The significance of total carbon in greensand systems

Alexander Brown, Fellow of the Institute of Cast Metal Engineers, Penistone, Sheffield S36 9QU, England

Abstract: The need for control of raw materials is critical to the success of iron casting production from greensand systems. The base silica sand is often overlooked with the main focus on bentonite additions. Carbonaceous additives can be considered a “necessary evil” to ensure a good surface finish and reduction in sand related surface defects. Other additives are used when systems get out of balance and these in turn add further to the complex nature of greensand systems.

For castings requiring cores this becomes a bigger issue as many differing resin systems are employed for core production and these must be taken into consideration when controlling both the carbonaceous levels and the overall grading of the sand system. The twin effects on additional carbon and loss-on-ignition and overall sand grading need careful understanding and control.

Various control methods are examined including traditional methods such as volatiles and loss-on-ignition along with bentonite determination methods and grading methods. Newer control methods such as total carbon are reviewed along with the overall package of testing and control methods. Various predictive methods are looked at as a control feature as well.

The quality of additives and their role and more importantly their interaction is highlighted, as this is an area often neglected as foundrymen battle for success in consistent quality castings. Suggested in-coming control tests are discussed allied to additions at the mixer.

Also reviewed is the interpretation of results and the action required to ensure control and more importantly consistent quality castings from greensand systems with the emphasis on the understanding and control of carbonaceous additive on casting performance.

Key words: graded coal; bentonite; greensand; total carbon; volatiles

CLC number: TG221 Document code: A
Article ID: 1672-6421(2009)03-247-08

1 Control of raw materials

Much has been documented on additives to greensand systems. This paper looks at the need to have a complete understanding of the sand system and by knowing a system those in control can make judgements based on fact. Of the many green sand systems I have observed worldwide, most share many common features that give cause for concern. This is not because the operators do not have the means to control the system, but because their decisions are based on a lack of validated data.

Some of my concerns are:
- Poor sampling;
- Frequency and timing of samples;
- Lack of calibrated testing;
- Focus on the wrong control areas;
- Lack of understanding of primary and secondary sand tests;
- Little focus on silica sand or sand grading;
- Bentonite emphasises detriment to carbonaceous additive;
- Poor in-coming test procedures;
- Over reliance on suppliers.

All of the above are important but equally good castings can

Fig. 1: Ideal knockout condition

Basic understanding of raw materials is equally important as good quality control measures and consistent operating practice
be produced from systems with little or no control. By control, I mean basic understanding of all the raw materials used together with in-house testing and/or approved certification, coupled with good, consistent casting practices. This is measured by general scrap rates and the costs associated with knockout and shot blasting, costs so often not taken into consideration when selecting the raw materials to be used in the system.

1.1 System mass balance
A great deal of information can be gathered from doing a complete mass balance on a greensand system. This exercise picks up so much useful data, which should be a regular exercise in all foundries, especially if the casting weights or size of castings alters over time. Consider the simple question “What is the total sand weight in the greensand system?”

Normally this met either a wild estimate or a complete blank response.

1.2 Mass balance check list
- Return sand storage silo/bunker capacity;
- Return sand temperature/moisture (at various points);
- Weight of sand on line/in boxes etc.;
- Core weight input (if applicable);
- Fines extraction/sand losses;
- Additive control/weigh calibration/stock against usage;
- Sand carryover at knockout;
- Shot blasting times/consumption;
- Scrap levels/sand related defects;
- Sand to metal ratio/casting weight data;
- Volatiles data at mill and in return sand;
- Loss-on-ignition data at mixer and in return sand.

From the data gathered a much clearer picture can emerge. Most important, we know that control systems can actually monitor the burn-out rates of bentonite and carbonaceous additives. Most observers agree that additions at the muller require time to be effective, and by understanding how the sand reacts to varying sand-to-metal ratios, proactive steps can be taken. Various foundries have used predictive software or even a simple traffic light system to monitor heat demand, with good results. The author believes that it is not the actual system that matters, but, importantly, understand what is happening and being one step ahead of it.

1.3 Base silica sand
Those foundries producing castings without cores are obviously in a much better position than those with cored products. Core systems simply have to accept coarser sand as a dilution, but with careful selection this does not have to be a problem. More important is knowing the AFS (Average Fineness Number) and AGS (Average Grain Size) and determining what produces the best casting surface at the most economical cost. The AFS clay-grade washing and sieving of the washed sand needs regular review, and these tests, along with optimum additive rates, are the keys to success in a greensand system.

Total clay grade = 11.65%, AFS = 65.91, AGS = 0.268 mm

Fig. 3: Typical washed system sand sieve graph

1.4 Bentonite types and addition rates
The binder suppliers will claim many advantages for their products but many differing bentonites are used with success.
overseas foundry
249
august 2009
throughout the iron casting world. that said consistency is the main aspect to control, and that is entirely another matter. few foundries have the specialized equipment needed for incoming control, so testing should be limited to meaningful values and working with your supplier will establish a working specification.

1.5 carbonaceous types and addition rates
many products are available with many claims. coal, either as high quality bituminous or lower-grade material, is the main additive, and grading selection should also be tailored to the castings being produced. coal is by far the cheapest and safest carbonaceous additive to green sand systems. its unique, all round properties make it easy to use; its use is so under-rated that in most cases it is underused, and most systems do not benefit fully from its various beneficial properties.

most other carbon additives are highly volatile products normally added to poorer quality coals to enhance levels of volatile content. these can cause additional problems in high concentrations due to hydrogen/nitrogen gases, and are quickly eliminated from a system without contributing to the coke build-up (total carbon). this can be an expensive approach to adding carbonaceous additives, and too often the operator has no idea what products he/she is using, as the blends are often “trade secrets”. to understand a system and its interaction with additives you simply have to know what you are adding and why. the classic system of using one, single source bentonite and coal is by far the simplest and most cost-effective route to producing quality castings.

2 experimental methodology
2.1 mixer controls and technical support
the need for control in this area is obvious as changes here are reflected throughout the system. regular mixer maintenance coupled with calibration of additives and usage checks against actual stock purchases can often spot problems before they give concern. this should be part of the mass balance procedure that should be a routine feature.

<table>
<thead>
<tr>
<th>primary tests</th>
<th>secondary tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>sieve analysis</td>
<td>compactability</td>
</tr>
<tr>
<td>active clay</td>
<td>moisture</td>
</tr>
<tr>
<td>afs clay grade</td>
<td>green compression strength</td>
</tr>
<tr>
<td>volatile</td>
<td>green shear strength</td>
</tr>
<tr>
<td>loss on ignition</td>
<td>wet tensile strength</td>
</tr>
<tr>
<td>shatter index</td>
<td></td>
</tr>
<tr>
<td>permeability</td>
<td></td>
</tr>
</tbody>
</table>

getting the primary and secondary testing balance right is difficult for foundries. too much, and the testers see no positive advantages other than routine test control. too little, and there is no starting point for investigation and correction once things go wrong.

concentrate on the primary tests to ensure consistency. especially during periods of good casting performance, take time to monitor what makes the system work. look to the secondary tests to reinforce the casting quality and only test if you are prepared to react on the results. meaningless testing is a waste of resources. ensure proper reporting and graphing of data. ultimately, all sand testing shows a “trend”. even if the testing methods are not perfect, if conducted on a consistent basis it will show the trend line to which you are able to react.

bentonite testing has been well documented. one area for control is in the raw material acceptance testing at the foundries. this can be established in conjunction with the
supplier, and simple tests such as swelling ability, sieve grading and specific gravity are useful in association with active clay calibrations.

One of the most difficult tests to get consistent results is the volatile test, and yet many foundries use this as the guide for carbonaceous additions irrespective of the casting quality. With 3 or 4 decimal place measurement and a weight loss at a specified temperate (910°C) and time (7 minutes) on a small sample weight (1 or 2 grams), it can be a difficult test, especially between different laboratories. This volatile test is normally used in conjunction with the loss-on-ignition test and investigations into an alternative method to supplement these tests will ensure focus on this critical area for consistent casting performance.

2.2 Total carbon testing

This control method was used by the Lincoln Castings Ltd. on its LM1 and LM2 moulding lines, starting around 2001. This was introduced as a routine test for their straight coal/clay system. Over the following year it became obvious that the interaction of total carbon, sulphur, volatiles and loss-on-ignition was critical to the quality of the castings.

The radar graph shown in Fig.5 was used to monitor the relationship and it was proved that if the total carbon, loss-on-ignition and volatiles were kept in the desired ranges, the casting performance was acceptable. If any of the results fall into the grey area (area for concern), then positive action had to be taken. Equally, going out of the maximum area also required reduction of additives. Sulphur levels normally mirrored the total carbon and ran in the range 0.06 to 0.09.

2.3 Testing units

A testing unit, a SC144 carbon/sulphur machine, used at Lincoln Castings Ltd., was supplied by Leco UK. It was selected because it determines carbon/sulphur in various organic matrices from low concentrations (e.g. bentonite) to high levels, such as coal and coke, as well as higher carbon products, such as recarburisers and graphites. This instrument offers a simple solution that determines carbon and sulphur simultaneously using direct combustion and infrared detection.

Fig.5: Radar graph for total carbon

No hazardous chemicals are used and accurate results are provided in 3 minutes from a small sample weight of 0.3 grams, using reusable refractory sample boats, without accelerating elements. Coupled to the unit is an automatic weighing unit with a dedicated software package, allowing for data storage, statistical analysis and customized operating parameters.

The samples (such as bentonite, coal, silica sand, as well as system and return sand and extraction fines) are tested on a daily basis to ensure proactive steps can be taken, coupled with the routine sand testing. Analysis begins with a nominal weight of 0.3 grams being weighed in a combustion boat. The sample is placed in a pure-oxygen environment regulated at 1,350°C. The combination of high temperature and oxygen flow caused the sample to combust and it go through an oxidation and reduction process that causes carbon and sulphur-bearing compounds to break down and free the carbon and sulphur. The carbon then oxidises to form CO₂ and the sulphur forms SO₂.

The combustion system allows the sample gases to remain in the high temperature zone, and this permits efficient oxidation. Gases flow through two anhydrone moisture traps and into the infrared detection zone. The carbon and sulphur dioxide values are then converted, taking into account the sample weight, calibration and known moisture value.

The SC 144 can be classed as high end, multi-element
detection instrument, and various laboratories worldwide were checked to determine the effects of alternative units. Many labs have older type carbon and carbon/sulphur units, mostly doing metal analysis. It was decided to check samples on both a SC 144 and a CS 244 to determine the difference in results based on a wide range of samples.

The CS 244 and other units in the CS series are ideal for smaller lower volume laboratory looking for a cost effective solution, without sacrificing precision, reliability and accuracy. These CS units use induction heating element and a larger sample weight of 1 gram. Also used are accelerating elements such as high purity iron, tungsten or copper with a temperature in excess of 2,000ºC for 15 seconds, to ensure complete combustion. Any CO or SO$_2$ is converted to ensure only CO$_2$ and SO$_2$ are measured. Both these gases absorb infrared energy at precise wavelengths with the spectrum. Energy is absorbed as the gases pass through the infrared absorption cells.

The CS unit uses a refractory crucible and it is recommended that a lid be used as the method to prevent any of the samples being removed by the pressure blast of oxygen used in this unit. The graphs of readouts show the difference in both machine types. Research that compared their performances showed the CS cannot measure the initial fast release of volatile gas and therefore the total carbon readings are around 1% lower than using the SC unit.

2.4 Calibration of the units

Both units are calibrated using a calcium carbonate at 12% carbon and 0.0106% for sulphur. Calibration graphs and running widely varying samples show the units are very accurate, with excellent reproducibility.

2.5 Sand testing

As a control measure, many foundries have relied on loss on ignition and volatile tests to measure carbonaceous addition. Coupled with AFS clay grade and active clay measurement, this was considered adequate testing, along with the usual series of permeability, strength and moisture. Experience has shown that active clay levels in most systems range from 1% and 2% higher than required and these levels are regarded as a safety feature. Whereas we know, foundry workers make excellent mouldable sand, this does not always translate into top quality castings.

Volatiles testing can be a difficult and total carbon determination removes the need for total reliance on this method. A common problem with volatiles testing is the use of a wide necked crucible with a poor fitting lid. These always give a larger false reading and the use of the standard parallel sided crucible is urged, with a tight fitting lid. Loss-on-ignition is of course an easier test and this can be backed up with further testing on washed and unwashed sand samples. Conduct both volatiles and loss-on-ignition tests before and after washing the clay grade out to determine the contribution from the carbonaceous additive. Approximately 1% of volatile in a sand system actually comes from the bentonite addition.

2.6 Interpretation of total carbon results

One foundry does not have all the answers, so it was important to collect sand samples from as wide a group as possible. By selecting samples from foundries of Malaysia, Thailand, Czech Republic, Denmark, South Africa, India as well as the UK, etc., it was possible to include all available core binders and also differing silica sand, bentonites and carbonaceous additives, including those containing lustrous carbon.

All participating foundries were assessed for optimum use of raw materials and control of sand testing and moulding properties to ensure a level playing field. If they met the criteria, sand samples were collected over a period of time (all through 2005) to look at trends and importantly at casting performance. The key measurables were casting scrap related to sand condition, surface finish quality, sand carryover at knockout and shot blast times. Of course, not all of this can be attributed to carbonaceous additive, but in the end I settled on a good, average and poor ratings. This may at first look seem too simple for a table to be useful, but I believe the results and conclusions justify the selection. Now further work needs to be done to put numbers against the various selected categories.

<table>
<thead>
<tr>
<th>Table 2: Foundry performance categories</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Good</td>
</tr>
<tr>
<td>Average</td>
</tr>
<tr>
<td>Poor</td>
</tr>
</tbody>
</table>
Having defined the foundries, samples were collected over the year and washed and unwashed samples were tested for volatiles and loss-on-ignition, as well as using the SC 144 unit to determine the total carbon and sulphur levels. I personally visited each foundry, in order to monitor casting performance and to cross check our own laboratory results. It soon became apparent that the categories matched the level of total carbon within bandwidths.

3 Results and discussion

3.1 Measured total carbon

As no database of information was available, over 20 foundries were tested with total carbon ranging from a low 1.5% to a high of 6.68%. Out of interest and because the SC 144 also measures sulphur at the same time, we recorded the numbers and found a range from 0.045% to 0.13%. Against each sample we did a volatiles and loss-on-ignition test to see if there was a relationship, and to check the foundries’ own results, which in itself was a useful exercise, and quite differing results were obtained. Three independent laboratories were used, including foundries and suppliers to verify results over the year.

Table 3 show the results from a single session using various samples from low to high carbon content on the SC 144 unit. The CS results show the difference in the detection systems but the accuracy shows the possibilities and the versatility of the units for rapid testing and control.

Table 4 shows the results from the average of samples taken from each foundry’s system sand. Both volatiles and loss-on-ignition tests were also carried out to supplement the total carbon results. All these results come from the SC 144 unit, so we can be confident we have measured the total carbon content.

3.2 Evaluation of volatiles and loss-on-ignition properties

The whole matter of the use of carbonaceous additives and their purpose has been well documented. This work simply adds to the conclusion that there is an interaction between the total carbon in a sand system and a level of active effective volatiles and a loss-on-ignition maximum for successful casting production. Often overlooked in problem solving is the amount of volatiles, which must come from the bentonite, and typically this is classed as 10% of the AFS clay grade. To investigate this further, washed and unwashed tests reveal the true active volatiles content from the carbonaceous additive. Many foundries

<table>
<thead>
<tr>
<th>Sample</th>
<th>Description</th>
<th>SC Carbon</th>
<th>CS Carbon</th>
<th>SC Sulphur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>Blank</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Blank</td>
<td>Blank</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Standard</td>
<td>CaCO3 Standard</td>
<td>12.027</td>
<td>12.000</td>
<td>0.011</td>
</tr>
<tr>
<td>Standard</td>
<td>CaCO3 Standard</td>
<td>12.027</td>
<td>12.000</td>
<td>0.011</td>
</tr>
<tr>
<td>A</td>
<td>System sand 1</td>
<td>4.699</td>
<td>4.800</td>
<td>0.071</td>
</tr>
<tr>
<td>B</td>
<td>System sand 2</td>
<td>2.382</td>
<td>2.300</td>
<td>0.013</td>
</tr>
<tr>
<td>C</td>
<td>Natural graphite A</td>
<td>94.948</td>
<td>93.200</td>
<td>0.290</td>
</tr>
<tr>
<td>D</td>
<td>Natural graphite B</td>
<td>89.498</td>
<td>88.200</td>
<td>0.522</td>
</tr>
<tr>
<td>E</td>
<td>System sand 3</td>
<td>3.850</td>
<td>4.100</td>
<td>0.076</td>
</tr>
<tr>
<td>F</td>
<td>System sand 4</td>
<td>2.806</td>
<td>2.950</td>
<td>0.532</td>
</tr>
<tr>
<td>G</td>
<td>System sand 5</td>
<td>1.848</td>
<td>2.075</td>
<td>0.045</td>
</tr>
<tr>
<td>H</td>
<td>Raw coal import</td>
<td>70.614</td>
<td>67.300</td>
<td>0.859</td>
</tr>
<tr>
<td>I</td>
<td>Coal/Bentonite blend</td>
<td>50.108</td>
<td>50.700</td>
<td>0.705</td>
</tr>
</tbody>
</table>

Range of samples from both SC and CS units at one session

<table>
<thead>
<tr>
<th>Performance</th>
<th>Foundry</th>
<th>Foundry type</th>
<th>Total carbon</th>
<th>Sulphur</th>
<th>Volatiles</th>
<th>Lol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptable</td>
<td>A</td>
<td>H SG GI H</td>
<td>3.85</td>
<td>0.075</td>
<td>1.85</td>
<td>5.85</td>
</tr>
<tr>
<td>Poor</td>
<td>B</td>
<td>H GI M</td>
<td>2.80</td>
<td>0.054</td>
<td>1.72</td>
<td>4.03</td>
</tr>
<tr>
<td>Poor</td>
<td>C</td>
<td>H SG M</td>
<td>1.84</td>
<td>0.052</td>
<td>1.55</td>
<td>3.45</td>
</tr>
<tr>
<td>Acceptable</td>
<td>D</td>
<td>V SG GI L</td>
<td>3.56</td>
<td>0.076</td>
<td>2.03</td>
<td>6.04</td>
</tr>
<tr>
<td>Good</td>
<td>E</td>
<td>V SG GI L</td>
<td>4.65</td>
<td>0.078</td>
<td>2.25</td>
<td>6.50</td>
</tr>
<tr>
<td>Good</td>
<td>F</td>
<td>V SG GI H</td>
<td>4.90</td>
<td>0.065</td>
<td>2.25</td>
<td>6.10</td>
</tr>
<tr>
<td>Acceptable</td>
<td>G</td>
<td>H GI L</td>
<td>4.70</td>
<td>0.085</td>
<td>2.40</td>
<td>7.20</td>
</tr>
<tr>
<td>Good</td>
<td>H</td>
<td>V GI L</td>
<td>3.67</td>
<td>0.075</td>
<td>2.15</td>
<td>6.34</td>
</tr>
<tr>
<td>Good</td>
<td>I</td>
<td>H SG H</td>
<td>4.54</td>
<td>0.083</td>
<td>2.35</td>
<td>5.95</td>
</tr>
<tr>
<td>Good</td>
<td>J</td>
<td>V GI H</td>
<td>3.50</td>
<td>0.113</td>
<td>2.15</td>
<td>7.40</td>
</tr>
<tr>
<td>Good</td>
<td>K</td>
<td>V SG H</td>
<td>3.67</td>
<td>0.854</td>
<td>2.34</td>
<td>6.43</td>
</tr>
<tr>
<td>Acceptable</td>
<td>L</td>
<td>H GI M</td>
<td>3.60</td>
<td>0.064</td>
<td>1.95</td>
<td>5.95</td>
</tr>
<tr>
<td>Good</td>
<td>M</td>
<td>H SG H</td>
<td>5.20</td>
<td>0.073</td>
<td>2.35</td>
<td>6.40</td>
</tr>
<tr>
<td>Poor</td>
<td>N</td>
<td>H GI H</td>
<td>3.34</td>
<td>0.076</td>
<td>1.65</td>
<td>4.56</td>
</tr>
<tr>
<td>Acceptable</td>
<td>P</td>
<td>H SG GI M</td>
<td>3.54</td>
<td>0.075</td>
<td>2.10</td>
<td>6.34</td>
</tr>
<tr>
<td>Acceptable</td>
<td>Q</td>
<td>H SG GI M</td>
<td>3.15</td>
<td>0.084</td>
<td>1.83</td>
<td>7.20</td>
</tr>
<tr>
<td>Poor</td>
<td>R</td>
<td>H GI H</td>
<td>2.95</td>
<td>0.082</td>
<td>1.87</td>
<td>5.20</td>
</tr>
<tr>
<td>Poor</td>
<td>S</td>
<td>V GI M</td>
<td>2.87</td>
<td>0.075</td>
<td>1.76</td>
<td>5.60</td>
</tr>
</tbody>
</table>

H=Horizontal  V=Vertical  SG=Spheroidal graphite cast iron  GI=Grey iron  H=Heavy + 50 kgs  M=Medium +25 kgs  L=<25 kgs  Performance= scrap, surface finish, sand carryover and shot blast times  Lol=loss-on-ignition
are simply unwilling to move their loss-on-ignition numbers above 5%, which limits the active volatiles, which in turn limits casting performance.

Figure 8 shows the approximate levels of volatiles for good casting performance from results obtained in one foundry. Each foundry could construct its own graph based on the parameters selected. Obviously other factors come into play but it is clear that the quality active volatile release is one of the major players for casting excellence. The “classic” loss-on-ignition (LoI) to volatiles ratio of 3:1 still hold true in most cases and when further linked to total carbon levels the picture becomes clearer.

Clay-grade LoI is the difference between the washed and unwashed LoI tests. Adding this difference to total carbon will produce the total LoI. Importantly, it shows the correlation between the tests. The example listed below shows a clean sand system lacking active volatiles and low in total LoI.

Total carbon = 3.34%
Volatiles = 1.65%
LoI (unwashed system sand) = 4.81%
LoI (washed system sand) = 3.34%,
Difference = 1.47%
Total LoI = Total carbon + Difference

4 Other control methods

The Mass Balance predictive method is used to ensure heat losses after casting (burn out) are reacted to before pouring, and to ensure that additional additives are added or decreased ahead of heavier or lighter castings. This method finds favour in well organized foundries that control additive levels effectively. It allows for lower levels to be added as normal and larger additions ahead of the heavier casting load. This depends on the sand-to-metal ratio, but with all foundries aiming for maximum efficiency it makes good sense to understand how the system will react to pattern changes and varying heat loads.

This system can be incorporated into the sand plant computer system and can equally be used for manual adjustments, using what some foundries call the “traffic light” system. They use red to indicate heaviest castings on the program, amber for mid-range products and green for lighter heat loads on the system. Irrespective of the system, the important aspect is to be aware of the system, the heat loads proposed, and to be able to take action before corrective measures are required. Rushed changes based on “feel” can work but informed change is the safer, more positive approach.

4.1 Return sand control

This is one of the most neglected operating practices in the greensand foundries. For most foundry workers, what happens to sand after casting is a mystery. What manages to stay in the system simply re-appears for mulling, and so it goes on. Here is a massive area of potential saving, coupled with the knowledge that a well prepared return sand will be lower in temperature, higher in moisture (ideally at 2%+) and better developed in terms of bentonite and general condition.

A well-developed return sand is much easier to re-mull. In fact, lower addition levels will be required, which in turn leads to lower moisture in the system sand. With lower moisture levels, the conditions for a reducing atmosphere are better and, coupled with adequate carbon levels and active volatile content, this will ensure better performance and result in improved casting quality.

4.2 Visual casting examination – knockout

Casting knockout is another standard operating practice that often is overlooked as an area of potential quality control. The results of all calculations and control are available simply by looking critically at the resultant castings. The sand peel from the castings, the amount of sand carried over, and the colour of the castings is often a good early indicator of casting quality.

5 Conclusions

Greensand systems can be both simple and complex — simple in terms of additives and control; complex in
the amount of variables possible and the need for constant vigilance—but they are simply the most cost effective method for volume iron casting production.

The research shows that total carbon can be a very useful measuring and control tool for greensand systems, coupled with accurate volatiles and loss-on-ignition tests. Without exception the foundries categorised as acceptable in this research had total carbon figures in excess of 3%. In foundries categorised as good, it was no coincident that the volatiles and loss-on-ignition figures were also in what the author would describe as "a good area."

Foundries would do better to arm themselves with meaningful data regarding carbonaceous additives. Total carbon determination could include all aspects of a sand system, including raw materials, and this would simplify decision-making. Areas such as return sand and fines extraction could be monitored easily with better control.

All sand systems have differing moisture sensitivity. Using bentonite from known, approved sources coupled with correctly graded coal, with low ash content (less than 3%), ensures the coal does not complete with the bentonite for available water. The key for foundries is to understand the properties of raw materials they use, and to control the consistency. Once this has been established, it will be possible to rely on a minimum amount of additives to achieve the goal of consistent quality castings. Ensuring adequate carbonaceous levels is not difficult but for many foundries it still remains only a secondary focus. World-class performance is being demanded by casting buyers, and successful suppliers will need to ensure they operate “in the correct zone” with effective known source additives.

Fig.10: Large greensand castings with smooth surface

About the author:
Currently Coal/Clay Product Development Manager for the James Durrans Group based at Penistone, Sheffield, England. Educated to HND level Metallurgy (1968–1973), enhanced by training and early work experience in the former British Steel Foundry at Tollcross, Glasgow. Continued for 8 years as Works Metallurgist in several local steel foundries specializing in mould and core making, in resin bonded sand systems.

In 1978 an opportunity arose to join one of the leading consumable supply companies James Durrans and Sons Limited. Starting as a Technical Sales Representative covering Scotland, Ireland and Northern England was able to develop a wide knowledge base in re-carburisers, coatings, blackings and coal/clay products.

In 1994 promoted to Sales Manager, a position held until 2001 when several new specialist positions were created including Coal/Clay Product Development Manager which allows more focus on customer requirements and opportunities to visit customers worldwide. Involvement in manufacturing, raw material purchasing, and hands-on experience solving customer problems has lead to a greater understanding of process application and the ability to assist Greensand Foundries in reducing scrap levels and increasing productivity.

Fellow of the ICME and a member for 30 years and now concentrating on use of Coal/Clay Products and their critical role in producing iron castings worldwide. Awarded ICME Oliver Stubbs Gold Medal in 2007 and the British Foundry Prize in 2008.