SFSA CASTEEL REPORTER

Steel Founders' Society of America

a monthly publication
serving SFSA steel casting industry Members

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February — 2006

Casteel Commentary Highlights:
The Casteel Commentary concerns the improvement of labor productivity. A BLS report gives benchmarks for foundries and other metalworking industries. We need to challenge ourselves to improve and remain competitive. This is going to become even more important as we try to operate in a tight labor market.

Building Construction Market Development

SFSA will attend and have a booth at American Institute of Steel Construction's (AISC's) annual conference – North American Steel Construction Conference (NASCC). This year's conference will be held in San Antonio, TX on February 8-10. Over 2,000 Engineers, fabricators, erectors, detailers, and architects attend the event. SFSA has exhibited and presented for several years and this has lead to many valuable relationships for development steel casting applications in building construction. Dr. Robert Fleischman from University of Arizona will discuss casting applications in seismic building construction. Having an exhibit at the conference enables SFSA to network with this new industry. Additional information can be found at www.aisc.org.

AFS Wisconsin Regional

SFSA has two presentations at the AFS Wisconsin Regional on February 9. Malcolm will be presenting a technical overview and Raymond will be discussing the long-term outlook for steel casting market demand. Registration and program information is available via email at waifs@earthlink.net.

SFSA - UMR Research Review

SFSA sponsored research on investment casting shell cracking and lost foam production will be reviewed on February 17, in Conway, SC. This meeting will be hosted by CONBRACO. Von Richards and the students from UMR will be presenting their latest work. This review is open to all members. Contact Malcolm Blair for details.

Carbon & Low Alloy Committee

The Committee is meeting on February 23 in Iowa City to review our research program. If you are interested in attending, please contact Malcolm Blair.

Spring Management Meeting

SFSA is organizing a Spring Management meeting for members in Chicago on March 9 at the Spring Hill Suites at O'Hare. The session will have registration at 9 a.m. and will run from 9:30 to noon. Our featured speaker will be Bernard Lashinsky, a steel economist well known in North Central Division for his insightful analysis of the steel-manufacturing marketplace. He will be followed by Raymond who will offer an update on the outlook for our industry for the balance of the year. This meeting is available at no charge to members. We have a special room rate at the hotel so you will want to mention SFSA. There is limited room availability. Mark your calendar and plan to attend. This will be an important meeting to attend.

Other Upcoming Events

Other upcoming events include the AFS Texas regional on March 24-25, the Kickoff or our DLA research projects on March 31 in Charleston, SC, the AFS Congress in Columbus April 18-21, the ISO Steel Casting meetings in Washington DC on April 24-25 and the AFS Government Affairs Conference in DC on April 26-28.

SFSA is organizing a spring meeting and plant tours in Muskegon for May 9 and 10. You will want to mark your calendar. The Marketing Committee and the Board of Directors will meet in conjunction with the meeting. A technical session will also be offered.

The AFS Northwest Regional is in Seattle on March 3 and 4. Raymond will be presenting a talk on troubleshooting the casting process and a second session on design of experiments.

China Tour and other International Meetings

China remains a mystery to many of us. SFSA is organizing a plant study tour of China for May 20-27. The cost in China will be $5500 including meals, transportation, and lodging. You will need also to obtain a visa and arrange your own air transportation. Our plan is to fly into either Beijing or Shanghai. Then we will travel to some of the better steel foundries operation in China. Final details are being worked out and will be distributed when they are finalized. Please let me know if you are interested in this opportunity.

Two other international opportunities are possible. The first is the biannual International Foundry Forum 2006. This is organized by the Europeans and is intended to give an overview of the global state of the foundry industry. Leading suppliers and foundries are able to attend by invitation only. This years meeting will be held September 28-29 at the Hotel Cascais Miragern. Lisbon Portugal. Details are available at www.international-foundry-forum.org. You may also wish to consider joining SFSA next year for a trip to GIFA. This is the largest trade show for foundry equipment. We will also organize plant tours for our delegation in Germany, the Czech Republic and Poland if possible. This will be in June 2007.

Max Powell

A good friend and foundryman passed away January 11, 2006, Max Powell. Max worked at Quality Electric Steel for 40 years. He was always supportive of SFSA and regularly was the leader organizing Southern Division Meetings. The family has requested that donations be made to the American Heart Association.

Innovation

One cost driver in chemically bonded molding systems is the sand to metal ratio. Our flasks and production line lead us to rectangular molds without regard to the casting configuration. Often the casting occupies the center of the cavity and the mold corners do nothing to make a casting but cost just as much as any other mold area. Some have used students or trainees to blind off corners or to install mold lighteners. This can be done on the least efficient or highest production molds. This reduces cost and improves reclamation by eliminating sand that is far away from the casting.

Specifications Note

Customer Question

I am seeking to benchmark how casting customers manage the process of salvaging/repairing castings after they discover a casting defect that is not acceptable to their acceptance criteria. I would like to restrict this question to customers who are purchasing castings to visual quality acceptance levels only (MS-SP55).

Questions:

* When defect(s) are discovered and salvaged by the customer, do the customers demand full compensation from your foundry for all costs involved with the repair?

Also...

* Since the customer purchases a visual quality casting, do your customers normally absorb the full cost to salvage the casting you provided?

* Do some customers acknowledge that visual quality castings may always contain a certain amount of defects?

* If so, are your customers willing to absorb a designated amount of the repair cost and only accept a charge back costs above a certain level?

* If so, what is typically the amount absorbed by your customer for a given casting?

Do you have a negotiated rate by casting or an average rate that your customer accepts?

* What are the typical costs/hour that you accept/ and or allow your customers to charge your for re-work to your castings?

Answer

Visual inspection is subjective and no standards are in use that are quantifiable. Attached is a paper by Iowa State University, 2005, evaluating the use of visual inspection and its reproducibility. Since there is no quantifiable standard and MSS-SP55 uses pictures to define acceptance, it is a poor standard. In reality, the customer and foundry discuss and define acceptable surface conditions using the standards as the basis for the discussion. The standard is ascetic and unrelated to performance.

When a casting is rejected at the customer, the supplier normally has the choice to replace or to reprocess the casting. He may arrange with the customer to have the reprocessing done at the customer's facility and pay for the use of those resources. In any case, a rejected casting belongs to the foundry and they are responsible to fill the order with an acceptable product.

If a casting feature like porosity or inclusions is found on further processing at the customer, like in machining, then it belongs to the customer. The foundry has met the purchase requirement for visual inspection and other NDE methods were not specified. It is a common commercial practice to replace the casting at no charge but it is not a requirement. In some cases and only by prior agreement, the foundry will take responsibility for any hidden condition and absorb the full cost. But this is only where the casting has been in production for a long time and the foundry is confident that they can meet the requirements. If clean machined surfaces are needed and the customer does not wish to take the risk of these hidden conditions, he can purchase the casting machined and hold the foundry or machine shop responsible for the quality of the machined surface. The foundry has no way of inspecting or processing short of machining to know what may be on the machined surface.

Defects according to ASTM E1316 are flaws that do not meet the specified acceptance criteria. Flaws are conditions detectable by NDE. Castings purchased to visual inspection do not have defects internally because no NDE is specified and no rejectable flaws are detected. There may be undesirable features like inclusions and porosity but defects are rejectable conditions that are detectable. All materials have features associated with the material and processing that may be undesirable and require reprocessing but they are defects only when they are rejectable detectable flaws.

Market News

Bookings for steel castings continued to increase at double-digit rates in November according to the SFSA tend cards. Shipments were up in most steel castings but down slightly in high alloy markets. This is probably just an anomaly of the out of sight bookings experienced last November that we are using as the baseline. Steel shipments are down, reflecting both the beginning of some slowdown in the consumer economy in response to higher energy costs and interest rates and the expansion of steel making capacity worldwide, especially in China. Two documents attached to this newsletter show the situation in China.

This stabilization of demand at the current higher levels should continue to provide opportunities. Steelmakers have seen some recovery in demand and are still able to pass through much of the rising cost of materials and energy as seen here. Orders for capital goods remain strong, the price of commodities remains high, and demand for capital equipment to try to increase production and improve profits remains unfilled.

For example, railroad freight car production was forecast to be 52,300 for 2005 but actual production was estimated at 66,000. The forecast for 2006 is still high at 62,000 indicating another good year for steel foundries serving that market.

We are planning to add to our monthly survey questions about backlog and lead-time. If you like seeing the trends in the industry we need your participation in our monthly trend survey!

International Edition

Sunrise subscriber Thursday, Jan 19, 2006

AK Steel announces February surcharges

19 Jan 2006, Thursday

AK Steel Corp. adjusted some surcharges for February, lowering one and boosting another.

Flat-rolled carbon steel has a $205 per ton surcharge for products shipped in February, down from the $215 surcharge added to products shipped in January.

The company increased its electrical steel surcharge to $280 per ton in February, up from the $255 surcharge tacked on in January.

The surcharges are based on reported prices for raw materials and energy used to manufacture the products, with the December 2005 purchase cost used to determine the February 2006 surcharges.

Middletown based AK Steel produces flat-rolled carbon, stainless and electrical steel products as well as carbon and stainless tubular steel products for the automotive, appliance, construction and manufacturing markets.

Casteel Commentary

Labor productivity improvement is critical to remaining competitive. Improvements in productivity allow higher wages, absorption of rising benefits costs, and improved profits. Measuring profitability remains an open question. The Bureau of Labor Statistics has a report on productivity improvements from 1987 through 2003. Some competitive metal working industries are shown in the table.

Productivity and Costs by Industry % change per year for 1987 to 2003

Type of Production	Output per hour %	Output %	Hours %	Compensation %	Unit labor costs %
Foundries	2.3	0.8	-1.5	1.7	0.9
Forging	2.8	1.5	-1.3	1.6	0.1
Machining	2.6	3.0	0.4	4.0	0.9
Fabrication	1.7	1.3	-0.4	2.6	1.3
Steel products from purchased steel	1.5	0.6	-0.9	1.6	0.9

Foundries taken as a whole reflect typical improvements. Each Member company can calculate their own performance against this standard. You can take change in output per hour worked of direct labor as a measure of productivity. This could be done on the traditional basis of hours worked and tons shipped. It could also be done based on number of castings shipped. If the improvement per year averages less than 2% you are falling behind in the race to compete. If you exceed 3% on average, you should remain competitive with the bulk of industry. This productivity can also be evaluated by operation. Is melting improving? Is the labor productivity in molding and coremaking improving? How much productivity improvement has been seen in finishing?

An alternate measure of labor productivity is annual sales per employee. That number should be over $100,000 and moving above $150,000 based on total sales and total headcount. This measure can be artificially improved by outsourcing labor-intensive operations and this is what the large OEMs do. The other output approach outlined above can also be fooled by maximizing the material flow and shipped tons of less difficult and less profitable work.

Raymond

STEEL FOUNDERS' SOCIETY OF AMERICA
MEETINGS CALENDAR

2006

February

17	Shell Cracking and Lost Foam Research Review, Conway, SC
23	Carbon & Low Alloy Research Committee Meeting, Iowa City, IA

March

9	Spring Management Meeting, Chicago, IL

May

9/10	Spring Meeting & Plant Tour, Muskego, MI
16	Specifications Committee Meeting, Toronto, Ontario
20/27	China Tour, TBD, China

September

9/12	SFSA Annual Meeting, Eldorado Hotel, Santa Fe, NM

December

13/16	National Technical & Operating Conference, The Drake Hotel, Chicago, IL

2007

December

12/15	National Technical & Operating Conference, The Drake Hotel, Chicago, IL

STEEL FOUNDERS' SOCIETY OF AMERICA
BUSINESS REPORT

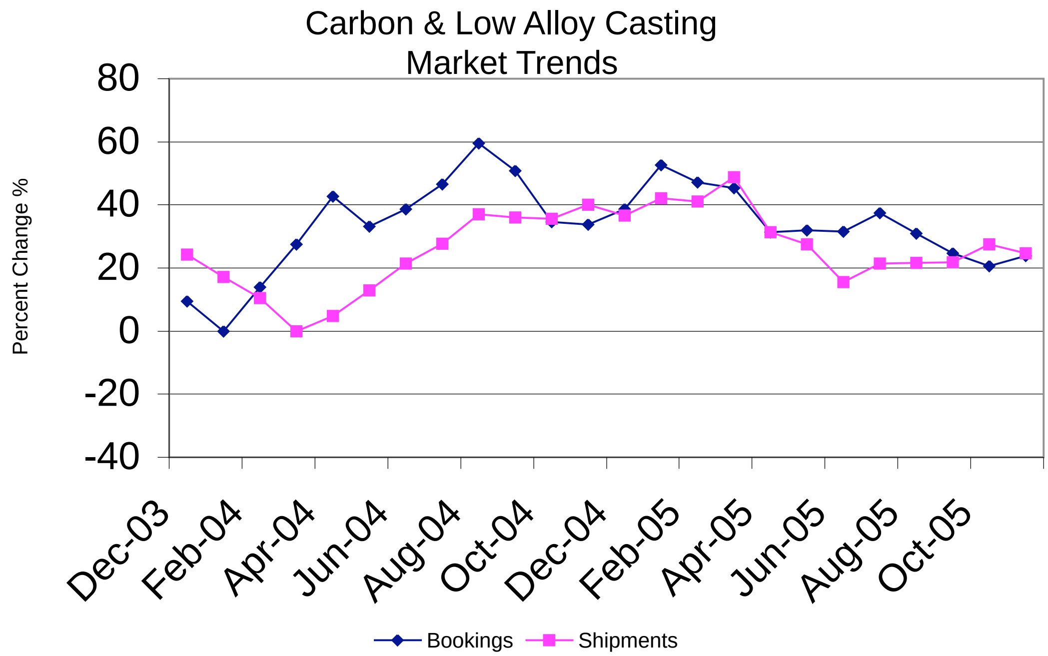
SFSA Trend Cards (%-12 mos. Ago)	3 Mo Avg	Nov	Oct
Carbon & Low Alloy			
Shipments	24.6	25.0	30.0
Bookings	23.8	31.0	19.0
High Alloy			
Shipments	-8.6	-20.0	-0.6
Bookings	19.2	-27.0	94.5

Department of Commerce
Census Data

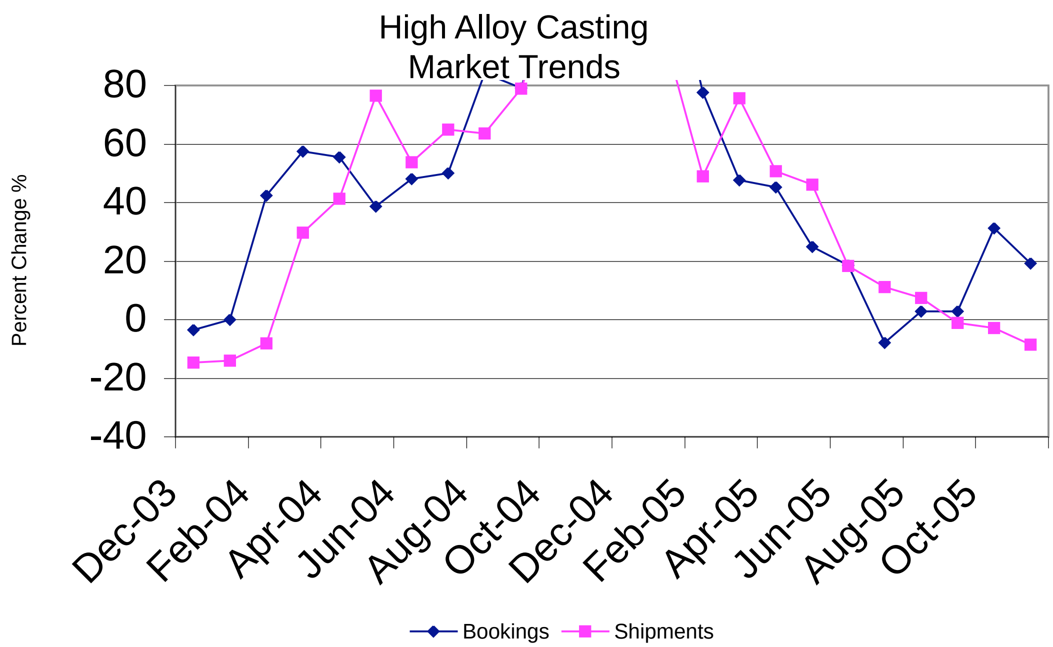
Iron & Steel Foundries (million $)			
Shipments	1,709	1,715	1,719
New Orders	1,730	1,734	1,721
Inventories	2,023	2,010	2,021
Nondefense Capital Goods (billion $)			
Shipments	66.9	68.8	67.3
New Orders	75.0	85.8	71.8
Inventories	112.9	113.3	112.6
Nondefense Capital Goods less Aircraft (billion $)			
Shipments	62.3	62.6	62.7
New Orders	63.0	62.3	63.7
Inventories	94.7	95.3	94.3
Inventory/Orders	1.50	1.53	1.48
Inventory/Shipments	1.52	1.52	1.50
Orders/Shipments	1.01	0.99	1.02

American Iron and Steel Institute

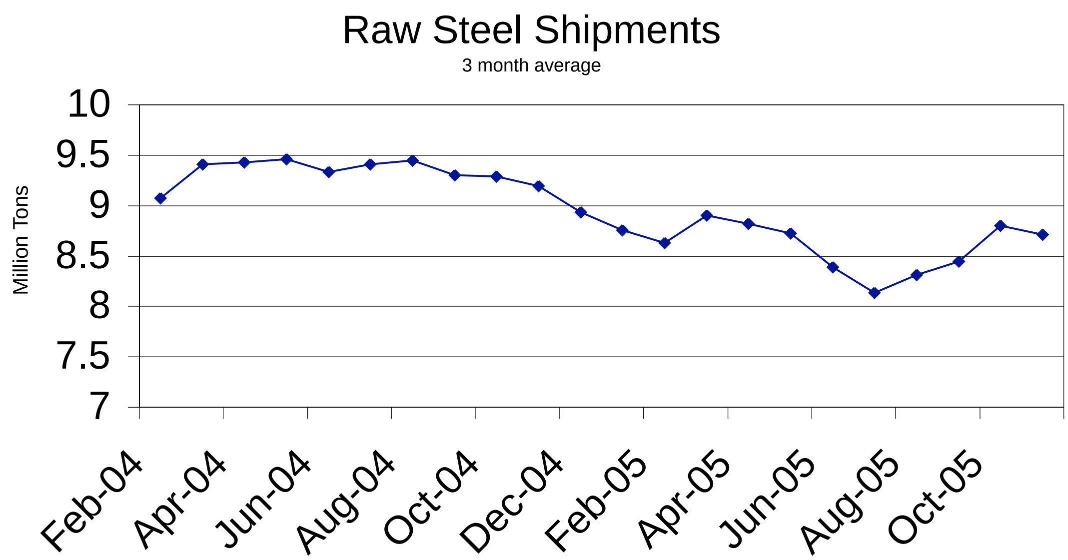
Raw Steel Shipments (million net tons)	8.7	8.7	8.8



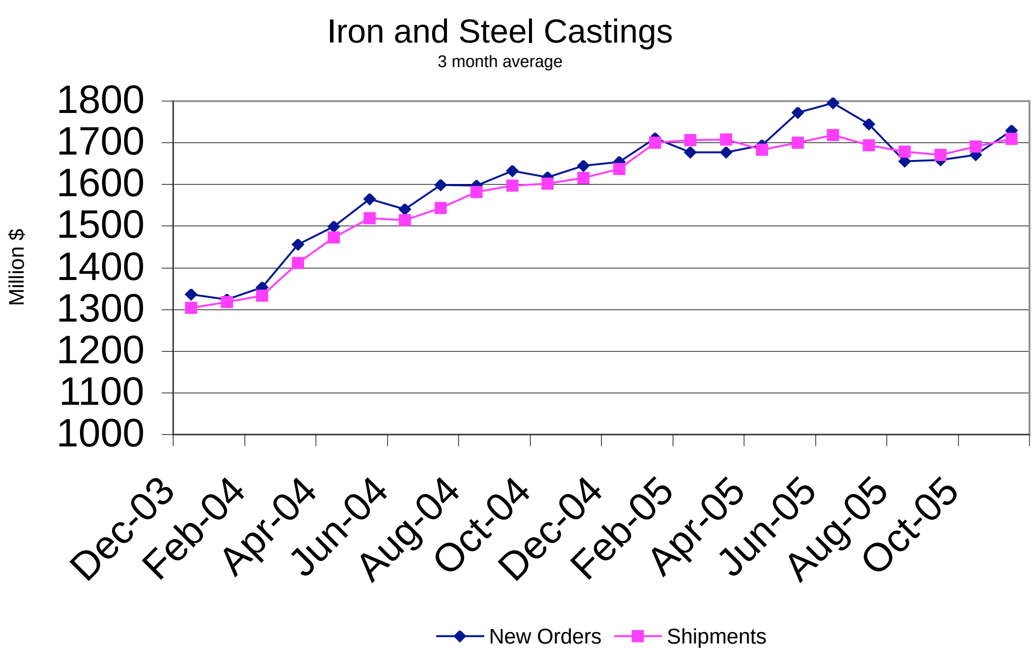
SFSA Postcards



SFSA Postcards



AISI Data



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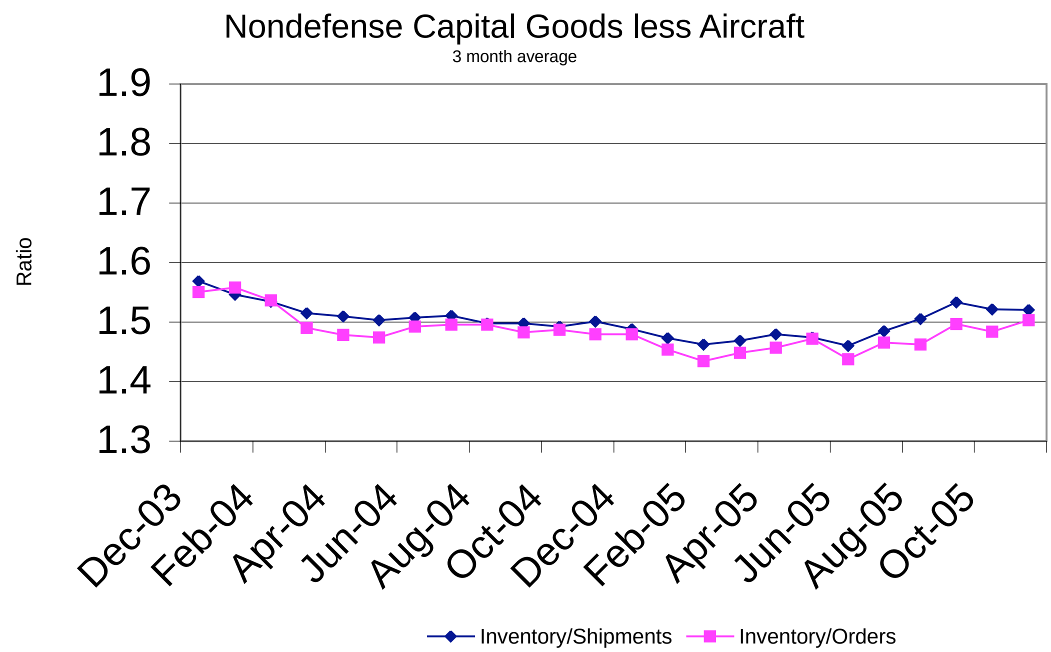
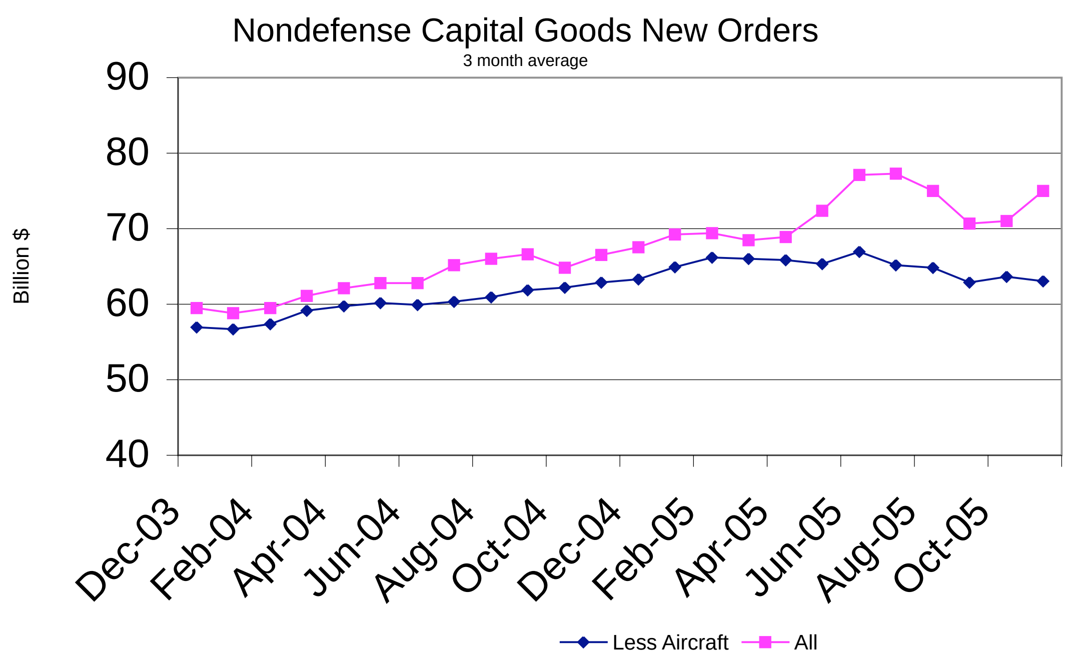


Department of Commerce



Department of Commerce

Proceedings of the 2005 Steel Founders' Society of America – Technical and Operating Conference

Measurement Error of Visual Casting Surface Inspection

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Abstract

Visual inspection of steel casting surfaces is a critical step in the processing of castings. Several inspections are conducted by inspectors, operators, supervisors, management, and ultimately the customer. Over-inspection will cause unnecessary processing times and costs. Under-inspection will cause additional rework or customer returns. A method to assess the amount of measurement error that exists in a subjective inspection task, such as surface inspection, was developed. The method was used to determine the amount of measurement variation that exists at three steel foundries. The results showed that there is significant repeatability error (variation within an operator's performance) when the same inspector inspected the same castings. However, the reproducibility error (variation between operators) was worse. This indicates a need for better training and communication of customer requirements via work instructions or comparator plates.

INTRODUCTION

Visual evaluation of casting surfaces is conducted several times during the production of steel castings. The most obvious persons conducting these visual evaluations are the inspectors which mark up areas to be upgraded. However, evaluations are also done by operators while they are processing the castings, by management, by sales, and ultimately by the customer. Studies show that currently there is no satisfactory method, whereby the surface quality requirements can be communicated throughout the manufacturing and purchasing phases of casting production. The lack of a reasonable measurement system for quality causes several implications, including uncontrolled processing times. Undetected surface defects will result in additional rework cycles or worse, returns from the customer. Marking acceptable anomalies as defects will result in excessive processing.

The goal of this study is to assess the amount of variation introduced by these inspections. To accomplish this goal, a new methodology is developed in this paper that is needed to quantify the amount of measurement variation in terms of repeatability (variation within the same operator) and reproducibility (variation between different operators).

PREVIOUS WORK

A review of research in the areas of surface inspection and surface measurement were analyzed as a starting point for this study. Although no studies in the visual assessment of casting surface inspections were found, many studies in the optical casting surface defect detection, recognition, and classification were noted. A study with encouraging results looked at an automated visual inspection system for the detection of defects in a range from images of castings (Newman et al., 1995). The system used computer-aided design model information and inspection algorithms in several stages, including surface classification and inspection. The inspection system was able to correctly classify over 90% of the casting images. Some not so successful attempts were also made in the automated detection of surface defects in machined castings. A study by Woods and Allen (1989) utilized computer vision to automate the inspection of machined steel components for cracks using the fluorescent magnetic particle method. Unfortunately, the study's results indicated that although the candidate generation stage was promising, reliable detection of all defects was achieved only at the cost of an unacceptably high overall false positive rate.

Although some success was achieved in the automated surface inspection systems, they were limited to a specific type of surface defect, such as surface cracks. These automated systems are usually not practical, as the castings need to be inspected for a number of different types of surface defects. A study by Someji et al. (1997) explained that because of the various defect types and their complicated shapes, defect inspection of castings is dependent on the human eye. However, the study also claimed that this process could get unstable by the tiredness of a person or a change in the environment, and become highly subjective.

A gage R&R study by Lee et al. (1992) on subjective evaluation of image data from the medical industry was also examined. The study used nine medical x-ray CT head images from three patients as test cases. Six radiologists participated in reading the 99 images (some were duplicates) compressed at four different image compression ratios, original, 5:1, 10:1, and 15:1. The study found that the six readers agreed more than by chance alone and their agreement was statistically significant, but there were large variations among readers as well as within a reader. What this study analyzed is very similar to the visual casting surface inspections, as both are highly subjective because of their reliance on the human eye.

DEFINING MEASUREMENT ERROR

Defect detection is a very important task that is dependent on the human eye during the casting surface inspection process. In order to assess the amount of variation introduced by the visual casting surface inspections, the measurement error associated with this process has to be defined.

In practice, visual surface inspections of the castings are performed by operators who identify areas of the casting that need grinding or welding as defects, and mark those areas with a marker. This study utilized inspectors that perform these tasks on a daily basis. This required a total of four inspection trials for each casting, as every casting needed to go through two operators twice. After the castings were marked for defects, round stickers were used to cover the markings as shown in Figure 1. This made locating and quantifying the size of the marked areas possible. More detail about the sticker size and the application process can be found later. After the location of the stickers was recorded, the casting was cleaned and presented to the other operator. At least a day transpired before the same operator inspected the castings the second time.

Figure 1. Example of the casting with surface anomalies, the markings made by the inspector, and the stickers used to identify the defect size and location.

In this study, a cluster of stickers in the same region is called a master cluster and defined as a group of stickers that have contact with each other and located anywhere among the four combined inspection trials of the same casting. The master cluster concept is introduced to characterize a marked area by an operator as a supposed defect region. Master clusters represent the supposed defect regions identified and marked by the operators during the inspection trials. A search zone is created about each sticker, and all other stickers from any trial are checked to see if they are in this zone. If they are, the stickers are assigned to the same master cluster. The radius of the search zone is the radius of the sticker multiplied by a user defined search zone coefficient (with a default value of 2.5). It is possible for a sticker to have multiple touching stickers if the center positions of more than one sticker fall within the search zone, especially from different inspection trials.

A visual representation of the master cluster concept is displayed in Figure 2. In this case, operator 1's trial 1 contains 7 stickers for 3 supposed defect regions, and trial 2 contains 4 stickers for 3 supposed defect regions for the same casting. Operator 2's trial 1 contains 5 stickers for 3 supposed defect regions, and trial 2 contains 4 stickers for 3 supposed defect regions for the same casting. Therefore, the four combined inspection trials of the same casting by two different operators result in 4 master cluster regions. The combining of the inspection trials of a casting can also be described as superimposing its inspection images on top of each other. This combination operation is displayed with a union ($\cup$) symbol.

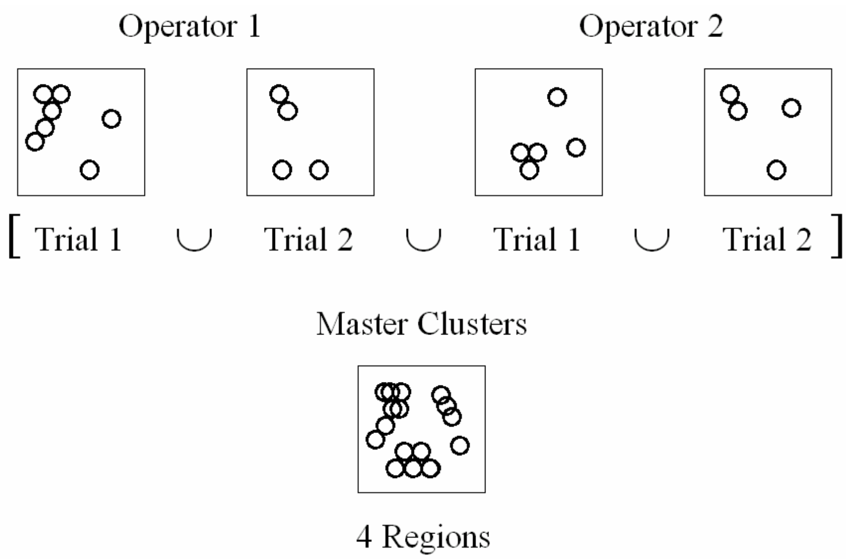

Figure 2. Defining master clusters with the four combined inspection trials of the same casting. The two stickers at the bottom of the casting from trial 2 of operator 1 both falls in the same master cluster region, since they are connected by stickers from other trials.

Defining Repeatability

Repeatability error of an operator is the amount of variation between the two inspections of that operator of the same casting. Repeatability is defined here by two aspects. The first represents how well an operator performs in identifying the same supposed defect regions between the two inspection trials of the same casting. The other aspect represents how well the operator performs in defining the size of the supposed defect regions between the two inspection trials of the casting.

The two inspection trials are compared by one-to-one sticker matching to determine the repeatability of that operator. This one-to-one sticker matching process is also done with a search zone. During the one-to-one sticker matching process, if the center position of another sticker from the other inspection trial of the same casting falls within this zone, then the two stickers are considered to be matched. It is also possible for a sticker to have multiple matching stickers if the center positions of more than one sticker fall within the search zone.

The repeatability of an operator is reported as two different percentage values. The first aspect of repeatability indicates how well the operator performed in identifying the same supposed defect regions between the two inspection trials of the same casting, reported as percent defect match. The second percentage value indicates how well the operator performed in defining the size of the supposed defect regions between the two inspection trials of the same casting, reported as percent sticker match. Higher values indicate better repeatability.

A visual representation for the repeatability of two different operators can be seen in Figure 3. Operator 1's trial 1 contains 7 stickers for 3 supposed defect regions, and trial 2 contains 4 stickers for 3 supposed defect regions for the same casting. The two inspection trials of the same casting are then compared. This comparing operation is displayed with an intersection ($\cap$) symbol. Operator 1's two inspection trials for the same casting match 7 stickers out of 11, and 2 master clusters out of 3 in total. For this hypothetical example, operator 1's repeatability is 67% and 64% for master cluster and sticker matching, respectively. This was repeated for each operator in the study.

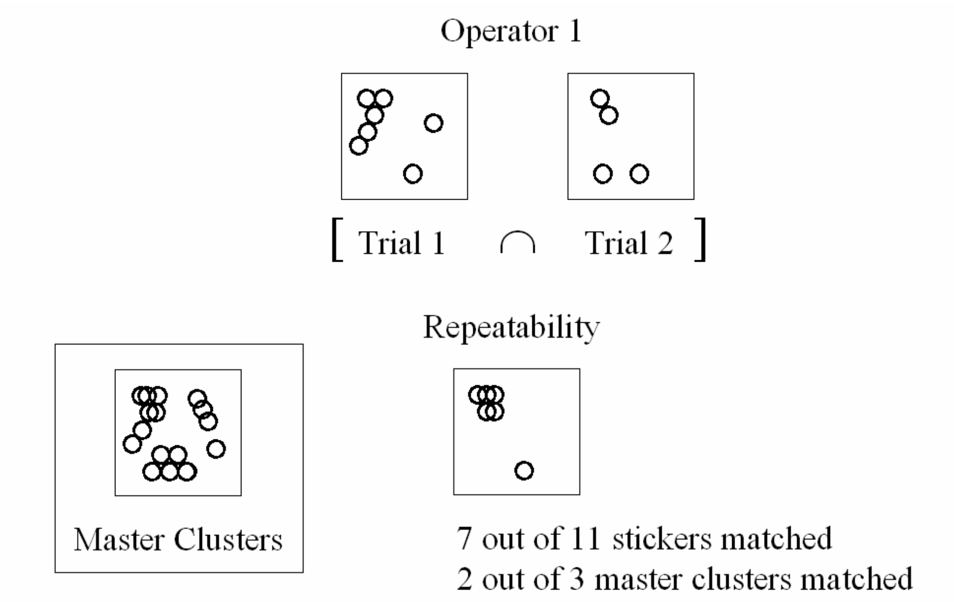

Figure 3. Defining repeatability of operator 1 with the same casting.

Defining Reproducibility

Reproducibility error is the amount of variation caused by differences between the two operators. The two inspection trials of the operators are combined to represent the best evaluation of each operator for that casting. Therefore, better repeatability from the operators will result in better reproducibility between the operators.

The combined inspections of the two operators are compared by one-to-one sticker matching to determine the reproducibility of the operators. This one-to-one sticker matching process is also performed with a search zone. During the one-to-one sticker matching process, if the center position of a sticker from the other operator's inspection trial of the same casting falls within this zone, then the two stickers are considered to be matched. It is also possible for a sticker to have multiple matching stickers if the center positions of more than one sticker fall within the search zone. Similar to repeatability, the reproducibility of two operators is also reported as two different percentage values. The first value indicates how well the operators performed in identifying the same supposed defect regions, reported as percent defect match. The second value indicates how well the operators performed in using the same size markings to define the same supposed defect regions, reported as percent sticker match. The higher values correspond to better reproducibility.

A visual representation for the reproducibility of two operators can be seen in Figure 4. In this case, operator 1's trial 1 contains 7 stickers for 3 supposed defect regions, and trial 2 contains 4 stickers for 3 supposed defect regions for the same casting. Operator 2's trial 1 contains 5 stickers for 3 supposed defect regions, and trial 2 contains 4 stickers for 3 supposed defect regions for the same casting. Then, the two inspection trials of the operators are combined to represent the best evaluation of each operator for that casting. Operator 1's combined trial contains 11 stickers for 4 supposed defect regions, and operator 2's combined trial contains 9 stickers for 4 supposed defect regions. The two combined inspection trials of the operators for the same casting are then compared. The operators' two inspection trials for the same casting match 12 stickers out of 20, and 3 master clusters out of 4 in total. For this hypothetical example, the two operators' reproducibility is 75% for master cluster matching and 60% for sticker matching.

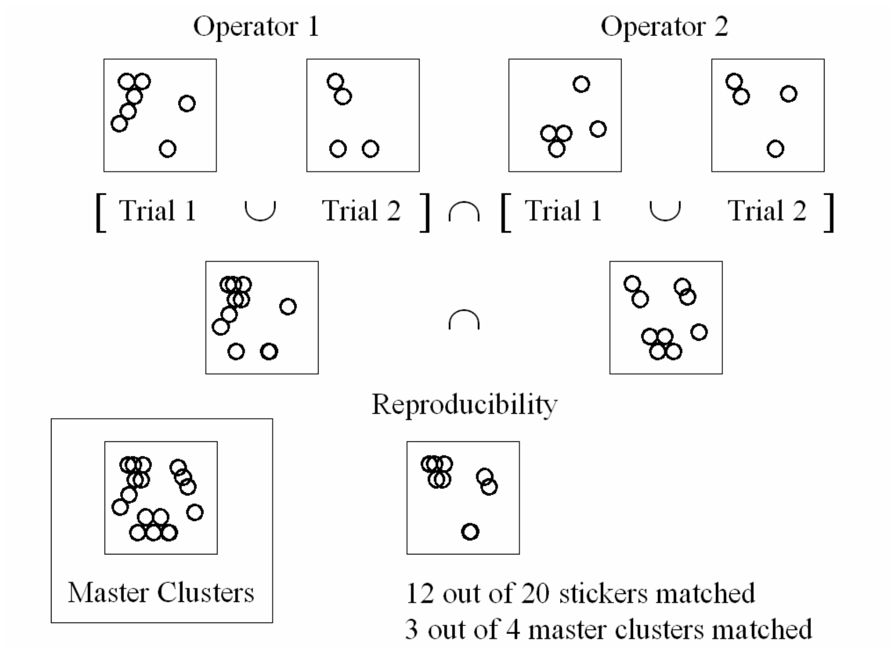

Figure 4. Defining reproducibility of two operators with the same casting.

METHODOLOGY

The first step was the collection of the visual quality inspection image data of the castings from three steel foundries. The next stage was the extraction of the coordinate data from the images. The final stage was the analysis of this coordinate data.

Image Data Collection

Image data was collected at three steel foundries, which collectively represent the North American steel casting industry quite well, outside of the railroad market. The companies ranged from 150 to 300 employees, and produced castings for a variety of construction equipment, pump and valve, and industrial equipment applications. One of these companies almost exclusively pours high alloy castings, another almost exclusively carbon and low alloy steel castings, and the third pours about 75% carbon and low alloy with the remainder being high alloy and wear resistant grades.

A similar procedure was used at each foundry for the image data collection. The setup included 2 visual inspectors and 6 castings in Foundry 1, and 10 castings in Foundries 2 and 3. The castings were marked for defects by the operators employing the same method that they typically use to inspect castings. The only difference was that only one side of the castings was inspected for this study. The order was chosen randomly by the trial moderator. Each of the two operators inspected each casting twice, on different days, to reduce bias. Between trials, the castings were shot blasted. Figure 5 shows an example casting as marked by an operator and after the stickers were applied

Specific instructions were provided to the trial moderator of each experiment as to how the stickers needed to be placed; some examples are shown in Figure 6. Careful attention was paid to carry out this process as consistently as possible. Then, digital pictures of the sticker-covered castings were taken.

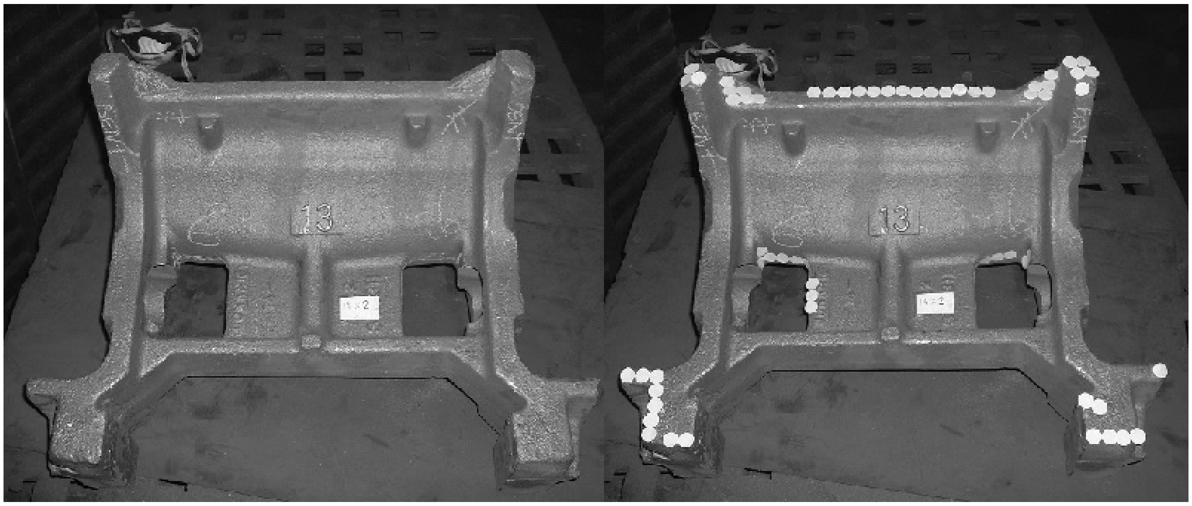

Figure 5. Casting marked by an operator (a) and stickers applied to the markings (b).

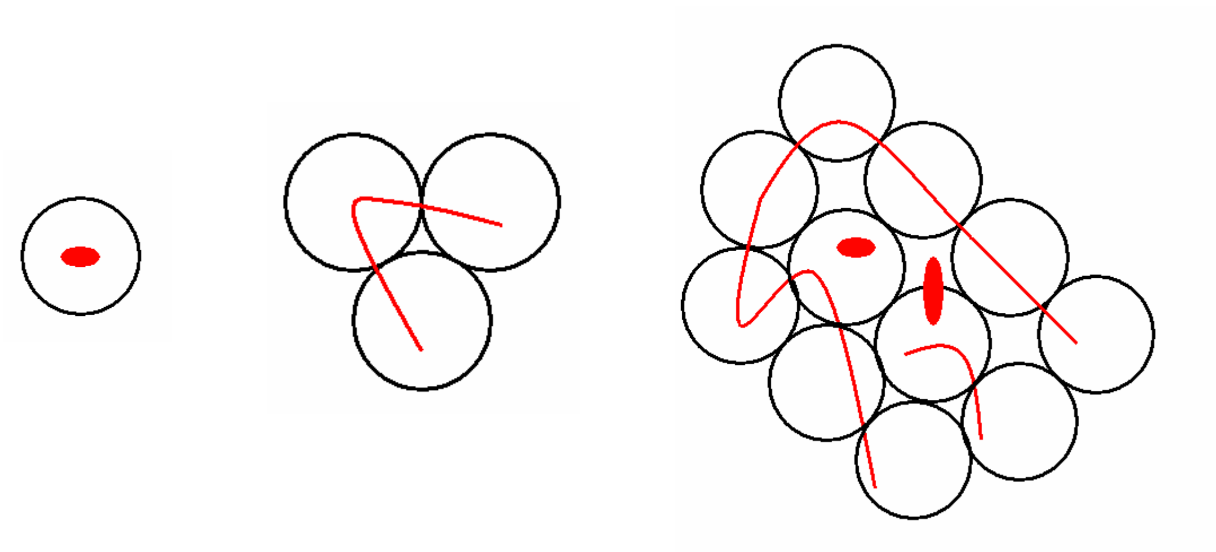

Figure 6. Example defect markings and how they were represented with stickers.

Sticker Coordinate Data Extraction

All images went through a series of processes to satisfy specific requirements of the image analysis software, and eliminate noise. The image cleaning process was done using Adobe Photoshop. Key steps in the image cleaning process included manually selecting the outlines of the castings and stickers. The image cleaning eliminated image noise, but did not change the location of the stickers.

After all the images are cleaned, they were loaded into DVT FrameWork image analysis software. DVT FrameWork is most commonly used in analyzing images for quality control purposes and was used to determine the coordinates of the stickers. The software compensated for the orientation and translation of the casting within the image. The sticker coordinate data was then outputted to MS Excel.

Analysis

After the sticker coordinate data was saved in a spreadsheet, another MS Excel file was used for the analysis, via algorithms implemented in macros. The master cluster operation was used to take the sorted sticker coordinate data and group the stickers into master clusters. The default search zone coefficient for the master cluster search was 2.5. If two stickers were touching, their centers would be 2 times the radius apart. The default was set at 2.5 to catch stickers which were close to touching. The default coefficient value was used for the Foundry 1 data; a value of 3.0 (a 20% increase of the default value) was used for the data from Foundries 2 and 3 because of the lower image quality and higher number of stickers that were at an angle to the image view. Further discussion on the determination of search zone coefficients and a sensitivity analysis can be found later.

The repeatability operation was used to take the sorted sticker data grouped into master clusters and conduct a one-to-one sticker matching between the different trials of the same castings inspected by the same operator. This process was done for each operator separately and repeated for each casting to determine the repeatability of each operator. The default search zone coefficient for the repeatability search was set at 1.5. The goal of the search zone in this case is to find stickers which are in the same location, but on different trial images. A value of 1.5 finds stickers whose centers are within 1.5 times the sticker radius. Although Foundry 1 used the default 1.5 for the search zone coefficient, Foundries 2 and 3 used 1.8 (a 20% increase from the default value) because of the lower image quality and higher number of stickers that were at an angle to the image view.

The reproducibility operation was used to take the sorted sticker data grouped into master clusters and conduct a one-to-one sticker matching between the same trials of the same castings inspected by different operators. This process was done with the combined images of the two trials of the same operator for the same casting and repeated for each casting to determine the reproducibility of the two operators. The default search zone coefficient for the reproducibility search was 1.5. Foundry 1 used the default coefficient value, and Foundries 2 and 3 used 1.8 (a 20% increase from the default).

RESULTS

The results of the analysis showed that there is a significant amount of repeatability and reproducibility error in the visual casting surface inspections. The repeatability of the two operators from the same foundry was found to be very similar. The repeatability for each operator is displayed in Figure 7. The reproducibility for each foundry (pair of operators) is displayed in Figure 8.

There was some concern that the blasting operations between trials might affect the casting surface quality, and bias the results. Pictures of the unmarked castings before and after the inspections do not show significant changes. There was also not a significant difference in the defect detection rates of the operators between their first and second inspection trials.

The search zone coefficient is a number, which, when multiplied by the radius of a sticker, creates a circular search zone around the sticker's center position. If the center position of another sticker from any of the four inspection trials of the same casting fell within this zone in the master cluster operation, then the two stickers were considered to be touching and assigned to the same master cluster. If the center position of another sticker fell within the respective zone in the repeatability or reproducibility operations, then the two stickers were considered to be matched. A sensitivity analysis of the search zone coefficient showed that the size of the search zone was appropriate, as reported by Daricilar (2005).

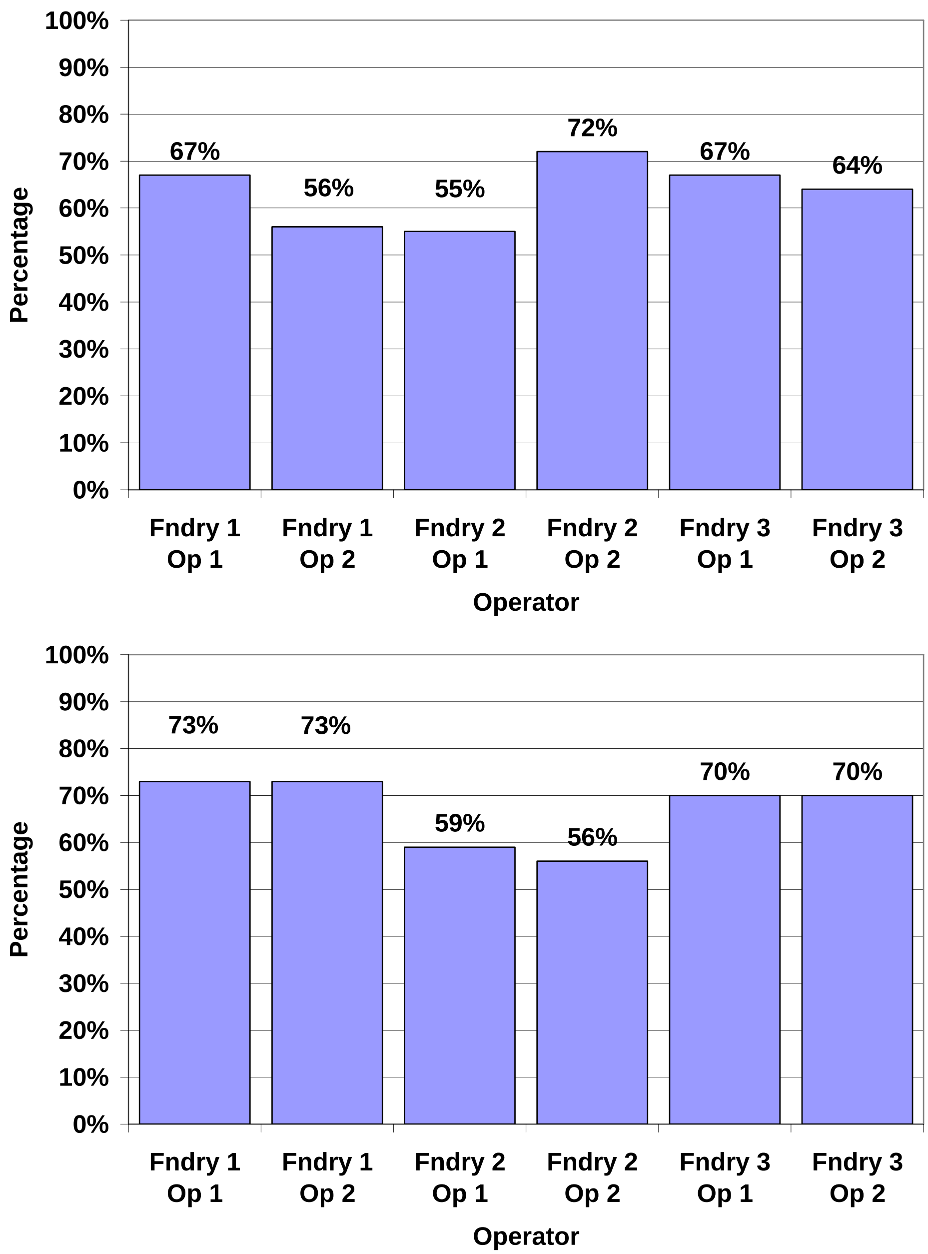

Figure 7: Repeatability values for each operator a) Percent defect match b) Percent sticker match

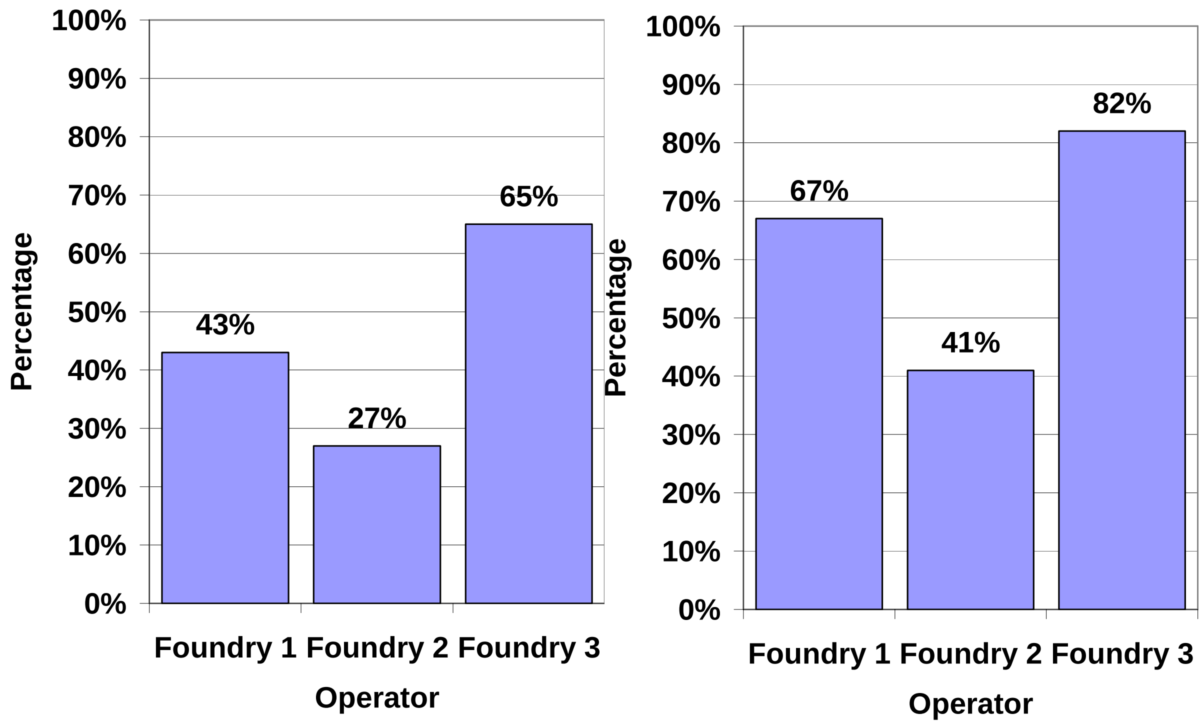

Figure 8: Reproducibility between the 2 operators at each foundry a) Percent defect match b) Percent sticker match

CONCLUSIONS

The results of the analysis showed that there was significant variation in both repeatability and reproducibility measurements from all three foundries. Although the repeatability measurements were somewhat consistent within the foundries, the reproducibility measurements displayed considerably more variation. This poses a particularly big problem in the industry, indicating a need for more training and the use of tools such as comparator plates and work instructions that detail customer requirements.

Another cause for concern was the higher variability detected in the defect match compared with the sticker match percentages in the repeatability and reproducibility measurements from all three foundries. The error associated with the defect match creates a bigger problem for the foundries, as incorrectly identifying or missing a whole defect region is much worse than identifying an already detected defect region as a bigger or smaller area. This variability in the defect detection process means that some defects go undetected from the inspection process and create rework or they reach the customer. Meanwhile, some allowable anomalies are incorrectly identified as defects. The uncertainty in the surface defect detection causes uncontrolled processing times leading to more inefficiency in cleaning room operations, such as excessive grinding and welding, and adversely affects other aspects such as production scheduling and material handling. All of these implications lead to increased cost of operations at steel foundries. Harwood (2004) reported that the cost of cleaning room operations are within the range of $0.76 to $5.34 per square inch (depending on the depth of the defect area) for welding operations, and $0.46 to $1.25 per square inch (depending on the surface quality after welding) for grinding operations. This means that there are high costs associated with every unnecessary defect marking placed by the casting surface inspection operators.

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China steel exports surge due to domestic overcapacity

19 Jan 2006, Thursday

The sharp rise in China's steel exports last year and the fall in imports were the result of excess capacity and redundant production in the country, analysts said. The General Administration of Customs announced that China's 2005 steel and steel product exports rose 44.2% to 20.52 million tonnes while steel imports were down 11.9% at 25.82 million tonnes.

"There continues to be tremendous overcapacity and irrational production in China with domestic supply greatly outpacing demand, so the rapid rise in exports and falling imports would be the logical result," said Mr Wu Xianfeng, steel analyst at Guotai Junan Securities. But he added that China is unlikely to stop importing certain kinds of steel soon. "Although imports were down somewhat, China will continue to have a need for crucial high-end value-added steel and steel products going forward and imports are best suited to meet this demand," he told. He said there was no relief in sight, at least in the short term, for the ailing sector which has seen prices plummets in China by over 3,500 yuan per ton since the peak in April. "For crude steel, not only will overcapacity in China continue to boost exports and limit import demand, but will also prove a drag on selling prices for much of this year if not longer," he said.

Mr Tian Shuhua, senior analyst at China Galaxy Securities, said the rapid increase in exports was symptomatic of structural ills within the sector. "China's steel sector is experiencing many systemic problems. As recently as a few years ago, China was the world's largest steel importer and only exported token quantities. But the sharp rise in steel exports seen last year is an unhealthy development for the industry," he said. He said exports were further spurred by reductions in export tariffs, and helped pull down prices on world markets for a sector already suffering from shrinking margins." It is an unhealthy path for the sector to take and shows that massive restructuring is still needed to keep the industry afloat. The rapid rise in exports also suggests that many smaller, less efficient producers are desperately trying to offload steel on world markets due to overcapacity at home," Mr Tian said.

China has been encouraging consolidation in the sector to rein in redundant overcapacity. Some major producers have also shown restraint by pledging to cut production voluntarily. The country is expected to have overcapacity of at least 100 million tonnes of steel for 2005 amid expected demand of 300 million tonnes tons. The country's steel production capacity is expected to hit 490 million tonnes in 2006 and 538 million tonnes in 2008, up from 419 million tonnes in 2004, earlier media reports said.

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January 23, 2006

Industry View
Cautious

Chinese Steel Industry

Record Steel Output with Big Decline in Net Imports in 2005

Conclusion: With rapid capacity expansion in flat products by Chinese mills, we have seen two major trends in 2005: 1) accelerating steel production; 2) a continued dramatic decline in net imports (implying import replacement). Despite a recent moderate steel price rebound in China, we believe overcapacity will remain an overhang unless exceptionally strong demand in the US and elsewhere induces Chinese exports to increase and thus also pushes up domestic prices, given the current deep domestic price discount.

Rapid Production Growth: With December crude steel output reaching 32m tonnes in China, full year crude steel output jumped 29% yoy to a record high of 348m tonnes in 2005, roughly in line with our forecast of 350m tonnes. 2005 finished steel production surged 38% yoy to 369m tonnes. Overall, robust capacity expansion by Chinese steel mills has been put into operation and raised total production. 2005 crude steel output growth of 29% is the fastest in the past ten years, and we expect a slowdown to 11.5% in 2006 given a current weak steel pricing environment and decelerating investment in the industry.

Dramatic Decline in Net Imports: 2005 was also characterized by a rapid decline in net imports of finished steel, given that Chinese steel mills swiftly expanded capacity in flat products to replace imports. Although China remained a net importer of finished steel in 2005, net imports dropped 65% yoy to 5.3m tonnes. If we include semi products, China already turned into a net exporter of 458kt tonnes in 2005. (Exhibit 5)

China became a net exporter in December, the first time on a monthly basis in 2005. Net exports of finished steel were 40kt in December, compared with 550kt of net imports in November. We believe the deep domestic steel price discount vs. the global price (the HRC price discount vs. the US is over US$200/t) has induced Chinese steel mills to increase their exports.

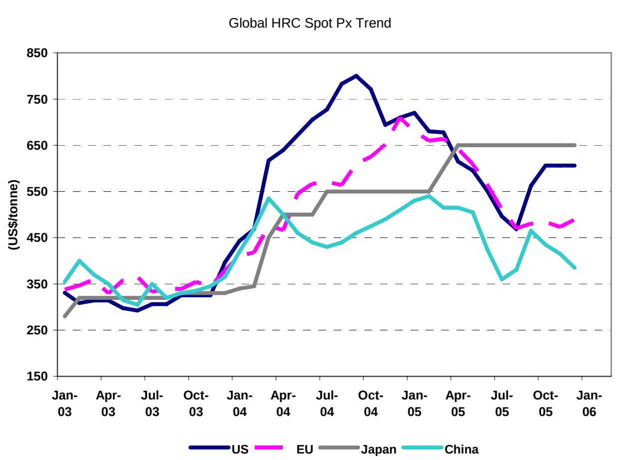
Apparent Consumption Solid, but Lagging Production Growth: Apparent consumption growth in 2005 was 32.3% yoy to 374.6m tonnes. However, it lagged production growth of 38%.

Stabilizing Domestic Steel Prices: There are signs of a domestic steel price recovery in some grades of flat product, while long product prices remain weak. Prices of HRC and CRC have rebounded by 2~3% recently on a week-on-week basis, owing to increasing exports, which moderate domestic oversupply pressure to a certain extent. We see limited downside in domestic prices given that current prices are already lower than the cash operating cost of an average Chinese steel mill. However, given the current overcapacity overhang, we do not anticipate a strong price rebound ahead unless exceptionally strong demand in the US and elsewhere continues to drive up exports from China or a domestic production slowdown in response to the weak prices. Going forward, we see export growth and the global steel price gap as the two leading indicators of domestic steel price trends.

We maintain our Cautious view on the Chinese Steel industry, but would closely watch the export growth trend.

Exhibit 1

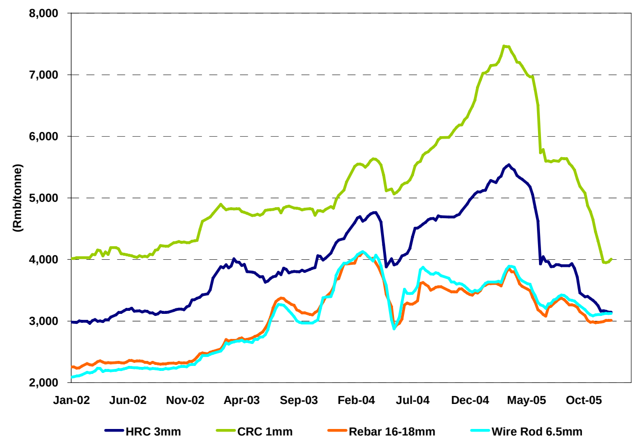
Global HRC Monthly Price Trend



Source: CRU, Morgan Stanley Research

Exhibit 2

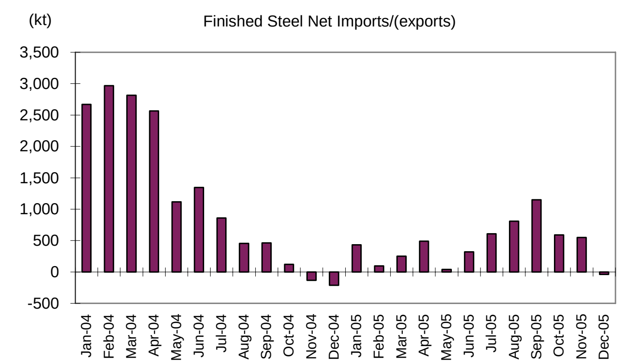
China: Domestic Weekly Steel Spot Price Trend



Source: Mysteel, Morgan Stanley Research

Exhibit 3

China: Monthly Net Imports/(Exports) of Finished Steel



Source: Mysteel, Morgan Stanley Research

Exhibit 4

China: Finished Steel Supply and Apparent Consumption

	Output (kt)	YoY (%)	Imports (kt)	Exports (kt)	Net Imports (kt)	YoY (%)	Apparent Consumption (kt)	YoY (%)
Jan-05	26,110	23.3%	1,925	1,492	433	-83.8%	26,543	11.3%
Feb-05	25,368	12.1%	1,588	1,489	98	-96.7%	25,466	-0.5%
Mar-05	30,655	28.3%	2,460	2,207	253	-91.0%	30,908	15.7%
Apr-05	29,531	28.3%	2,560	2,070	490	-80.9%	30,021	17.4%
May-05	31,106	36.4%	2,160	2,120	40	-96.4%	31,146	30.2%
Jun-05	30,366	28.8%	2,520	2,200	320	-76.2%	30,686	23.1%
Jul-05	31,361	28.9%	2,138	1,530	608	-29.4%	31,969	27.0%
Aug-05	32,695	28.6%	2,150	1,340	810	78.3%	33,505	29.5%
Sep-05	32,252	22.1%	2,500	1,350	1,150	148.3%	33,402	24.3%
Oct-05	33,105	23.7%	1,930	1,340	590	385.6%	33,695	25.4%
Nov-05	33,058	18.5%	2,100	1,550	550	-516.4%	33,608	21.1%
Dec-05	33,727	22.0%	1,780	1,820	-40	-81.0%	33,687	22.8%
2004	295,552	26.6%			15,039	-50.2%	310,591	17.8%
2005	369,333	37.9%	25,810	20,508	5,302	-64.7%	374,635	32.3%

Source: Mysteel, Mysteel, Morgan Stanley Research

Exhibit 5

China: Monthly Imports and Exports of Steel

	Net Imports/(exp)				Imports				Exports			
	Finished		Semis	Total	Finished		Semis	Total	Finished		Semis	Total
(kt)	Vol	% YoY	Vol	Vol	Vol	% YoY	Vol	Vol	Vol	% YoY	Vol	Vol
Jan-05	433	-83.8%	-460	-27	1,925	-40.8%	100	2,025	1,492	156.6%	560	2,052
Feb-05	98	-96.7%	-690	-592	1,588	-52.8%	150	1,738	1,489	276.1%	840	2,329
Mar-05	253	-91.0%	-1,320	-1,067	2,460	-28.9%	140	2,600	2,207	241.9%	1,460	3,667
Apr-05	490	-80.9%	-680	-190	2,560	-24.6%	120	2,680	2,070	149.7%	800	2,870
May-05	40	-96.4%	-460	-420	2,160	1.4%	130	2,290	2,120	109.5%	590	2,710
Jun-05	320	-76.2%	-440	-120	2,520	3.3%	130	2,650	2,200	101.1%	570	2,770
Jul-05	608	-29.4%	-530	78	2,138	-3.9%	120	2,258	1,530	12.1%	650	2,180
Aug-05	810	78.3%	-300	510	2,150	15.8%	80	2,230	1,340	-4.4%	380	1,720
Sep-05	1,150	148.3%	-24	1,126	2,500	40.8%	114	2,614	1,350	2.9%	138	1,488
Oct-05	590	385.6%	-110	480	1,930	18.4%	50	1,980	1,340	-11.1%	160	1,500
Nov-05	550	-516.4%	-276	274	2,100	17.1%	106	2,206	1,550	-19.5%	382	1,932
Dec-05	-40	-81.0%	-470	-510	1,780	-8.9%	70	1,850	1,820	-15.9%	540	2,360
2004	15,039	-50.2%	-2,230	12,809	29,273	-21.2%	3,830	33,103	14,233	356.4%	6,060	20,293
2005	5,302	-64.7%	-5,760	-458	25,810	-11.8%	1,310	27,120	20,508	44.1%	7,070	27,578

Source: Mysteel, Mysteel, Morgan Stanley Research

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Company (Ticker)	Rating (as of)	Price (01/20/2006)
Oliver Y Du		
Angang New Steel (0347.HK)	++	HK$4.88
Baoshan Iron & Steel (600019.SS)	O (03/16/2004)	Rmb4.06
Maanshan Iron & Steel (0323.HK)	U-V (12/02/2005)	HK$2.63

Stock Ratings are subject to change. Please see latest research for each company.