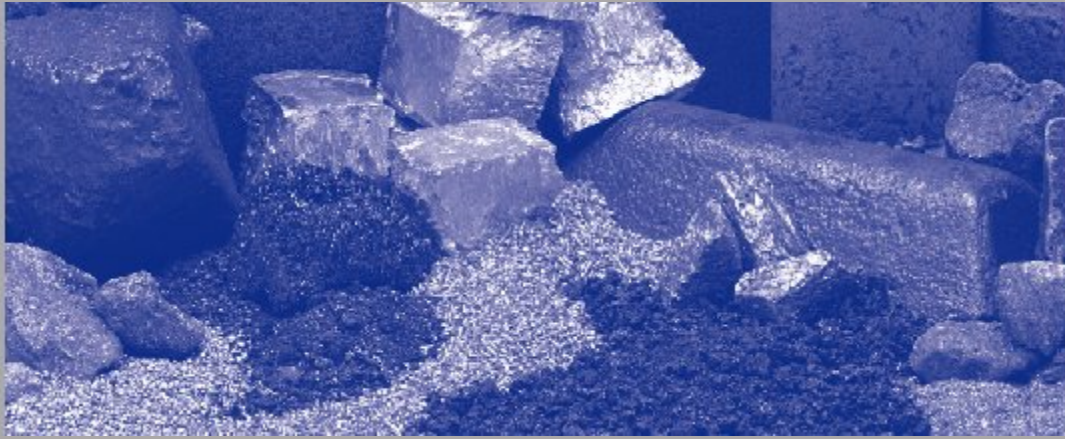


TECHTALK



MILLER
AND COMPANY

LEADERSHIP IN FOUNDRY AND STEEL RAW MATERIALS



VOLUME 30: CHALLENGES LOOM DUE TO IMPROVING STEEL TECHNOLOGY

Miller and Company LLC
9700 West Higgins Road
Suite 1000
Rosemont, Illinois 60018
Phone: 847.696.2400
www.millerandco.com

CHALLENGES LOOM DUE TO IMPROVING STEEL TECHNOLOGY

Introduction

Any number of times you probably have heard an iron founder mutter something along the lines of “the quality of the steel scrap is terrible...” Is the scrap rusty, filled with dirt, or cut to the wrong size? Maybe. Or, is it that alloying elements in the steel are causing difficulties in the use of that scrap in controlling the composition of the iron castings? In truth, from the perspective of composition, the quality of steel is absolutely superb for making engineered components from steel. The steel industry worldwide is meeting the technical challenges established by their ever more demanding customers – the automotive industry, appliances, heavy construction, and packaging – to provide high strength, formable, weldable, energy absorbing products that have ever better mechanical and chemical properties in thinner and thinner sections. The steel produced has never been “better” and is getting “better” all the time.

As the old saying goes; “One man’s trash is another man’s treasure.” This is so true of the steel scrap being generated today and steel that will be recycled in the years to come. The improvements in steel, the effective use of a host of elements from aluminum to zirconium, present challenges for the iron founder. These challenges will be more difficult in the future. Foundries must understand, measure, and control the effects of the alloying elements in the steel scrap melted.

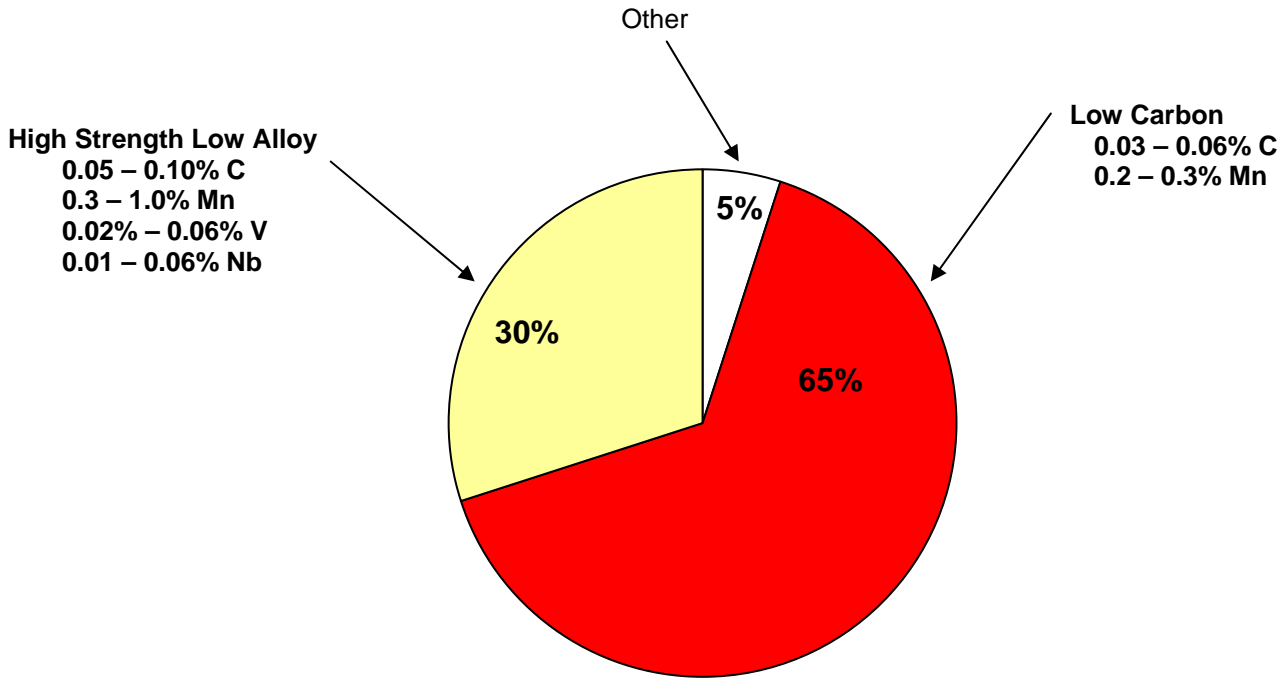
In the ferrous foundry industry, our customers are also requiring that their components meet rigorous performance and environmental standards. An example is the requirement for high impact properties in ductile iron at low temperatures for the burgeoning wind energy market. These requirements are part of the European Standard EN-GJS-400-18U-LT commonly referred to as GGG40.3. This standard not only has the normal mechanical requirements for ferritic iron but specifies V notched Charpy impact requirements at – 20C (-4 F). To meet low temperature impact properties the foundry must produce ferritic ductile iron components that need be free of cell boundary phases such as phosphides and carbides. Otherwise the impact properties won’t pass. Other metallurgical characteristics such as high nodule counts from effective, late inoculation are key to minimizing detrimental cell boundary phases, but melt composition is a primary consideration. And, in that melt is scrap steel that has possible alloying elements such as P, V, Ti, Cr, Mo, B, Mn, and Cr which can result in carbide or phosphide phases which segregate to cell boundaries. This is now a problem to be solved and will be a greater challenge in the future as alloying elements in the steels increase. Effects will not only be a problem in these “high end” applications, but will impact all foundries in the years to come.

What will the future bring?

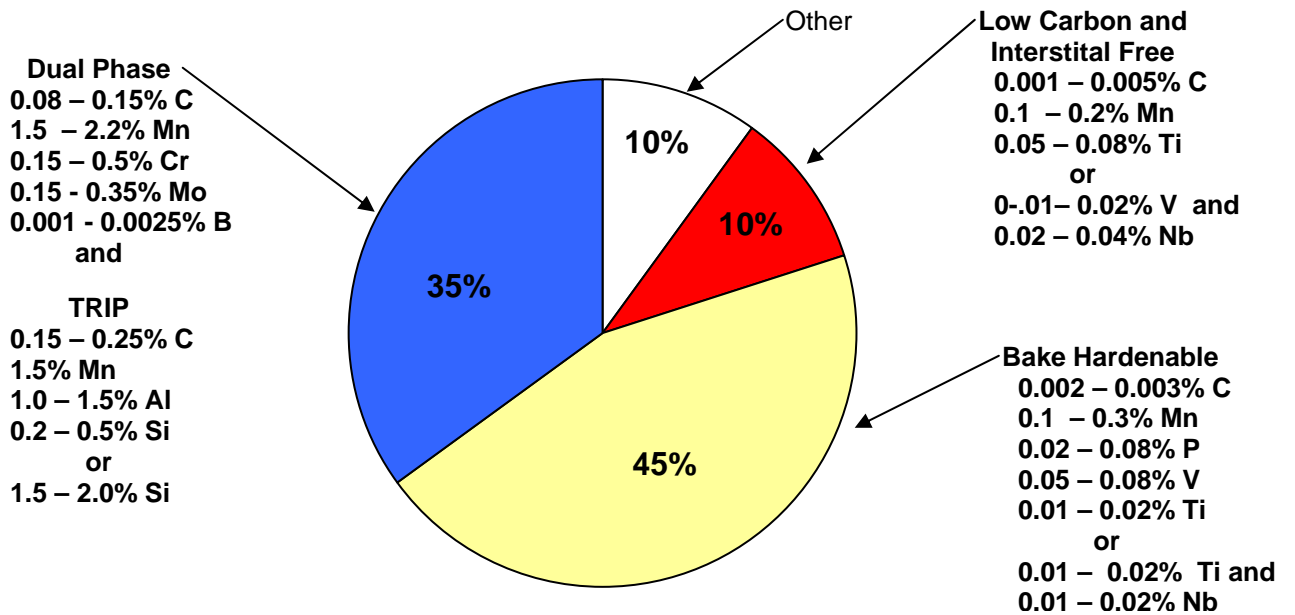
To get a glimpse of what may be coming down the road, consider what the steel industry is doing in response to demands from the automotive industry. At the AFS Wisconsin Regional meeting in February 2005, Dr. Roger Pradhan, of ISG (now Mittal) gave a most enlightening presentation about the composition of various grades of steel developed or being developed for the automobile industry. His presentation included the types of steels in a car today, specifically a GM car, and what those steels might be in 2010.

These new steels have names such as “interstitial free,” “bake hardenable,” “dual phase,” or “transformation induced plasticity” or TRIP steels. Their compositions, heat treatments, and resultant properties have been developed for cars that need to be lightweight, yet have doors and fenders that resist denting and offer energy absorption for crash safety. These steels may need to be readily formed, resist corrosion, and be effectively coated or painted. The charts below exhibit the compositions and the existing or projected percentages of use of steel in GM automobiles.

Present GM Auto



Projected 2010 GM Auto



Steel Scrap in the Raw Material Stream

In the U.S. about 70 million tons of steel scraps are processed each year. Ferrous foundries consume a relatively small percentage, about 10%, of that amount. The majority of steel scrap is consumed as feedstock in the steel industry. The automotive industry contributes about 15 million tons of that 70 million tons, so there will be changes in the make-up of the stream of scrap as these automotive steels are processed and then years later when the worn out car is recycled. And, essentially all cars are recycled. Even if you do not use the scrap generated in car production, in time you will very well use recycled steel from the automotive industry.

Therefore, as time goes on, iron foundries will need to be aware that the steel scrap being used as a charge material will contain concentrations of elements that may not have been present in sufficient amounts in the past to be of concern, but will have future impact. Today, it is entirely possible that some of these elements are not even being measured in spectrometer analyses in iron foundries; or, if measured, are essentially ignored. Elements such as boron, niobium, and vanadium come to mind. And those elements that are routinely measured such as copper, chromium, manganese, and phosphorus may, depending upon the grade of steel, be present at higher levels in the future. For instance, note the manganese levels in dual phase steels or phosphorus in the bake hardenable steels. Control of Mn and P in ductile iron is of fundamental importance. See Figures 1 and 2.



Figure 1. A 1000X photomicrograph depicting cell boundary carbides in ductile iron. (Reference is Ductile Iron Handbook, American Foundrymen's Society, 1992. p 228) Such a phase results from carbide stabilizing elements such as Mn, Cr, V, Mo, Nb and Ti segregating to the cell boundary during solidification.

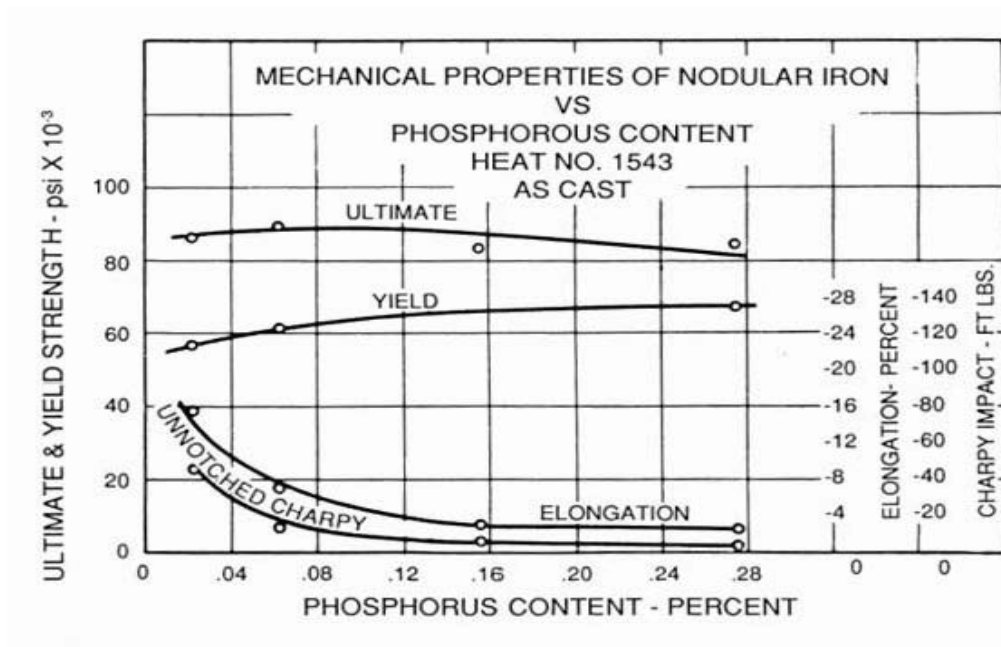


Figure 2. Graph depicting the effect of phosphorus on the mechanical properties of ductile iron. Particularly, note the sharp decrease in elongation and unnotched Charpy as the phosphorus increases. Phosphorus will segregate to the cell boundary during solidification to form a brittle phosphide phase. (Reference is Ductile Iron Handbook, American Foundrymen's Society, 1992, p.81).

Certainly, in flake graphite irons, the nature of the material – the fact that flake irons are inherently brittle and some degree of cell boundary phosphide or carbide phases might be tolerated – may not be so much affected as ductile irons. But in ductile iron, potent carbide stabilizers such as V, Nb, Mo, Cr, and Mn tend to segregate to cell boundaries and decrease elongation and reduce impact. The effects of those elements are additive. And phosphorus, which will form a hard, brittle phosphide phase at the cell boundary, will destroy elongation and impact properties in ductile iron. In addition, these cell boundary phases and micro carbides will negatively affect the machinability of the cast iron component.

Knowledge is Power

The important thing to do is to not accept on faith that the steel scrap is always going to be the same, and nothing will cause your foundry a problem. As the alloying elements in the scrap steel become more diverse and prevalent, it is imperative that a foundry effectively sample and analyze incoming materials.

Closer collaboration with the scrap dealer and with your dealer's sources will be ever more important.

It is necessary the foundry be cognizant of changes in the composition of steel scrap. The ductile shops have had some oftentimes painful and costly experiences with low levels of boron introduced from the steel scrap over the past several years (see TechTalk Volume 27). There are cases of low levels of vanadium in scrap causing problems with production of ferritic ductile iron because vanadium is such a potent strengthener. Foundries will need to measure elements that they may not be monitoring today and pay heed to incremental changes in concentrations of those elements. Technicians must have the knowledge and the ability to make necessary changes in charge make-up and in sourcing scrap purchases. The most inexpensive scrap may not be the most reliable in terms of chemical consistency.

The Solution to Pollution is Dilution

Some elements in the steel can be taken care of by treating the molten iron with other elemental additions. Neutralizing low levels (up to about 0.03% total) of Ti, Al, Sb, Pb, Bi, and Sn by adding a small quantity (0.01 to 0.02%) of rare earth elements (Ce, La, Nd, Pr) to ductile iron during treatment is a long established practice. Unfortunately, there is no magic pill to neutralize elements in advanced steels such as manganese, vanadium, niobium, chromium, molybdenum, phosphorus, or boron.

The solution to the problem is to modify the charge to reduce the levels of these elements. The use of Sorelmetal, a high purity iron; which contains low and consistent levels of elements such as Mn, P, V, Nb, Ti, Mo, and B; can be used in the charge to dilute, to lessen, the levels of these trace elements in the melt. That is why for applications such as high impact strength ductile iron, the use of Sorelmetal is absolutely essential. "The solution to pollution is dilution," is a statement I have heard Gene Muratore of Rio Tinto Iron and Titanium tell founders on several occasions. Operators must have the capability to adjust feedstocks in order to properly control melt composition. "You can't fool Mother Nature." The table below gives some typical trace elements in the grade RTF10 Sorelmetal.

| Manganese | Phosphorus | Chromium | Copper | Vanadium | Niobium | Boron | Molybdenum |
|-----------|------------|----------|----------|----------|---------|----------|------------|
| <0.035% | <0.035% | <0.030% | 21.5 ppm | <0.020% | <15 ppm | <0.5 ppm | 25 ppm |



Use of the proper grade of Sorelmetal, and all grades are not the same, at varying percentages in the charge, can help the operator dilute the concentrations of troublesome trace elements in the melt to acceptable levels.

An added challenge is the use of coated steels – galvanized and other coatings – in automotive steels. Pradhan reported that even now, 80% of automotive steel is coated, Galvanizing – a zinc coating – on the steel presents problems with fume control in cupolas and with both fume control and interaction with refractories in electric furnaces. Segregation of galvanized scrap or technologies to control its effects are needed.

Can't Stop Progress

The wheels of technology continue to take us along the path to the future. The users of steel require the steelmaker to be more and more innovative. The changes in steel composition will demand the iron foundry be aware of what compositional changes are coming and able to cope with them. Walking along the same path as in the past will not get the foundry to the proper destination in the years ahead. Users and processors of castings set the bar ever higher with respect to properties and machinability. To be successful, a foundry must comply. We are indeed blessed to live in interesting times.

H. Fred Linebarger
Director of Technology
Miller and Company LLC
9700 West Higgins Road
Suite 1000
Rosemont Illinois 60018

© Miller and Company LLC, 2003. All rights reserved. No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopy, recording or by any information storage and retrieval system without permission from Miller and Company LLC.

3/23/07