Benchmarking Iron Control

by
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Experts agree that reducing variation in key processes leads to improved quality.

There is little doubt that controlling tensile strength is a key process in gray iron foundries. Most gray iron castings are sold on the basis of tensile strength. While the specifications usually only indicate a minimum requirement, the machinability of the iron diminishes when the strength becomes too high. The goal is usually to keep the strength as low as possible but to make sure that <u>all</u> tests meet the specification. If improved control reduces the variation in the process, the targeted strength can be reduced. Not only does that make the castings more machinable, it may reduce the cost of the iron.

In the real world of limited resources, there is a practical consideration; time and money spent on trying to improve the control of any process beyond a certain point could be better spent improving the control of some other process. The Quality Control Committee of the Cast Iron Division has gathered information to help foundries decide the value of improving the control of their iron.

The committee surveyed the industry to determine the current state of iron control. A survey form was developed and sent to all iron foundries in the AFS database (see Appendix I). The survey requested reports on the variation, as measured by standard deviation, on the results from a minimum of 25 consecutive tensile tests. In order to reduce confusion in interpreting the information, foundries only reported on iron produced to conform to class 30 requirements. Responses were received from 40 foundries.
The results of the survey indicate that the average standard deviation of tensile tests is 2378.6 psi. The lowest standard deviation reported was 1120 and the highest 3845. In order to give a better perspective of the significance of the information, we can look at the necessary target strength in these foundries. Assuming the foundry would want to maintain its target 3 standard deviations above the minimum specified, the foundry with the lowest standard deviation would have to target 33,360. The foundry with the high standard deviation would have to target 41,535 in order to achieve the same confidence that their tests would pass. It's easy to see that the foundry producing the low variation could produce a more machinable iron.

The survey also requested information that the committee felt might provide some clues as to the cause of variation in the iron. One such question was whether the testing was done by a commercial laboratory or in-house. Of the 40 responses, 16 indicated a commercial laboratory was used. The average standard deviation of the tensile strength for those foundries was 2373 psi. The average for the others was 2383. While some of the committee felt that in-house testing would have revealed lower variability, the reported results did not support that theory.

Another comparison made was melting method. As can be seen in Figure 1., melting method did show significantly different results. Twelve operations reported melting with cupolas, and the average of their standard deviation was 2731 psi. Twenty-two operations melted electrically, and their average standard deviation was 2400 psi. While only 6 reported using a duplex melting system their average standard deviation was down to 1594 psi. These differences confirm accepted perceptions of the melting methods. The control of the iron from a cupola without duplexing is the most difficult of the three options. While electric melting is believed to be easier to control, the averaging that takes place due to the flywheel effect of duplexing reduces variation.

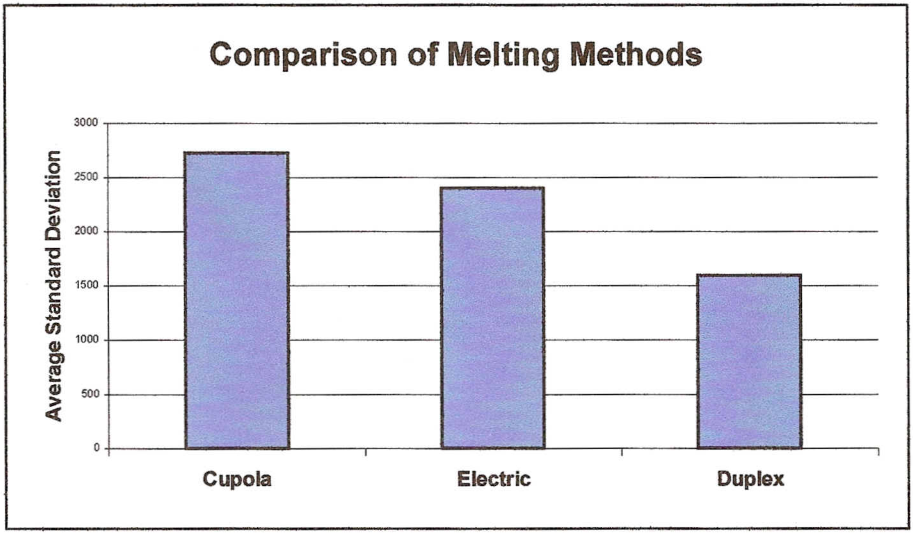

Figure 1 – Comparison of Melting Methods

While the survey requested the foundries report the average standard deviation of at least 25 tests, the actual number of tests in the average and the length of time taken to generate the samples were also reported. That information allowed the calculation of the number of tests per year for each operation. It was theorized that the larger number of tests per year would be indicative of larger operations, and those foundries might have been able refine their process control to a greater degree. That would be indicated by lower variability. Figure 2 is a scatter diagram showing the relationship between the number of samples per year and the variation. It appears the expected relationship does not exist.

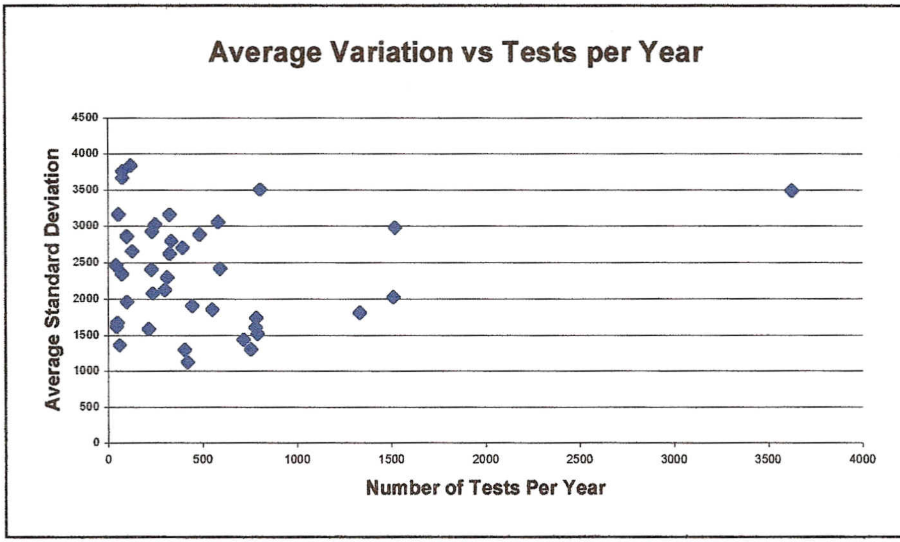

Figure 2 – Relationship to testing frequency

In hopes of determining the causes of variation, the survey also requested the foundries report the variability in their chemical analysis during the time period the tensile data was generated. An attempt to determine what was affecting the variability was made by performing linear regression analysis using the standard deviation of the tensile strength as the dependent and each of the reported items as the independent variable. It was very interesting to note that the two elements showing the greatest effect were sulfur and manganese. As can be seen in Figures 3 and 4, the variability of the tensile results increase with the increase in the variability of both sulfur and manganese.

What makes this of particular interest is that the Cast Iron Division is currently supporting research on the effect of Sulfur-Manganese ratio on tensile strength. It appears this data supports their contention that control of the ratio is important in controlling the strength. While the variation of Mn/S ratio was not reported, it is logical to assume that if the increased variability of either of the individual elements increased the variation of tensile strength, then increased variability in the Mn/S ratio would also affect tensile strength variation.

While this study provides a benchmark for evaluating how well a foundry is controlling its iron, it should be noted that these results might be better than the industry's real averages. By having the information, the reporting foundries indicate that they have some interest in this aspect of control. One is left to wonder about those foundries that did not report.

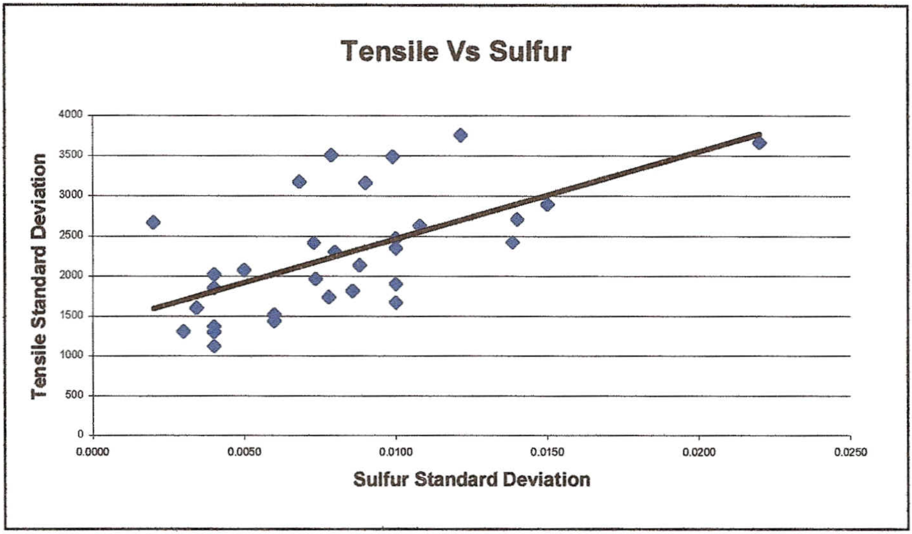

Figure 3 – Tensile vs Sulfur Variation

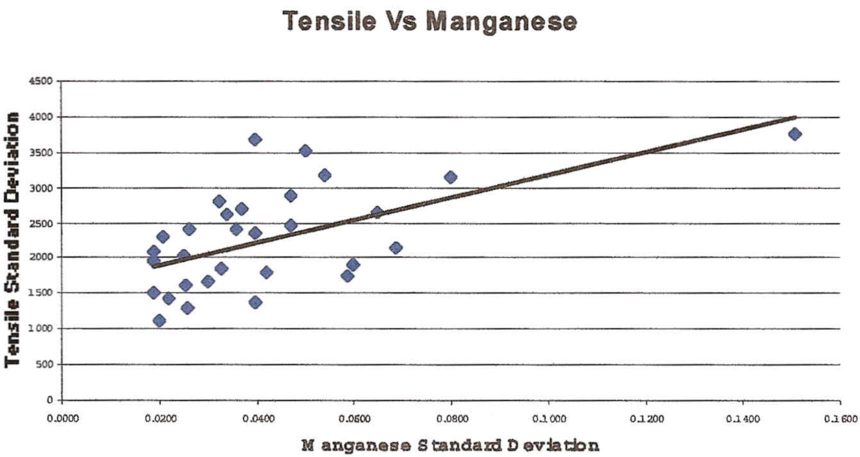

Figure 4 – Tensile vs Manganese Variation

COVER LETTER

Dear Foundryman:

The AFS Cast Iron Division's Quality Control Committee (5-J) is trying to quantify the control being exercised in today's iron foundry. In order to begin this endeavor it was decided to look at the control being exercised in producing the class 30 gray iron test bars. To help us in this matter, we are requesting that you fill out the enclosed form regarding the standard deviation of your test results for a number of consecutive tests and a little information about how the testing was accomplished.

We realize that no one will want to release information that might be sensitive to their operation; therefore, we are only asking questions regarding the degree of control being exercised. We don't expect you to run any special tests. We hope that all of the information will merely come from your records.

We would like the tensile tests you report to be consecutive (no fair picking out only the good ones) and a minimum of twenty-five test bar results. If you don't track the chemistry information directly with your test bar results, we ask that you make the report of that information covering your data for the same time period instead of just using the same number of tests.

While it isn't necessary, we would like you to include your name and telephone number so that a follow up can be made if there is any clarification of information that needs to be done.

It is our hope to turn this information into a Modern Casting article that will give you either bragging rights with your management about what a good job you're doing controlling your iron or ammunition to get what you need to improve control.

If you have any questions regarding this activity or the other activities of the Cast Iron Quality Committee, please feel free to call me at the number listed below.

Sincerely,

Roy Lobenhofer
847.806.1212
On behalf of the
Cast Iron Division's
Quality Control Committee

Appendix I: Survey and letter sent to foundries

AFS CAST IRON DIVISION'S QUALITY CONTROL COMMITTEE'S SURVEY OF IRON CONTROL

STANDARD DEVIATIONS OF CLASS 30 TENSILE TESTS

NUMBER OF TESTS REPRESENTED IN SAMPLE ________ TIME SPAN ________

STD. DEV. OF TENSILE TESTS _______

STD. DEV. OF BHN OF TEST BARS ______

RESULTS FROM ______ IN HOUSE TESTING _____ COMMERCIAL LAB

MELTING - CUPOLA ____ INDUCTION ____ DUPLEX ______

IN HOUSE THERMAL ANALYSIS RESULTS

STD. DEV. OF C _____

STD. DEV OF Si

OTHER CHEMICAL ANALYSIS

SOURCE _________________________

ELEMENT	STD. DEV.	ELEMENT	STD. DEV.

PLEASE LIST STANDARD DEVIATIONS OF ANY OTHER TESTS WHICH YOU DEEM SIGNIFICANT ON AN ADDITIONAL SHEET.

OPTIONAL:

CONTACT PERSON'S NAME ____________________

COMPANY NAME ______________________________

TELEPHONE NUMBER _______________________

PLEASE FAX RESULTS TO 847.806.1229