The 2009 Ductile Iron Society Annual Meeting was held from June 3-5, at the Eden Resort & Suites in Lancaster, PA. Our meeting included a visit to Buck Company in Quarryville, PA. Thanks goes out to Dick McMinn, Mike Galvin and the rest of the staff of Buck Company, for organizing the tour of the foundry.

For those who attended the tour we were all given a gift manufactured by the foundry which included ductile iron, bronze and aluminum all fused together. Did anyone figure out how they did it? Thanks again to Buck Company for their generous hospitality.
The organizing of this meeting certainly went with some anxious moments. Thanks to all of our members who attended the meeting. Due to the economic climate in our industry, we just about were forced to cancel the meeting due to low registration. Then in the last few weeks leading up to the meeting, we ended up with 81 members and guests attending. Once again, THANKS to all those who attended and made it again a very successful meeting.

The Board of Directors held their meeting on Wednesday June 3 from 3pm till 5:30pm. The Board approved another $29,500 in funding for two new Research Projects for the fiscal year 2009/10. In 2009 the Ductile Iron Society completed two Research Projects #42 and # 43. Project #44 is still ongoing and should be completed by the end of 2009. The final report will be available in early 2010. More information is available on the DIS Website at www.ductile.org under the DIS Member Area, Research Activity in Progress. The Board also approved the Spring 2010 meeting to be held in Vancouver, British Columbia, Canada with planned tours of Robar Industries, Ltd. and Century Pacific Foundry Ltd. The Fall 2010 meeting is planned for Cleveland, Ohio with the emphasis on “Heavy Section Castings Symposium.”

The Board approved $8000 to be handed out in four-$2000 scholarships to be presented at the Foundry Education Foundation (FEF) Conference in Chicago at the Drake Hotel in November 2009. Also the Board approved revised by-laws for the Society which has not been updated in over 20 years.

The Society recognized and would like to thank the following retiring Board members for their dedicated service over the last three years;

Don Craig of Selee Corporation
Matt Liptak of Cadillac Castings
The Board approved the appointments of three new incoming directors as of July 1, 2009 serving for three years.

They are,

J. B. Brown of Bremen Castings
Dave Knapp of Glidewell Specialties Foundry Company
John Cameli of Tecpro Corporation

On Thursday, June 4th, the attendees were presented with nine great speakers. Their biographies are included with this edition on the left hand index side along with a summary of their presentation. At lunch, Joe Farrar, President of the Ductile Iron Society, and President of Farrar Corporation delivered the DIS Annual Report for 2008/09 to the members in attendance.

Here is a recap of that presentation.

“The past year has been one that we have not seen in many years. I am sure I don’t need to review all that has happened with you foundrymen since we are all affected by what is happening with our economy. This has also hit the Ductile Iron Society. Your Society has done everything this past year to contain spending and costs associated with running the Society. The Board of Directors approved
last June 2008 a small increase in dues, since they had not changed in over 10 years. This increase will help fund future Research Projects. The Society will end the 2008/09 fiscal year in the black. However, the Society has lost a few members since we last met in Las Vegas. This has not only affected the Foundry Producers but also our Associate Members. We also hope that many of our dropped members will return to the DIS after this economy turns around.

During this past year we have made some significant changes in the management of your society. The Ductile Iron Society continues to work closer with the Iron Casting Research Institute. Susie Lambert has now been our administrator for just about two years. Bruce Blatzer continues to assist during our meetings and Bob Bigge continues to play an active role on our Research Committee.

During this past year we held two general meetings. The first one was our annual meeting held in Milwaukee, WI with a tour of Kohler Industries with 99 attending. This was also a special meeting because we celebrated the 50th Anniversary of the Ductile Iron Society. The second meeting last fall was also a special meeting because it was the 4th Keith Millis Symposium in Las Vegas, NV. The attendance for the Symposium was 202.

Four Keith D. Millis scholarships were awarded at the 2008 Foundry Education Foundation Conference held on November 21, 2008 at the Drake Hotel in Chicago. They went to Joel Deibler of Penn State, Nathaniel James of the University of Northern Iowa, Kurt McCluskey of the University of Wisconsin-Platteville, and Steven Williams of the University of Alabama-Birmingham. Each student received $2500. Congratulations to our four students from the DIS.”

Also John (Chip) Keough, Chairman of the University Relations Committee, gave a short summary on a program they are working on. The Committee is going to produce T-Shirts for students planning on attending this year’s FEF Conference.
printed on the back, to help cover the production cost. He also announced to the members that they were searching for a caption for the front of the shirt. He challenged the group to be creative and think up a great caption and it would be finalized at the banquet that evening.

The Society would like to acknowledge the following new members since our last meeting in Las Vegas. They are Seneca Foundry and Kirk McCullough from Webster City, Iowa and Penticton Foundry in Penticton, British Columbia, Canada.

Joe Farrar (L) and Kirk McCullough (R) of Seneca Foundry

Please make a note on your calendar that our Fall 2009 meeting will be held at the Radisson Inn – Sharon in West Middlesex, PA on September 30 – October 2 with a tour of Hodge Foundry in Greenville, PA. For more information, please visit the DIS website at www.ductile.org and click on the “DIS/ICRI Fall 2009 joint meeting”.

See you all in September!

James N. Wood
Executive/Technical Director
Ductile Iron Society
Ductile Iron Annual Meeting
Speaker Bios

Thursday, June 4 Afternoon Session

PM CHAIRMAN GENE MURATORE PRESENTS
SPEAKER GIFT TO THORSTEN REUTHER

THORSTEN IS CURRENTLY THE TECHNICAL LEADER AT HOFMANN CERAMIC OUT OF GERMANY AND HAS BEEN THERE SINCE 2001. HIS MAIN ACTIVITIES ARE IN THE FIELDS OF RISERING AND GATING OF IRON CASTINGS. THORSTEN STARTED HIS CAREER WITH MOLTEM METAL IN THE STEEL PLANT IN BUDERUS IN WELZLAR, GERMANY IN 1986. AFTER ALL HIS STUDIES WERE COMPLETE HE WORKED FOR THE FOUNDRY FRITZ WINTER IN STADTALLENDORF, GERMANY. HE COMPLETED HIS DIPLOMA THESIS UNDER THE DIRECTION OF DR. ING MILAN LAMPIC.

THE DIS WELCOMES THORSTEN WHO IS HERE TO TALK ABOUT “FORMER THEORIES OF FILTRATION WHEN COMPARED WITH NEW COGNITIONS”
The Ductile Iron News

CHAIRMAN MURATORE PRESENTING
SPEAKER GIFT TO DR. KATHY HAYRYNEN


THE DIS WELCOMES BACK AGAIN KATHY WHO IS HERE TO TALK ABOUT “AGRICULTURAL APPLICATIONS OF AUSTEMPERED IRON COMPONENTS”

MIKE RIABOV

MIKE GRADUATED FROM THE MOSCOW INSTITUTE OF STEEL AND ALLOYS IN 1995 WITH HIS BACHELOR’S DEGREE IN METALLURGICAL ENGINEERING. MIKE THEN MOVED TO THE UNITED STATES AND CONTINUED HIS EDUCATION BY GRADUATING FROM THE UNIVERSITY OF NORTHERN IOWA IN 1999 WITH HIS MASTERS DEGREE IN INDUSTRIAL ENGINEERING. MIKE THEN WAS EMPLOYED BY CITATION CORPORATION IN BROWNTOWN, WI IN THE POSITION OF PLANT METALLURGIST FROM 1999 TO 2005. IN AUGUST OF 2005 MIKE THEN MOVED TO NEENAH FOUNDRY COMPANY SERVING AS THE PLANT METALLURGIST AND SINCE DECEMBER 2006 AS THE MANAGER OF TECHNICAL SERVICES.
THE DIS WELCOMES MIKE WHO IS HERE TO TALK ABOUT “EFFECTIVE METALLURGICAL INTERPRETATION OF DUCTILE IRON AT NEENAH FOUNDRY”

JIM MAJSAK RECEIVING HIS SPEAKER GIFT FROM CHAIRMAN GENE MURATORE

JIM IS CURRENTLY EMPLOYED AT POWERIT SOLUTIONS AS THE EAST COAST BUSINESS DEVELOPMENT ENGINEER. JIM IS RESPONSIBLE FOR SALES AND SUPPORT OF POWERIT’S SPARA EMS PRODUCT LINE, WHICH IS USED FOR DEMAND CONTROL, DEMAND RESPONSE AND REALTIME PRICE RESPONSE APPLICATIONS. JIM BRINGS OVER 2 DECADES OF EXPERIENCE AND KNOWLEDGE OF INDUSTRIAL AUTOMATION SYSTEMS INTEGRATOR HELPING CUSTOMERS STREAMLINE THEIR MANUFACTURING PROCESSES AND PRODUCTION SYSTEMS. JIM HAS MOST RECENTLY SPOKEN AT THE 13th ANNUAL OHIO ENERGY CONFERENCE HELD IN COLUMBUS, OH IN FEBRUARY 2009.

LARRY COLLINS

LARRY IS CURRENTLY EMPLOYED AT ENERNOC AS THEIR BUSINESS DEVELOPMENT MANAGER, SPECIALIZING IN DEMAND RESPONSE SOLUTIONS FOR COMMERCIAL AND INDUSTRIAL CONSUMERS IN THE PJM INTERCONNECTION TERRITORY. BEFORE JOINING ENERNOC, LARRY WAS A KEY ACCOUNT MANAGER FOR PPL UTILITIES AND SELECT ENERGY COMPANY. PRIOR TO THOSE SALES AND MARKETING POSITIONS, LARRY SERVED AS A PLANT ENGINEER WITH AMERICAN ELECTRIC POWER COMPANY. LARRY IS A MEMBER OF THE ASSOCIATION OF ENERGY ENGINEERS AND HOLDS THE CERTIFIED ENERGY MANAGER DESIGNATION FROM AEE.
Ductile Iron Annual Meeting Speaker Bios
Thursday, June 4 Morning Session

BRUCE BLATZER RECEIVES SPEAKER GIFT FROM CHAIRPERSON KATHY HAYRYNEN

BRUCE GRADUATED FROM THE UNIVERSITY OF ALABAMA IN TUSCALOOSA IN 1969 WITH HIS BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING AND IN 1973 HE OBTAINED HIS MBA IN MANAGEMENT FROM GEORGIA STATE UNIVERSITY IN ATLANTA. BRUCE IS CURRENTLY THE EXECUTIVE DIRECTOR OF THE IRON CASTING RESEARCH INSTITUTE AND HAS BEEN THERE SINCE 1996. BRUCE’S CAREER STARTED WITH U.S. PIPE IN 1968 THEN HE MOVED ON TO CATERPILLAR, LYNCHBURG FOUNDRY/INTERMET, AND THEN TO HIS CURRENT POSITION WITH ICRI. BRUCE BUILT A THERMAL ANALYSIS SYSTEM WITH LABVIEW SOFTWARE AND HARDWARE TO CHECK THE METALLURGICAL FINGERPRINT OF ICRI MEMBER IRONS. HE IS A PAST CHAIRMAN OF THE AFS CUPOLA COMMITTEE 8-F AND ALSO A MEMBER OF ASM, SAE, AND IS A CERTIFIED ENGINEER WITH ASQ.

THE DIS WELCOMES BRUCE WHO IS HERE TO TALK ABOUT “AN ICRI CASE STUDY”
DON RHODA RECEIVING SPEAKER GIFT
FROM KATHY HAYRYNEN


THE DIS WELCOMES DON WHO IS HERE TO TALK ABOUT “DUCTILE FOUNDRIES IN CHINA”

MARC KING WITH CHAIRMAN KATHY HAYRYNEN

MARC GRADUATED FROM MICHIGAN TECHNOLOGY UNIVERSITY IN 1996 WITH A BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING. MARC IS CURRENTLY THE METALLURGIST FOR HILER INDUSTRIES. HE HAS SERVED IN THE METALLURGICAL POSITION WITH SEVERAL FOUNDRIES IN HIS WORKING CAREER. HILER HAS TWO FOUNDRIES THAT ARE SHELL MOLDING, KINGSBURY CASTINGS DIVISION WHICH POURS DUCTILE IRON AND CARBIDIC DUCTILE IRON, AND THE ACCURATE CASTINGS DIVISION WHICH POURS GRAY IRON, WHITE IRON, Ni HARD, Ni RESIST, DUCTILE NiRESIST, AND A VARIETY OF BRASS AND BRONZE ALLOYS.

THE DIS WELCOMES MARC WHO IS HERE TO TALK ABOUT “THIN SECTION DI STUDY”
PAUL MIKKOLA RECEIVES SPEAKER GIFT
FROM KATHY HAYRYNEN


THE DIS WELCOMES PAUL WHO IS HERE TO TALK ABOUT “CREATING A VALUABLE TECHNOLOGY PORTFOLIO”
BRUCE BLATZER RECEIVES SPEAKER GIFT FROM CHAIRPERSON KATHY HAYRYNEN

BRUCE GRADUATED FROM THE UNIVERSITY OF ALABAMA IN TUSCALOOSA IN 1969 WITH HIS BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING AND IN 1973 HE OBTAINED HIS MBA IN MANAGEMENT FROM GEORGIA STATE UNIVERSITY IN ATLANTA. BRUCE IS CURRENTLY THE EXECUTIVE DIRECTOR OF THE IRON CASTING RESEARCH INSTITUTE AND HAS BEEN THERE SINCE 1996. BRUCE’S CAREER STARTED WITH U.S. PIPE IN 1968 THEN HE MOVED ON TO CATERPILLAR, LYNCHBURG FOUNDRY/INTERMET, AND THEN TO HIS CURRENT POSITION WITH ICRI. HE IS A PAST CHAIRMAN OF THE AFS CUPOLA COMMITTEE 8-F AND ALSO A MEMBER OF ASM, SAE, AND IS A CERTIFIED ENGINEER WITH ASQ.
CASTING INVESTIGATION

An ICRI Service Case Study

Bruce T. Blatzer
Executive Director
ICRI

- Unique foundry service organization
- Metallurgical Engineers
- On call as needed
- Timely technical assistance
- Other technical services
Goals

- Technology Transfer
- SERVICE to our members
Mission Statement

- Technical proficiency – low cost, high quality iron castings
Services (Meeting Needs)

- Plant visits
- Lab investigations
- Telephone consultations
- Email and internet discussion board
- Literature searches
- Operators, Technical, Special Meetings
- Surveys and projects
- Visits to member’s customers
- Training Classes, Eg. Spectrometer, cupola, iron pouring
Products

- Verbal and written communications
- Reports written for
  - Plant visits
  - Laboratory Investigations for defect analysis
  - Meetings
  - Surveys
  - Special Projects
Unique Products

- Spectrometer Proficiency Testing
- Thermal Analysis Audit
Interlaboratory Spectrometer Proficiency Testing

- Finishing 12th year
- Semi-annual
- Anonymity of labs
Thermal Analysis Audit
Typical Investigation

- Visual examination
- Photo documentation of the part
- Remove defective section
- Examination with binocular microscope
- Mount and prepare for metallographic exam
- Examine at up to 1000X magnification
- Etch sample if necessary
- Photograph, document findings and generate report
Tools for Defect Investigation
Casting as - received
View of crack
Two castings were submitted to ICRI lab
Visual examination, macro photos taken
Examination with binocular microscope
Defective area
- Removed
- Crack fracture completed on one casting
- Mounted
- Prepared for metallographic examination
- Examined via metallograph
- Photomicrographs
- Examination with scanning electron microscope

Report
Section containing crack removed and put back together
Sections after crack fracture completed and after carefully fitting the two pieces back together to study the crack geometry.
Removed section halves after fracture
Mounted Section

Crack goes through cored area.
Stitched photomicrograph of the cracked area.
Portion of Cracked Area

Etched photomicrograph at 100X. The matrix is fully pearlitic which conforms to the customer specification.
SEM photo showing flat protrusion on what should be a rounded surface
SEM Photo
## Flake Analysis Report

<table>
<thead>
<tr>
<th>Image</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
<th>Class 5</th>
<th>Class 6</th>
<th>Class 7</th>
<th>Class 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>47</td>
<td>102</td>
<td>65</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>41</td>
<td>87</td>
<td>74</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>55</td>
<td>92</td>
<td>48</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>48</td>
<td>83</td>
<td>60</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>49</td>
<td>96</td>
<td>53</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>0</td>
<td>71</td>
<td>240</td>
<td>460</td>
<td>300</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

|       | 0.00%   | 0.00%   | 6.63%   | 22.41%  | 42.95%  | 28.01%  | 0.00%   | 0.00%   |

Specification calls for size classes 4 through 6
Conclusions and Recommendations

- No foreign material found
- Suspicious flat protrusion
- Hardness was slightly below specification
- 207 HB vs spec range of 217 – 269 HB
- Repair corebox
- Make new castings
- Retest
Suspicious Protrusion

Probably formed by core box ejector pin not fully retracted.
DIS Members can take advantage of ICRI Services

- Limited time offer, until October 31, 2009
- Confidential (always)
Ductile Iron Society

DIS

Welcome to Buck Company
DON RHODA RECEIVING SPEAKER GIFT
FROM KATHY HAYRYNEN


THE DIS WELCOMES DON WHO IS HERE TO TALK ABOUT “DUCTILE FOUNDRIES IN CHINA”
A sample of **Zhongwen**

- **Ni Hao !**
- **Ni Hao Ma ?**
- **Hen Hao !**
- **XieXie !**

- **Hello !**
- **How Are You ?**
- **Very Good !**
- **Thank You !**
A view of Ductile Iron foundries in China

by Don Rhoda, Toledo, Ohio
Dana, retired process metallurgist
Steering Suspended Axle
Ag Tractors from 80 to 360 Horsepower

www.dana.com/offhighway_systems
### THE SIX ALLOY FORMULAS AND THEIR PROPERTIES IN KAO GONG JI

<table>
<thead>
<tr>
<th>名称及内容</th>
<th>含铜量 (Cu%)</th>
<th>含锡量 (Sn%)</th>
<th>颜色</th>
<th>抗拉强度 (Kg/mm²)</th>
<th>硬度 (HB)</th>
<th>延伸率 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>钟鼎之齐: 金之分其金,而锡居一</td>
<td>85.71</td>
<td>14.29</td>
<td>橙黄</td>
<td>32~34</td>
<td>140~150</td>
<td>6~8</td>
</tr>
<tr>
<td>斧斤之齐: 金之五分其金,而锡居一</td>
<td>83.33</td>
<td>16.67</td>
<td>浅黄</td>
<td>34~36</td>
<td>150~170</td>
<td>1~6</td>
</tr>
<tr>
<td>戈戟之齐: 金之四分其金,而锡居一</td>
<td>80</td>
<td>20</td>
<td>黄白</td>
<td>30~32</td>
<td>190~210</td>
<td>1~3</td>
</tr>
<tr>
<td>大刃之齐: 金之三分其金,而锡居一</td>
<td>75</td>
<td>25</td>
<td>灰白</td>
<td>27~28</td>
<td>250~110</td>
<td>&lt;1</td>
</tr>
<tr>
<td>齿杀矢之齐: 金之五分其金,而锡居一</td>
<td>71.43</td>
<td>28.57</td>
<td>银灰</td>
<td>25~27</td>
<td>&gt;300</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>鉴燧之齐: 金,锡半</td>
<td>66.66</td>
<td>33.33</td>
<td>银白</td>
<td>23~25</td>
<td>&gt;300</td>
<td>—</td>
</tr>
</tbody>
</table>
Transformation

- New China (PRC) in Transformation
  - 16% of the world speaks **English**
  - 16% of the world speaks **Mandarin**
- Decades of spectacular $$$ growth
- Openness to the west
- Began with Mao Zedong 1949
- 2008 Beijing Olympics - **National Pride**
China's Challenges

- Population movement - Infrastructure
- 200 million unemployed (roughly 1/2 of U.S population or England & France combined)
- Poorest 10% owns 2% of assets
- Richest 10% owns 40% of assets
- Entered W.T.O. 2001 - import barriers
- "Century of Humiliation" - Influence
Energy & Ground Vehicles

- 1990 = 6.3 million G.V.
- 2003 = 36.0 million G.V.
- 2020 = 131.6 million G.V. (est.)
- U.S. 800 cars/1000
- China 50 cars/1000
- Coal (2/3 of country’s energy)
- Electricity
China Mainland - Foundries

- Dongfeng in XianFan
- HuiJin in Jinan City
- Tianrun Crankshaft in Wendeng
- CMI Group in Suzhou (DISA)
- W.C.L. in ChangShu - DeS
- Chuwei in Suizhou City
Types of Foundries

- Russian Built - S.O.E, FAW, DongFeng
- Re-Furbished, New Capital - Huijin
- “Mom & Pop” - Small, Floor, Cupola
- Newest, Up-to-Date - CMI, OMR, Kieriu
F.A.W. - First Auto Works

- First Foundry: 200,000 T/Y DI/GI
- Second Foundry: 60,000 T/Y DI
- Wuxi Subsidiary: 50,000 T/Y DI/GI
- Dalian Subsidiary: 20,000 T/Y DI/GI
- Special Foundry: 7,000 T/Y DI
- United Casting: 7,000 T/Y AL
- Non-Ferrous: 5,000 T/Y AL
- Foundry Research: Tech. Center
FAW Foundry Co., Ltd.
First Casting Plant
Critics Complaint

Superior R & D:
Critics Complaint

Superior ???

Recieve
&
Duplicate
欢迎铸造界同仁、朋友光临吉林省铸造协会年会
Thank You - Good Bye

XieXie - Zaijian!
Marc King graduated from Michigan Technology University in 1996 with a Bachelor of Science in Metallurgical Engineering. Marc is currently the metallurgist for Hiler Industries. He has served in the metallurgical position with several foundries in his working career. Hiler has two foundries that are shell molding, Kingsbury Castings Division which pours ductile iron and carbidic ductile iron, and the Accurate Castings Division which pours gray iron, white iron, Ni hard, Ni resist, ductile Ni-resist, and a variety of brass and bronze alloys.

The DIS welcomes Marc who is here to talk about “Thin Section DI Study”
Improving Inoculation in Thin Sectioned Ductile Iron Castings

Marc King
Metallurgist
Hiler Industries - LaPorte, IN

Introduction:

The Kingsbury Castings Division of Hiler Industries has been producing ductile iron using the shell process for molding since the middle 1970’s. Shell molded castings are often intricate designs, requiring great attention to detail when melting, molding and pouring. Castings with thin sections, less than ¼ inch thick, are common due to the ability of the shell mold to remain stable during molding and pouring. Thin knife gates are often used to allow for cast parts to break off easily and cleanly. Chill defects are a major concern when castings less than 1/8 inch thick are poured.

Focusing on improving inoculation in order to reduce chill became the mandate for our foundry. Periodically I would pour and analyze chill wedges from the last iron poured to benchmark a baseline of how well our inoculation practice was working. Once a baseline was established, the effects of changing the inoculation practice could be determined.

The goal was to improve inoculation without altering the final iron chemical composition, particularly the silicon, sulfur and magnesium levels. Various proprietary inoculants were tested over the last 2 years. The results of some tests were positive while others were neutral or negative.

Additional tests combining an oxy-sulfide containing inoculant with both our standard and modified inoculation practices were proposed. The oxy-sulfide containing inoculant is called Sphere-o-Dox S, a patented product (U.S. Patent 6,293,988B1) produced by ASI International, Ltd. This report will briefly summarize the results of those trials.

Purpose of Study:

Improve the current inoculation practice in ferritic grade ductile iron by using ASI’s Sphere-O-Dox S either as an addition and/or partial substitution of the current calcium-bearing 75% ferrosilicon inoculant, Calsifer 75. Other modifications in inoculation included a combination of VP216 and Sphere-o-dox S Inoculants.

Description of Test:

The tests were conducted on a ferritic ductile-base iron. The ductile-base iron was melted in two 6000 lb, medium frequency, coreless induction furnaces. The base iron was magnesium treated by the sandwich method, using steel punchings for a cover over the magnesium ferrosilicon, in a 1200 lb batch weight open tundish ladle. Typically 19 lb of 6% 5R2 MgFeSi is used with 8 lb of cover steel for a 1200 lb batch in the treatment vessel.

5R2 Magnesium Ferrosilicon Specifications

<table>
<thead>
<tr>
<th>%Mg</th>
<th>%Si</th>
<th>%Ce</th>
<th>Total % Rare Earth</th>
<th>%Ca</th>
<th>%Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0 – 6.0</td>
<td>43 - 48</td>
<td>0.45 – 0.60</td>
<td>0.75 – 1.15</td>
<td>0.8 – 1.3</td>
<td>1.2 Max</td>
</tr>
</tbody>
</table>

The treated iron was then split into two 600 lb. open lip pouring ladles, inoculated and transferred to the pouring line. One ladle served a control group using the standard inoculation practice of 5 lb of Calsifer 75 FeSi inoculant per 600 lb ladle. (Thin section work requiring additional chill reduction uses 17 g Germalloy K15 cast inoculant inserts in the mold.) The other one was used for experimental modified practice.

A W3 chill wedge, a nodularity coupon and a chilled iron disk were poured at the end of the ladle to document the results. The chill wedges were cooled in the mold to prevent pearlite formation.
Proprietary Inoculant Compositions:

**Calsifer 75: 75% Calcium Bearing Ferrosilicon Inoculant**

<table>
<thead>
<tr>
<th>%Si</th>
<th>%Al</th>
<th>%Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>74 - 79</td>
<td>0.75 – 1.5</td>
<td>1.0 – 1.5</td>
</tr>
</tbody>
</table>

**VP216: High Aluminum Inoculant**

<table>
<thead>
<tr>
<th>%Si</th>
<th>%Al</th>
<th>%Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>68 -73</td>
<td>3.2 – 4.5</td>
<td>0.3 – 1.5</td>
</tr>
</tbody>
</table>

**Sphere-o-doxy S: Oxysulfide Inoculant Booster**

<table>
<thead>
<tr>
<th>%Si</th>
<th>%Oxy sulfides (Ca + Al + S + O2 + Mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>36 – 37</td>
<td>32 - 35</td>
</tr>
</tbody>
</table>

Test Procedure: Standard and Experimental Inoculation Practice

<table>
<thead>
<tr>
<th>Group</th>
<th>Standard Inoculation</th>
<th>Experimental Inoculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5 lb Calsifer 75</td>
<td>5 lb Calsifer, 0.6 lb Sphere-o-doxy S Inoculant</td>
</tr>
<tr>
<td>2</td>
<td>5 lb Calsifer 75</td>
<td>5 lb Calsifer, 0.3 lb Sphere-o-doxy S Inoculant</td>
</tr>
<tr>
<td>3</td>
<td>5 lb Calsifer 75</td>
<td>4 lb Calsifer, 1 lb Sphere-o-doxy S Inoculant</td>
</tr>
<tr>
<td>4</td>
<td>5 lb Calsifer 75</td>
<td>5 lb VP216, 1 lb Sphere-o-doxy S Inoculant</td>
</tr>
<tr>
<td>5</td>
<td>5 lb Calsifer 75</td>
<td>5 lb Calsifer, 1 lb Sphere-o-doxy S Inoculant</td>
</tr>
</tbody>
</table>

Chemical Analysis:

Chemical Analysis was obtained using the following equipment: Spectro Max CCD Spectrometer and a LECO CS 300 Carbon and Sulfur Analyzer.

Chemical Analysis: *Standard Inoculation Ladles*

<table>
<thead>
<tr>
<th>#</th>
<th>C</th>
<th>Si</th>
<th>S</th>
<th>Mg</th>
<th>Mn</th>
<th>Cu</th>
<th>P</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>Ti</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.65</td>
<td>2.58</td>
<td>.009</td>
<td>.038</td>
<td>.28</td>
<td>.089</td>
<td>.019</td>
<td>.032</td>
<td>.003</td>
<td>.035</td>
<td>.005</td>
<td>.011</td>
</tr>
<tr>
<td>2</td>
<td>3.62</td>
<td>2.63</td>
<td>.011</td>
<td>.040</td>
<td>.28</td>
<td>.092</td>
<td>.018</td>
<td>.031</td>
<td>.003</td>
<td>.029</td>
<td>.005</td>
<td>.012</td>
</tr>
<tr>
<td>3</td>
<td>3.63</td>
<td>2.61</td>
<td>.009</td>
<td>.041</td>
<td>.27</td>
<td>.090</td>
<td>.018</td>
<td>.032</td>
<td>.003</td>
<td>.030</td>
<td>.005</td>
<td>.011</td>
</tr>
<tr>
<td>4</td>
<td>3.65</td>
<td>2.58</td>
<td>.009</td>
<td>.037</td>
<td>.27</td>
<td>.057</td>
<td>.016</td>
<td>.035</td>
<td>.004</td>
<td>.024</td>
<td>.005</td>
<td>.013</td>
</tr>
<tr>
<td>5</td>
<td>3.66</td>
<td>2.57</td>
<td>.008</td>
<td>.033</td>
<td>.28</td>
<td>.058</td>
<td>.017</td>
<td>.035</td>
<td>.003</td>
<td>.027</td>
<td>.005</td>
<td>.012</td>
</tr>
</tbody>
</table>

*Standard Inoculation: 5 lb Calsifer 75/600 lb Ladle*

Chemical Analysis: **Experimental Inoculation Ladles**

<table>
<thead>
<tr>
<th>#</th>
<th>C</th>
<th>Si</th>
<th>S</th>
<th>Mg</th>
<th>Mn</th>
<th>Cu</th>
<th>P</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>Ti</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.61</td>
<td>2.80</td>
<td>.013</td>
<td>.040</td>
<td>.25</td>
<td>.12</td>
<td>.018</td>
<td>.033</td>
<td>.003</td>
<td>.034</td>
<td>.005</td>
<td>.013</td>
</tr>
<tr>
<td>2</td>
<td>3.65</td>
<td>2.75</td>
<td>.012</td>
<td>.037</td>
<td>.24</td>
<td>.12</td>
<td>.018</td>
<td>.032</td>
<td>.002</td>
<td>.033</td>
<td>.005</td>
<td>.012</td>
</tr>
<tr>
<td>3</td>
<td>3.61</td>
<td>2.64</td>
<td>.014</td>
<td>.044</td>
<td>.26</td>
<td>.11</td>
<td>.018</td>
<td>.035</td>
<td>.003</td>
<td>.042</td>
<td>.005</td>
<td>.014</td>
</tr>
<tr>
<td>4</td>
<td>3.68</td>
<td>2.51</td>
<td>.012</td>
<td>.033</td>
<td>.28</td>
<td>.06</td>
<td>.017</td>
<td>.036</td>
<td>.003</td>
<td>.026</td>
<td>.005</td>
<td>.015</td>
</tr>
<tr>
<td>5</td>
<td>3.67</td>
<td>2.62</td>
<td>.012</td>
<td>.039</td>
<td>.27</td>
<td>.06</td>
<td>.016</td>
<td>.032</td>
<td>.003</td>
<td>.025</td>
<td>.005</td>
<td>.014</td>
</tr>
</tbody>
</table>

**Experimental Inoculation/600lb Ladle:**

- Ladle 1: 5lb Calsifer + 0.6 lb Sphere-o-doxy S
- Ladle 2: 5lb Calsifer + 0.3 lb Sphere-o-doxy S
- Ladle 3: 4lb Calsifer + 1 lb Sphere-o-doxy S
- Ladle 4: 5lb VP216 + 1 lb Sphere-o-doxy S
- Ladle 5: 5lb Calsifer + 1 lb Sphere-o-doxy S

Note: A comparison of the elements most affected by the experiments shows a slight increase in Sulfur levels, but still within our specification. Both Silicon and Magnesium levels were unaffected by the experimental inoculation. No other elements were affected by the experimental practice.
**Chill Wedge Analysis:**

A W3 chill wedge was poured in each ladle of this study. Chill depth of each experimental sample was compared to a standard poured simultaneously. The wedge samples were broken in half. The chill depths were recorded. The samples were then prepared for metallographic examination. The nodularity and nodule count were taken at both the thicker body, and at the tip, to compare effectiveness in varying section size.

**W3 Chill Wedge:** ¾ in. wide at top, 1 ½ in. taper height, and 3” Long with a 1 inch riser

---

**Chill Depth Analysis (Inches):**

<table>
<thead>
<tr>
<th>Ladle #</th>
<th>Standard</th>
<th>Experiment</th>
<th>Difference</th>
<th>% Chill Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.35</td>
<td>.20</td>
<td>.15</td>
<td>43</td>
</tr>
<tr>
<td>2</td>
<td>.46</td>
<td>.30</td>
<td>.16</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>.61</td>
<td>.42</td>
<td>.19</td>
<td>31</td>
</tr>
<tr>
<td>4</td>
<td>.38</td>
<td>.10</td>
<td>.28</td>
<td>74</td>
</tr>
<tr>
<td>5</td>
<td>.37</td>
<td>.20</td>
<td>.17</td>
<td>46</td>
</tr>
</tbody>
</table>

**Note:** The results of Chill Depth illustrated that Chill was reduced by 31 to 74%. The greatest reduction in chill depth occurred when 1 lb of Sphere-o-dox S was combined with 5 lbs of VP216.

**Macro View Comparison of the Broken Wedges:**

- **Group 1**
- **Group 2**
- **Group 3**
- **Group 4**
- **Group 5**

Standard Inoculation: 5 lb Calsifer 75/600lb Ladle

Experimental Inoculation/600 lb. Ladle:
- Ladle #1: 5lb Calsifer + 0.6 lb Sphere-o-dox S
- Ladle #2: 5lb Calsifer + 0.3 lb Sphere-o-dox S
- Ladle #3: 4lb Calsifer + 1 lb Sphere-o-dox S
- Ladle #4: 5lb VP216 + 1 lb Sphere-o-dox S
- Ladle #5: 5lb of Calsifer + 1 lb Sphere-o-dox S
Chill Wedge Microstructure Analysis:
Nodule density is a good indication of inoculation effectiveness. Photomicrographs were taken at both the Tip and the Top of the chill wedge to illustrate inoculation effectiveness throughout the change in section thickness. The inoculation effectiveness can be compared visually between the sample groups.

**Group 1 - Std**: 5 lb Calsifer / **Exp**: 5 lb Calsifer + 0.6 lb Sphere-o-dox S

**Group 2 - Std**: 5 lb Calsifer / **Exp**: 5 lb Calsifer + 0.3 lb Sphere-o-dox S
Group 3 – Std: 5 lb Calsifer / Exp: 4 lb Calsifer + 1 lb Sphere-o-dox S

- Std: Top of Wedge, Unetched, 100X
- Std: Tip of Wedge, Unetched, 100X

Group 3 - Std

- Exp: Top of Wedge, Unetched, 100X
- Exp: Tip of Wedge, Unetched, 100X

Group 3 - Exp

Group 4 – Std: 5 lb Calsifer / Exp: 5lb VP216 + 1 lb Sphere-o-dox S

- Std: Top of Wedge, Unetched, 100X
- Std: Tip of Wedge, Unetched, 100X

Group 4 - Std

- Exp: Top of Wedge, Unetched, 100X
- Exp: Tip of Wedge, Unetched, 100X

Group 4 - Exp
Group 5 – Std: 5 lb Calsifer / Exp: 5 lb Calsifer + 1 lb Sphere-o-dox S

<table>
<thead>
<tr>
<th>Group</th>
<th>Ladle</th>
<th>% Nod.</th>
<th>NC Tip</th>
<th>Dif Tip</th>
<th>NC Middle</th>
<th>Dif Mid</th>
<th>NC Top</th>
<th>Dif Top</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Std.</td>
<td>95</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Exp.</td>
<td>95</td>
<td>300</td>
<td>50%</td>
<td>175</td>
<td>17%</td>
<td>150</td>
<td>20%</td>
</tr>
<tr>
<td>2</td>
<td>Std.</td>
<td>91</td>
<td>250</td>
<td></td>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Exp.</td>
<td>93</td>
<td>300</td>
<td>20%</td>
<td>175</td>
<td>17%</td>
<td>150</td>
<td>20%</td>
</tr>
<tr>
<td>3</td>
<td>Std.</td>
<td>92</td>
<td>175</td>
<td></td>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Exp.</td>
<td>94</td>
<td>275</td>
<td>57%</td>
<td>175</td>
<td>17%</td>
<td>150</td>
<td>20%</td>
</tr>
<tr>
<td>4</td>
<td>Std.</td>
<td>95</td>
<td>200</td>
<td></td>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Exp.</td>
<td>95</td>
<td>300</td>
<td>50%</td>
<td>200</td>
<td>33%</td>
<td>150</td>
<td>20%</td>
</tr>
<tr>
<td>5</td>
<td>Std.</td>
<td>93</td>
<td>200</td>
<td></td>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Exp.</td>
<td>95</td>
<td>250</td>
<td>25%</td>
<td>175</td>
<td>17%</td>
<td>150</td>
<td>20%</td>
</tr>
</tbody>
</table>

**Note:** Nodule counts were increased by 20 to 57% at the tip of the wedge when Sphere-o-dox S was added with either Calsifer 75 or VP216.

**Hiler Industries Metallographic Analysis Instruments:**

**Metallurgical Laboratory:** (Used for all metallographic analysis in this report.)
Olympus PME3 with digital camera and IA32 Analysis Software.

**Nodularity Coupon Analysis at the pouring floor:** (%Nodularity – Every Ladle Poured)
Olympus GX51 with digital camera and IA32 Analysis Software.
**Nodularity Coupon Microstructure Analysis:**
Nodularity coupons poured along with the chill wedge were used to investigate inoculation effectiveness in a sample with uniform thickness.

**Nodularity Coupon Sample Mold: Shell Sand**

Nodularity Coupons are made from shell sand. The samples are 11/16 inch thick.

**Nodularity Coupon Microstructure Analysis:**

**Group 1 – Std: 5 lb Calsifer / Exp: 5 lb Calsifer + 0.6 lb Sphere-o-doxx S**

[Images of microstructures for Std: Unetched, 100X and Exp: Unetched, 100X]

**Group 2 – Std: 5 lb Calsifer / Exp: 5lb Calsifer + 0.3 lb Sphere-o-doxx S**

[Images of microstructures for Std: Unetched, 100X and Exp: Unetched, 100X]

**Group 3 – Std: 5 lb Calsifer / Exp: 4 lb Calsifer + 1 lb Sphere-o-doxx S**

[Images of microstructures for Std: Unetched, 100X and Exp: Unetched, 100X]
Nodularity Coupon Microstructure Analysis: (Continued)

Group 4 – Std: 5 lb Calsifer / Exp: 5lb VP216 + 1 lb Sphere-o-dox S

![Std: Unetched, 100X](image1)

![Exp: Unetched, 100X](image2)

Group 5 – Std: 5 lb Calsifer / Exp: 5 lbs Calsifer + 1 lb Sphere-o-dox S

![Std: Unetched, 100X](image3)

![Exp: Unetched, 100X](image4)

Nodularity Coupon Metallographic Analysis

<table>
<thead>
<tr>
<th>Group</th>
<th>Ladle</th>
<th>% Nod.</th>
<th>Nodule Count</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Std.</td>
<td>95</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Exp.</td>
<td>97</td>
<td>175</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>Std.</td>
<td>91</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Exp.</td>
<td>93</td>
<td>150</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Std.</td>
<td>92</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Exp.</td>
<td>97</td>
<td>150</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Std.</td>
<td>93</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Exp.</td>
<td>95</td>
<td>175</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>Std.</td>
<td>95</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Exp.</td>
<td>97</td>
<td>150</td>
<td>20</td>
</tr>
</tbody>
</table>

Note: Nodule count was increased in each of the experimental groups.
Chill Wedge Tip Matrix Microstructure Analysis

The metal at the tip of the chill wedge represents an experimental thin sectioned casting due to the sensitivity for carbide formation. Investigation of the chill wedge tip region is critical for determining inoculation effectiveness. Increased Nodule Count and decreased Carbide formation at the tip of the chill wedge are indicators of increased inoculation potency. The ability of the enhanced inoculation to increase nodule count at the tip of the chill wedge was illustrated in a previous section of this report by investigating the unetched samples. The polished chill wedge samples were nital etched and the iron carbide formation at the tip was examined at 500X Magnification to investigate carbide formation. The following photomicrographs illustrate the dual benefit of the inoculant enhancer to increase nodule count and decrease carbide formation at the tip of the chill wedge.

Group 4 – Std: 5 lb Calsifer

![Unetched, 100X Magnification](image1)

![Nital Etched, 500X Magnification](image2)

Group 4 – Exp: 5 lb VP216 + 1 lb Sphere-o-dox S

![Unetched, 100X Magnification](image3)

![Nital Etched, 500X Magnification](image4)

Note: Nodule count is significantly increased and carbide formation is greatly reduced with the use of the high aluminum inoculant VP 216 combined with the inoculant enhancer Sphere-o-dox S in the tip of the chill wedge.
**Group 5 – Std: 5 lb Calsifer**

![Unetched, 100X Magnification](image1) ![Nital Etched, 500X Magnification](image2)

**Group 5 – Exp: 5 lb Calsifer + 1 lb Sphere-o-dox S**

![Unetched, 100X Magnification](image3) ![Nital Etched, 500X Magnification](image4)

**Note:** Nodule count is significantly increased and carbide formation is greatly reduced with the use of the calcium containing Calsifer 75 inoculant combined with the inoculant enhancer Sphere-o-dox S in the tip of the chill wedge.

**Summary:**

The reduced chill depth, increased nodule count, and reduced carbide formation in the chill wedges poured from experimental inoculation ladles, illustrated the ability of oxysulfide inoculants to be powerful inoculation enhancement tools. The addition of oxysulfide based Sphere-o-dox S inoculant booster in each of the experimental ladles reduced the chill depth, increased the nodule count and reduced carbide formation, compared to the standard inoculation method.

Nodule count was increased throughout the thickness of the broken chill wedge sections in the oxysulfide inoculant enhanced experimental samples compared to the standard inoculation sample. This indicates the ability of the oxysulfide inoculant to increase nodule count in 0-0.75 in thick sections.

The nodularity coupon represents a sample of constant thickness with no sections under ¼ inch thick. Nodule count was increased in the nodularity coupons of each of the oxysulfide inoculant enhanced samples.

The etched chill wedges from test Groups 4 and 5 illustrated a reduction in iron carbide formation at the end of the wedge tip in the samples using oxysulfide inoculant additions. The greatest reduction in carbide formation occurred when 1 lb of Sphere-o-dox S oxysulfide inoculant was added to 5 lbs of VP216 high aluminum inoculant proving the inoculation potency of both products.

Comparing the results from test Groups 1, 2, and 5 showed that the inoculation enhancement increased as the percentage of oxysulfide inoculant increased. It is believed that the amount of inoculant enhancer could be trimmed to reduce iron carbide formation in specific castings, creating flexibility in the use of this product combined with the existing foundry inoculation practice.

The results of test Group 3 illustrated that the amount of calcium bearing post inoculant could be lowered by 20% combined with oxysulfide inoculant to increase the inoculation effectiveness over that of the standard practice.
Test Group 4 showed that the combination of calcium bearing/high aluminum inoculant VP216 with the oxysulfide containing Sphere-o-dox S inoculant proved to be very effective with lowering the chill depth, increasing the nodule count and almost eliminating iron carbide formation at the tip of the test chill wedge. This combination will be further tested to determine if it will eliminate carbide formation in thin section work that is currently being heat treated with a carbide annealing cycle.

The oxysulfide inoculation enhancement in the experimental sets occurred without significant changes to the final chemical analysis of the ductile iron. Increasing inoculation potential without significantly altering %C and %Si will improve melt chemistry control if higher CE returns cannot be properly segregated.

Sphere-o-dox S will cause a slight increase in sulfur, and may require a slightly higher magnesium addition to prevent the formation of vermicular graphite.

Conclusions:

This study was performed to benchmark and improve the inoculation of ductile iron for thin-walled castings at Hiler Industries – Kingsbury Castings Division. Calcium bearing 75% ferrosilicon inoculant and high aluminum ferrosilicon inoculant were both combined with oxysulfide inoculant, and the following conclusions can be deduced:

- Chill was reduced by 31 to 74% with the greatest chill reduction occurring when 1 lb of Sphere-o-dox S was added to 5 lb of VP216.
- A significant increase in Nodule count was observed, an increase of 17 to 40%, whether added with the standard 75% ferrosilicon or the VP 216.
- It appears due to the results, i.e. elimination of chill and improved nodule count, that the late in-mold inoculation may not be required.
- Test Group 3 showed that the amount of calcium bearing post inoculant could be lowered by 20% combined with Sphere-o-dox S inoculant to increase the inoculation effectiveness over that of the standard practice. This may prove effective in reducing shrinkage in heavy section castings while still maintaining high nodule count
- Etched chill wedge samples verified that carbide formation was significantly reduced when using the Sphere-o-dox S inoculation booster.
- The inoculation enhancement occurred without major changes to the final chemical analysis of the ductile iron. This fact makes it less disrupting to melt chemistry control than raising carbon or silicon levels.

No physical tests were performed on the enhanced inoculation iron versus the standard practice, but this is something that I wish to investigate in the future. The results of this testing warrant further production analysis to improve the quality of the ductile iron casting process at Kingsbury Castings.

No tests were performed on other iron types, but the results show promise for investigating the use of oxysulfide containing inoculant in thin sectioned gray iron applications produced at our Accurate Castings Division.

Author:

Marc King
Metallurgist
Hiler Industries

Phone: 219-393-3122 ext. 3302
Email: mking@hilerindustries.com

Date Completed: 7-17-09

Presented: DIS Meeting- June 4, 2009; Lancaster, PA
PAUL MIKKOLA RECEIVES SPEAKER GIFT FROM KATHY HAYRYNEN


THE DIS WELCOMES PAUL WHO IS HERE TO TALK ABOUT “CREATING A VALUABLE TECHNOLOGY PORTFOLIO”
Picking a TECHNOLOGY portfolio and Climate Change

Paul Mikkola

(Slide 1)

Our industry faces many challenges as we look to the future. They will directly affect our foundry operations.

It goes without saying that increased energy costs and economy has impacted everyone here. On top of that, we have many pushing climate change approaches that will greater challenges ahead.

The focus today is to learn how to select and apply technology into your operations which will result in a competitive advantage.

Our past experience has shown that often new technology does not always deliver what it promises and results in reductions in equipment utilization, variables in quality resulting in financial lose. On the other hand Technology is also the key to our future but how do we select the right ones?

Let me be clear – maintaining the “status quo” will put you out of business but so will ill-conceived approaches to make major changes to your operation. To be innovative and creative not only takes your effort, leadership and passion, it also needs to be encouraged and nurtured by the environment or culture at your company. (Slide 2)

The single most important thing your company can do is to establish a culture in which creativity will flourish is to have sound corporate values.

Clashes between values and action can permanently taint a creative atmosphere. Once lost it is nearly impossible to recover. Foundries with detailed bureaucratic work rules and operation procedures can sometime create barriers to innovation.

We all know variation is our largest enemy to successful manufacturing, but so is a concentration of power to police the “status quo”. I have seen technical experts withhold knowledge as a misuse of their power and somewhat a job protection in these organizations.

Let’s treat mistakes and errors as just delays in the road to success rather than looking for a goat to blame.

Poor management also hides behind 6-sigma, ISO certification or even Sarbanes-Oxley to quell the innovative atmosphere.

What we want is a trusting, self-managing organization that works to an internalized set of professional standards.
But let me also make it clear that engineers who constantly miss goals involving implementation, cost, and timing of new technology will shrink your company. They cannot be tolerated and need guidance to improve.

We need to learn and understand the dynamics of innovation, and application of technology. Teaching an elephant to dance is never easy, but that’s the task ahead of us if we are to prosper.

Therefore, we all need to push our companies to reward the right behavior. Many of our foundries seem to be possessed with financial reliability and most favor reliable, predictable, but often meaningless results. These companies are likely to hire engineers to police the current system of methods and procedures.

I favor people who are comfortable handling fuzzy data, using their judgment and creating a sense of purpose in the foundry. What I see that we need is to stop promoting managers based on consistency of their track record and start promoting them for breaking out of the box. Don’t you want your company and people to be unique?

It would be great if foundries measured and rewarded their top leaders on how imaginative they are. I would think imaginative leaders would have the courage to find new ideas and lead people to take more educated risks. I predict these are the traits of future successful foundries. Maybe there would be more foundries in Fortune magazine’s “Top Places to Work”.

**How do we get there? Let’s start here…..**

A very good question to ask, as you look at each of your areas of your operations, would be. How many operations or techniques did not exist five years ago? *(Slide 3)* That would give you a clue on how progressive you are.

*(Slide 4)*

We have all hear it “Business is too much focused on the short-term profits and they weren’t spending enough for the future”. In fact your company compensation systems may create a short-term disincentive to take on the cost of transition to new technology that is why Motorola waited too long to shift from analog to digital phone systems even if that is what the customer wanted. They almost lost it....... 6Ω and all.

I am going to relate an experience with technical innovation and you can all relate to similar experiences in your companies.

I will attempt to give you a road map to follow. Charting your own courses are the first brave steps on the road to leadership. I hope that will help each of you on the job.

Following that, I will share some facts regarding the threat of climate change and the “Carbon Challenge”.

First let me give you an example; one of the world’s most creative guys in the world was Boss Kettering at General Motors. He was not only an engineer and scientist but a visionary leader.
He is most famous for inventing the electric car starters when he worked near Dayton, Ohio and in fact they named the town after him, Kettering, Ohio.

In the late 1930’s he was the head of General Motors Research Labs and a member of the GM Board of Directors. The research labs where located on 8-mile road near Detroit where CMI later had its casting research center where Gary Ruff, Tom Prucha and Ray Witt all worked, some famous names in the casting industry. Now back to the Boss Kettering story. (Slide 5)

During a GM Board Meeting, the head of Cadillac Division gave his operating report and indicated that they could not make enough cars to meet the market demand. Upon questioning Kettering discovered that the reason they could not make more Cadillac’s was because it took six days to dry the paint on these highly finished cars. During the Board Meeting the group discussed what the ideal time to paint and dry a car would be. The number two hours was stated and laughed at as a truly ideal but not realistic time frame. The group settled on one day as a realistic goal. Kettering took note and began his development program.

He called in the experts from DuPont and explained the goal only to have them explain why it would not be possible. He then got together the best minds at GM and a number of Universities with no results. Both of these group seemed to be blocked by their own knowledge.

Then, Kettering himself on a trip to New York was admiring a lacquered tray in a department store window. The finish was beautiful and he questioned himself on why he could not get that finish on a car. (Slide 6) After investigation in the store, he found out where the trays were made. He then drove to the shop in New Jersey to find out how they painted the lacquered finish trays.

When he got to the shop where the trays were made he told them what he had in mind. “Paint a Car?” The shop owner without question said it was not possible.... “Why?” Kettering asked.... “It dries too fast”.

You can imagine what a story he had for his paint friends at DuPont. He did get the two parties together and the “one hour” paint became a reality. Kettering could not wait to report his results. (Slide 7)

At the next Board meeting he presented his findings and expected much pressure from the operating groups to implement it in their plants. He waited but no one called.

After two months and a number of memos about this new discovery he became frustrated. In a final attempt to get his innovation utilized he called all the Operations General Managers to lunch at his 8-mile location. He had the managers leave their GM cars at Research Labs and he took the group to lunch. During lunch he had his team repaint each managers car a different color... Upon their return, he got his point across and the rest is history. (Slide 8)

Now for the road map... (Slide 9)
As Steve Covey said, “Start with the end in mind”. The first step in the process is to break the operation down to its most basic controllable parts.

Questions you should be asking about your process, products and operation–

- What are the advantages of current products we make?
- What are the disadvantages?
- What changes have been made in the last three years, what will happen in the next three?
- What are the cost impacts?
- Are others operating differently?
- What is the risk of change?
- What are the values of change?
- What is the idea state?
- Do we have talent in our organization we are not using to make improvements?

Now here is a simple way for you to measure technology risk your operation.

(Slides, 6, 7 & 8)

Cat #1 90%, Cat #2 75%, Cat #3 60%, Cat #4 50% Cat # 5 40% and Cat #6 30%

Thomas Jefferson said it well. “Seizing responsibility for yourself, intelligently considering the options before you and charting your own course are the first brave steps on the road to leadership?”

Let me repeat every idea starts with observation – going out and directly seeing what happens in the foundry or at your customers.

We can try out a lot of ideas fast by using computers and models but::::::::::::::::

Good engineering is not running experiments than plotting the results,... curve fitting to develop theories. What I would challenge each of you to first observe and try to understand the present state, and then imagine what the idea state would be. (Slide 13)

Develop a theory, using first principles, to understand why the current state is as it is and how it can be improved.

Then, run a series of experiments to prove your theory.
Failure is the first cousin of innovation. Expect some failure but learn from them. Accepting defeat does not mean wallowing in disappointment; it is merely recognizing your successes has been delayed and start the process all over again.

(Slide 14)

This cycle of learning is called many things:

“Do Loop”,
“Plan-Study-Do”
“6 Ω”

I like to call it the scientific learning cycle; it is more than solving an issue it learning the root reasons for the situation and understanding the depth and knowledge of why....

We all need to establish a safety zone of experimentation. This is most important for example in the melting and pouring areas.

If you are drilling below the water line of the boat be sure you know how to bail quickly. In addition always keep employee safety in mind, molten metal can be one of the most potentially dangerous materials in all of our industry, treat it as such.

The effective management of risk seems like a lost art in our foundries, if you are good at assessing the risk both engineering and management can raise questions while there is still time to make real-time adjustments. This approach will be helpful to you.

If it is your job to introduce or develop new technology you need to constantly question what can go wrong and consider way to mitigate the downside. A sort of Process Failure Mode Analysis, write these things down and think about them with your team. The same technique can be done for customer issues.

Another point to remember from this talk if nothing else is “Picking the right projects” it is even more important than doing “projects right”. When you pick projects you need to weigh the risk factors against the “value”.

(Slide 15)

Normally we always measure value in dollars but other metrics can be used such as meeting emission requirements, increasing plant capacity, reducing injuries, meeting customer requirements, safety, for example.

The third dimension in the equation is cost, talent available, and timing. Again the best technology delivered after the customer makes a sourcing decision is wasted effort. In addition if the cost is greater than the advantages re-evaluate your effort, but also keep in mind the Motorola example.
The area of technology development is important; unfortunately it is also poorly practiced in our industry allowing for many areas of improvement. Again I go back to the corporate culture that governs how the company, its managers and employees conduct themselves. This includes hiring and firing, reviewing work, approving budgets, development of strategies, and allocating resources among others. Beware of dangerous incentives; abrogate responsibilities of oversight and of course micromanaging. Irony innovation can be killed by too hands-on or too hands-off.

Let’s talk about the last area in technology… Technology transfer.

The reality was as I worked in manufacturing for 15 years nearly all in melting, even with an engineering background, new technology always scared me. I had responsibility for operations of 5, 65 ton 21.5 MW coreless induction furnaces that any downtime normally resulted in lost production in the foundry.

I saw new technology that seldom to work as promised; cost more than predicted and never started up without extreme cost, frustration and delays. On the other hand later in my career as the Technical Director at GM Central Foundry and later General Motors Powertrain, I thought the new technology would be welcomed by plant workers, would save the operation money and would be fun to start-up. In most cases they are all true. (Slide 16)

Actually, there are occasions when the new technology had been thrown out of our plant as a failure the system did improve. The greatest single lesson I have learned about new technology is that..... applying it makes the old methods improve if only to resist being replaced. While new technology never gets credit for this improvement of the old methods it is an improvement nonetheless. Maybe this is the greatest reason to keep applying new technology.

Big advances are born of big ideas, so you and your company need to push at the bounds of what we know and how we know it. This involves both looking ahead at the future and looking back at the past; uses science as I explained; not only your experiences to predict the future.

Groups like Ductile Iron Society are outstanding forums to help this journey.

Technology and its transfer is very hard work, it take practice. (Slide 17)

Three of the more important points I have leaned along the way; C#1

1. Good work, humbly offered is not normally rejected. C#2

2. Building relationship between the engineers, operators, and management is a major key to success. Because simplistically the first attempts of applying the new technology most likely will failure because of what we don’t know about it. With a sound relationship second and even third attempts can be made without looking for the “goat” of why it did not work. C#3

3. Always look at the technology from the eyes of the receiver.
If you really want to see innovation and change flourish at your foundry, you must both motivate awareness and facilitate action. Being active in your Society attending conferences like this, reading about technologies in foundry and other industries, then take back what you have learned share with others and get them excited about it.

Remember the “World’s best metal casting process has yet to be invented”

Let me give you an example on how I would address a technology plan to the new potential wind turbine business...... (Slide 18)  Now measure the risk to your operation using the chart I reviewed, than the value ... is it good business to you or will you be a high risk also ran?

As I close I would like to make some important points on carbon emissions and climate change.  

(slide 20 - 31)

Paul Mikkola

June, 2009
Probability of Success

![Graph showing probability of success across different risk categories. The graph has two lines: one representing probability of success and the other representing value (relative to 100 max). The x-axis represents risk categories, and the y-axis represents probability.]

Ducile Iron Society Spring 2009
Former Theories of Filtration When Compared with New Cognitions

PM CHAIRMAN GENE MURATORE PRESENTS
SPEAKER GIFT TO THORSTEN REUTHER

THORSTEN IS CURRENTLY THE TECHNICAL LEADER AT HOFMANN CERAMIC OUT OF GERMANY AND HAS BEEN THERE SINCE 2001. HIS MAIN ACTIVITIES ARE IN THE FIELDS OF RISERING AND GATING OF IRON CASTINGS. THORSTEN STARTED HIS CAREER WITH MOLTEM METAL IN THE STEEL PLANT IN BUDERUS IN WELZLAR, GERMANY IN 1986. AFTER ALL HIS STUDIES WERE COMPLETE HE WORKED FOR THE FOUNDRY FRITZ WINTER IN STADTALLENDORF, GERMANY. HE COMPLETED HIS DIPLOMA THESIS UNDER THE DIRECTION OF DR. ING MILAN LAMPIC.

THE DIS WELCOMES THORSTEN WHO IS HERE TO TALK ABOUT “FORMER THEORIES OF FILTRATION WHEN COMPARED WITH NEW COGNITIONS”
Former theories of filtration when compared with new cognitions

Thorsten Reuther
hofmann CERAMIC GMBH, Mühlweg 14, 35767 Breitscheid-Erdbach - Germany

ABSTRACT

This paper gives a short insight into the theme, why former theories of working with filters are not useful to explain all phenomenon’s in the field of modern gating. Some new aspects in relation to the mechanisms of filtration are also shown. These new aspects show that the existing mechanisms are more than likely worth reconsidering. We are now engaged in some very interesting research, which occupies the real filtration mechanisms.

One part of the paper shows the former three mechanisms, its explanation and the consequential critical questions. These questions could not be answered by the former theories and require the new theories.

The other part shows the theoretical consideration of how the filters really work instead of the former theories. To underline these theories, there are also some practical examples shown where the new theories are supported and which are against the former theories.

The paper demonstrates that filters can hold back inclusions and can prevent the forming of inclusions during the pouring process but in a way which is different from the previous knowledge.

INTRODUCTION

The following lecture contains a simple summary of a few important problems which are often sources of errors in foundries. The intention is to present the most important special features of this topic to the reader in a simple and comprehensible manner. In the past we were often faced with some problems which were connected with the field of the filtration of molten metals that we were not able to explain properly, or solve, with the background of the former theories and the believed mechanisms of how filters work.

Because of these unsatisfied situations, the author starts to think about some new ideas of how filters work in an in gate system and to create some new theories.

BACKGROUND

Today we are forced to manufacture our castings economically and with a very high standard of quality. Apart from that, specifically in the automotive industry, the designer demand of weight reduction is to be met by reducing the wall thickness of the castings. The high cutting speeds during machining also require increasingly higher casting quality. This means that customer requirements, especially those directed at casting suppliers, with respect to surface quality and the absence of non-metallic inclusions in the casting, have increased greatly and become much more demanding. It is exactly these casting defects, which can occur due to an unsuitable gating system that can lead to dangerous weak spots in highly stressed components.

FORMER MECHANISMS OF FILTRATION

Up until now, the functioning of all ceramic filters was divided into three mechanisms that not only intercept the coarse particles on the surface but also the fine particles inside the filtration media. These particles can be much smaller than the pores, the cells or the holes of the ceramic filters. But two of these three mechanisms pose some questions when we look at our long lasting practical experience in the field of filtration.

The three filtration mechanisms (Fig. 1) are:

A. Sifting out of large particles.

B.

C.

Figure 1 : Three filtration mechanisms.
This mechanism intercepts particles that are larger than the pores of the filter. This is a pure physical effect and of course it works in this way.

**B. Interception on the filter surface by filter cake.**

A so called filter cake forms on the feed side of the filter due to the gradual accumulation of impurities there. This filter cake, in a certain way, leads to a narrowing of the cross sections and to undercuts, through which the molten metal has to flow. Due to this, particles, which are smaller than the pores of the filter, can be intercepted here. But this mechanism poses the following questions.

- It is definite, that an extruded filter works well and can improve the casting quality. But how can it happen that a filter cake will “grow” on the small cell walls under the condition of high pouring rates? These small cell walls are not able to give such a support that the slag can create or grow to become a filter cake. Under real pouring conditions such a pulpy slag conglomerate would be pressed through the filter in cause of the dynamic pressure of the melt.

- How we can ensure, that the same open area of the filter will always be guaranteed and that the filter cake will always have the same “size”? If there is a real filter cake it would have in every casting a different shape and respectable size. This causes, in every case, a different covered area on the filter front that would change in every casting and give a different open area of the filter.

- Does the filter cake have a high enough mechanical stability, that it will not change its shape during the pouring process? Does the narrow thorough fair stay alive throughout the pouring time? A lot of the publications about the filter mechanisms show particles which appear to be solid slag particles. But in reality slag “particles” in the iron melt are not solid. They are more or less liquid, or at best doughy. With these conditions it is not possible to create a solid filter cake.

- Why should the molten metal flow through narrow thorough fair, when there is still enough open area? The iron flow always takes the path of the least resistance. That means that the iron would run through the open filter cells instead though small thorough fair if given the possibility.

**C. Particle Bonding on the Inner Surface of the Filter Cavities.**

This so called deep bed filtration intercepts those particles, like sand grains or small particles of refractory material which are smaller than the pores of the filter, and also liquid slag. It is important that we remember that the slag or dross in iron melts is more or less liquid and not solid. The turbulence of the molten mass while it is flowing through the filter often results in inclusions coming into contact with the inner walls of the filter. Here the particles adhere to the filter ceramic and are therefore prevented from getting into the casting. Also this mechanism poses the following questions.

- That liquid and doughy slag adheres very well on ceramic material is a fact that we know. But is the inner surface area of a filter really high enough to keep out all slag or dross?

- The thickness of the adhered inclusions on the internal filter walls becomes thinner with higher pouring rates. Higher pouring rates cause a higher dynamic pressure and all particles which are not bonded very strong with the ceramic material would be washed out again. Is the remaining amount of bonded slag really enough to ensure the quality of our castings? The typical thickness of a slag layer inside of the filter is shown in Figures 2a and 2b. Figure 2a shows a part of a foam ceramic filter. Figure 2b is a part from an extruded filter. Both slag layers are very thin and nobody knows exactly if this slag was bonded during the pouring process, or after the pouring process and during the solidification of the ingate system. Nevertheless the amount of slag in these thin layers is not important.

![Figure 2a: Slag layer – foam ceramic filter.](image)

---

This mechanism intercepts particles that are larger than the pores of the filter. This is a pure physical effect and of course it works in this way.

**B. Interception on the filter surface by filter cake.**

A so called filter cake forms on the feed side of the filter due to the gradual accumulation of impurities there. This filter cake, in a certain way, leads to a narrowing of the cross sections and to undercuts, through which the molten metal has to flow. Due to this, particles, which are smaller than the pores of the filter, can be intercepted here. But this mechanism poses the following questions.

- It is definite, that an extruded filter works well and can improve the casting quality. But how can it happen that a filter cake will “grow” on the small cell walls under the condition of high pouring rates? These small cell walls are not able to give such a support that the slag can create or grow to become a filter cake. Under real pouring conditions such a pulpy slag conglomerate would be pressed through the filter in cause of the dynamic pressure of the melt.

- How we can ensure, that the same open area of the filter will always be guaranteed and that the filter cake will always have the same “size”? If there is a real filter cake it would have in every casting a different shape and respectable size. This causes, in every case, a different covered area on the filter front that would change in every casting and give a different open area of the filter.

- Does the filter cake have a high enough mechanical stability, that it will not change its shape during the pouring process? Does the narrow thorough fair stay alive throughout the pouring time? A lot of the publications about the filter mechanisms show particles which appear to be solid slag particles. But in reality slag “particles” in the iron melt are not solid. They are more or less liquid, or at best doughy. With these conditions it is not possible to create a solid filter cake.

- Why should the molten metal flow through narrow thorough fair, when there is still enough open area? The iron flow always takes the path of the least resistance. That means that the iron would run through the open filter cells instead though small thorough fair if given the possibility.

**C. Particle Bonding on the Inner Surface of the Filter Cavities.**

This so called deep bed filtration intercepts those particles, like sand grains or small particles of refractory material which are smaller than the pores of the filter, and also liquid slag. It is important that we remember that the slag or dross in iron melts is more or less liquid and not solid. The turbulence of the molten mass while it is flowing through the filter often results in inclusions coming into contact with the inner walls of the filter. Here the particles adhere to the filter ceramic and are therefore prevented from getting into the casting. Also this mechanism poses the following questions.

- That liquid and doughy slag adheres very well on ceramic material is a fact that we know. But is the inner surface area of a filter really high enough to keep out all slag or dross?

- The thickness of the adhered inclusions on the internal filter walls becomes thinner with higher pouring rates. Higher pouring rates cause a higher dynamic pressure and all particles which are not bonded very strong with the ceramic material would be washed out again. Is the remaining amount of bonded slag really enough to ensure the quality of our castings? The typical thickness of a slag layer inside of the filter is shown in Figures 2a and 2b. Figure 2a shows a part of a foam ceramic filter. Figure 2b is a part from an extruded filter. Both slag layers are very thin and nobody knows exactly if this slag was bonded during the pouring process, or after the pouring process and during the solidification of the ingate system. Nevertheless the amount of slag in these thin layers is not important.
Why does a filter, which is made from a graphite material work? Graphite is used in the slag zone of steel ladles to avoid adhered slag. The adhesion between both materials is as low as possible and is this not the reason we get a little higher flow rates with these filters? These filters can not work with the "Deep Bed Filtration Effect". There must be another effect.

Why does a filter give the same good result when its thickness is reduced because of economical reasons? When we reduce the filter thickness we reduce the inner filter surface area too. Would it not mean that the deep bed filtration effect would be reduced too?

Especially that deep bed filtration effect was often connected with the real and most important effect of a ceramic filter. And because of this the filtration effect was pictured in a relation with the inner surface of a filter. Diagram 1 shows that relation.

**Diagram 1 : Relation filtersurface / filtration effect.**

**Figure 2b : Slag layer – extruded filter.**

---

**PRACTICAL FUNDAMENTALS FOR THE NEW THEORIES OF FILTRATION**

Why does a filter get “blocked” by dusty melts when these three mechanisms are not working as we thought? Of course when; for example, the level of the melt is lowered down to the filter surface while the pouring basin is not kept full. Then the floating slag in the melt will suddenly adhere to the surface of the filter and the filter will be blocked. In this way the pouring process is stopped.

But we think that in every regular case when the pouring basin or the funnel is kept full then the slag will not block the filter. Now we think, and we found out, that in nearly every case the viscosity of the melt is responsible for such effects (Fig. 3a and Fig. 3b).

**Figure 3a : “Blocked Filter”. View from below.**

**Figure 3b : “Blocked Filter”. Side view.**
In this case the pouring process was stopped some seconds after the start of the pouring and the foundrymen thought that slag was blocking the foam ceramic filter. After we cut the solidified runner with the filters we saw that there is no slag in the filter or on the filter surface. What we can see is that the liquid iron (ductile iron) was not able to flow through the filter.

The reason for this phenomenon is the high viscosity of the melt because of, for example, lower pouring temperatures or a variation of the metal analysis. An additional parameter is that the metal front that came in contact with the filter material, because of the thermal conductivity of the SiC-material, the foam ceramic filter reduced the temperature of the metal. The viscosity was thus increased so that the metal front was frozen inside of the foam ceramic filter.

This foundry uses a pore size of 10ppi (pores per inch) for the castings. We solved the problem with filters of a bigger pore size of 8ppi but without increasing the size of the filter which was 100x100mm!

One other practical example of the relation between open area and pore size was tested in a foundry where they used extruded filters with a cell size of 50csi (50 cells per square inch).

One of the biggest disadvantages of these filters types are the low mechanical stability because of their very thin cell walls. The extruded filters also have the most open area of all filter types. As a result, customers who wanted to replace these filters because of the problems with filter breakage, with either foam ceramic filters or pressed round hole filters thought that they had to take a bigger filter size.

The reason for this would be to get a filter with the same open area. The reasoning for this was the belief in the theory of the filter cake, which covers the filter, and that they had to keep enough open area. This foundry used two filter sizes, 100x100mm and 100x75mm. Because of the small amount of space on their patterns they were not able to place bigger filters in their in gate systems.

All trials with foam ceramic filters failed and they thought that the reasons were the less open area even when they used 8ppi foam ceramic filters. Because of the maximum porosity of 8ppi, we decided to make a test with pressed round hole filter. In figure 4 it can also be seen that this filter type has a smaller open area than the extruded filters (square cells).

In table 1 the data of both types of filters are shown in order to give a better overview.

### Table 1

<table>
<thead>
<tr>
<th>Filter type</th>
<th>Dimension</th>
<th>Cell- / holesize</th>
<th>Open Area</th>
<th>% of open Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellfilter, 50csi</td>
<td>100 x 75mm</td>
<td>2.95 x 2.95mm</td>
<td>5056mm²</td>
<td>67%</td>
</tr>
<tr>
<td>Round hole filter</td>
<td>100 x 75mm</td>
<td>Ø 2.17mm</td>
<td>3142mm²</td>
<td>42%</td>
</tr>
<tr>
<td>Cellfilter, 50csi</td>
<td>100 x 100mm</td>
<td>2.95 x 2.95mm</td>
<td>6752mm²</td>
<td>67%</td>
</tr>
<tr>
<td>Round hole filter</td>
<td>100 x 100mm</td>
<td>Ø 2.81mm</td>
<td>4165mm²</td>
<td>42%</td>
</tr>
</tbody>
</table>

A pressed filter with a hole diameter of 2.17mm was not able to fill the mould because of the filters “blocked” and they thought that the small holes filtered to much slag. A filter with a 2.81mm hole was then used and we received 8 out of 10 good castings even though the amount of open area was only 42%.
After this result we designed new filters for the sizes 100x100mm and 100x75mm with 3.5mm and 3.3mm diameter holes respectively. The data of these new filters are shown in table 2.

<table>
<thead>
<tr>
<th>Filter type</th>
<th>Dimension</th>
<th>Cell- / holesize</th>
<th>Open Area</th>
<th>% of open Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellfilter, 50csi</td>
<td>100 x 75mm</td>
<td>2.95 x 2.95mm</td>
<td>5056mm²</td>
<td>67%</td>
</tr>
<tr>
<td>Round hole filter</td>
<td>100 x 75mm</td>
<td>Ø 3.30mm</td>
<td>3650mm²</td>
<td>49%</td>
</tr>
<tr>
<td>Cellfilter, 50csi</td>
<td>100 x 100mm</td>
<td>2.95 x 2.95mm</td>
<td>6752mm²</td>
<td>67%</td>
</tr>
<tr>
<td>Round hole filter</td>
<td>100 x 100mm</td>
<td>Ø 3.50mm</td>
<td>5164mm²</td>
<td>52%</td>
</tr>
</tbody>
</table>

Table 2

With these new geometries we have never had a problem with “blocked” or broken filters in the last four years, with over 200,000 castings poured, even though the open area of the new designed pressed filter is less than with the original extruded filter. The reason for the good result is only the good relation between the hole diameter and the viscosity of the ductile iron melt.

Also an interesting paradigm was the solution of a problem with a big foam ceramic filter. The pouring weights are over 9 tons. Because of the narrow space for the in gate funnel they were only able to use a filter size of a diameter of around 200 – 240mm.

They used one foam ceramic filter with a dimension of Ø 200x30mm in 10ppi in a steel quality. Unfortunately time after time they faced problems with "blocked" or broken filters. When they had some blocked filters they thought that their iron was overloaded with impurities.

As a result of these problems they asked for a single filter which would be able to handle this high pouring weight. Unsuccessfully, they started to drill 10mm holes into the foam ceramic filters to avoid the blockages. Because of these holes the stability of the filters were reduced more, which lead to more broken filters.

The question was would the liquid iron flow through the pores of a foam ceramic filter when there were some holes drilled through the filter where the melt could flow much easier. So we gave them a strainer core with a dimension of Ø 230x30mm with 49 holes Ø15mm which is shown in figure 5 and was developed 20 years earlier. To see the real dimensions, reference figure 5, which shows also a pressed filter with a dimension of 100x100mm.

Figure 5: Strainer core Ø 230x30mm.

Until this day, with this solution, we produced around 220 heavy castings without any problems. All castings are “clean”. The question was, how could a strainer core “filter” a casting?

We solved a lot of these phenomenons in the last years where customers always thought in the same way about a higher amount of slag and filter cakes. We never had to increase the filter sizes, which would be necessary if we still believed only in the three old theories of the mechanisms of filtration.

THE NEW THEORIES OF FILTRATION

This means that it is not the amount of open area or the amount of inner surface of a filter that is important. The hole-, cell- or pore size in relationship with the viscosity of the molten metal is what is important in order to allow the melt to flow through a filter so it can successfully work! Of course the filter should not become the bottle neck in the in gate system, so the open area is nevertheless important to pay attention to.

We expect the main effect to be the fixed resistance to the flow in our in gate system that the filter gives us. It is this resistance to the flow that is the most important parameter for the filtration effect. This causes a tailback in front of the filter, so that there is a possibility to separate liquid slag and sand grains (Fig. 6 and 7) in front of the filter because of the density difference of the slag, sand and metal.
Figure 6: Flow in front and after a filter.

Area (1) is an area of turbulent flow. When the melt is reaching the filter there is a tailback (area 2) so that the inclusions can be separated (area 3). After the filter we find an area of laminar flow (area 4).

Figure 7: Flow in front and after a filter.

If the resistance of the flow is too low then the speed of the melt is not slowed down enough to create a proper tailback and to reduce turbulences. In this case the inclusions could be carried with the metal stream and could pass through the filter. If the resistance to the flow is too high the slow moving molten metal could solidify inside of the filter, or the pouring time could become too long if the open area is great enough to handle the slow moving iron.

We saw this effect in one of our investigations. We simulated the flow in a filter chamber (Fig. 8) where we added some colored inspection particles, which have had the same density as water so that there would not be any false separation effects. During the pouring process there was also a tailback which captured some particles in front of the filter.

The other very important effect is that the filter avoids creating turbulence after itself. Because of this laminar flow, the danger of reoxidation of the liquid metal is reduced. Especially in ductile iron we reduce the amount of dross because of that reduced turbulences. Another important effect is that the dynamic energy of the metal stream is reduced after the filter.

Figure 8: Flow simulation with water.

SUMMARY

This laminar flow and reduced dynamic energy effectively avoids the creation of slag and sand erosions in our down stream in gate system. The little adhered layer of slag on the internal filter walls helps a little bit too. But we expect that this effect was absolutely overvalued in the past. During some examinations of graphite filters it was viewable that directly on the filter walls were no adhered inclusions, but the casting quality was good.

The next figures clearly show that the filter holds back a lot of inclusions without the “Deep Bed Filtration Effect”. The inner structure of the filter is “clean” and a “filter cake” was not found.

All inclusions and impurities were found in front of the filter. We have inspected many filter seats after solidification in last years and we have found in nearly all cases pictures to be the same. It was obvious that the type of filter used was not relevant.

Figure 9: Inclusions in front of the filters.
The good results which we have found when using the heavy strainer core (see Fig. 5) is agreeable with the new theories too. Here the strainer configuration in the correct relation to the low viscosity of the melt allows the opportunity to create the appropriate tailback in front of the strainer core.

In this instance, the funnel can be kept full during the pouring process. In this example the impurities can be separated in the pouring funnel and the dynamic energy of the iron flow is reduced. This avoids effective sand erosion and turbulence (dross!) in the following in gate system (Fig. 13).

All of these practical examples show that we can get good results with all types of filters and that there is no reason to favor one type of filter because of its “Deep Bed Filtration Function” and we would change the diagram 1 in the following way to explain how the filter geometry is connected to the filtration effect.
Zone 1: Extremely low flow velocities and/or extremely high flow resistance lead to the danger of solidification (blocked filters)

Zone 2: Extremely high flow velocities and/or extremely low flow resistance lead to the entrainment of impurities and extremely low backflow

There are other reasons why we have to focus on the different types of filters. These would be the mechanical resistance, the dimensional accuracy and the accuracy of the flow rates that each filter type would provide.

We have generated some practical experiments to examine these effects more accurately than was reported in the past. We will present the findings of these latest experiments in the near future.

REFERENCES


2. “Mode of action of the separation of non metallic inclusions in ductile iron with the help of ceramic filters”, Prof. Dr.-Ing. L. Bechný, Skript Metallurgie, University of traffic- and communication-siences of Zilina, Slovakei, 1999.
Agricultural Applications of Austempered Iron Components Link

CHAIRMAN MURATORE PRESENTING SPEAKER GIFT TO DR. KATHY HAYRYNEN


THE DIS WELCOMES BACK AGAIN KATHY WHO IS HERE TO TALK ABOUT “AGRICULTURAL APPLICATIONS OF AUSTEMPERED IRON COMPONENTS”
Agricultural Applications of Austempered Cast Irons

Kathy L. Hayrynen, PhD, FASM
Tim Dorn
John R. Keough, PE
Vasko Popovski, PE
Steven Sumner
Arron Rimmer, PhD
Austempered Cast Irons

- Austempered Ductile Iron (ADI)
- Carbidic Austempered Ductile Iron (CADI)
- Austempered Gray Iron (AGI)
The Austempering Process vs Other Heat Treatments
The Austemper Heat Treat Process for Ductile Cast Iron

- **Grade 130** - 900-650-09 (MPa)
  - 269-341 HBW

- **Grade 230** - 1600-1300-01 (MPa)
  - 402-512 HBW

![Diagram showing Austenitizing and Austempering times with temperature phases: Pearlite and AUSFerrite.](image-url)
Austempered Ductile Iron - ADI
## ASTM A897/A897M-06
### Specification for Austempered Ductile Iron

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile Strength (MPa / Ksi)</th>
<th>Yield Strength (MPa / Ksi)</th>
<th>Elongation (%)</th>
<th>Impact Energy (Joules / lb.-ft.)</th>
<th>Typical Hardness (BHN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>750 / 110</td>
<td>500 / 70</td>
<td>11</td>
<td>110 / 80</td>
<td>241-302</td>
</tr>
<tr>
<td>1</td>
<td>900 / 130</td>
<td>550 / 90</td>
<td>9</td>
<td>100 / 75</td>
<td>269 - 341</td>
</tr>
<tr>
<td>2</td>
<td>1050 / 150</td>
<td>750 / 110</td>
<td>7</td>
<td>80 / 60</td>
<td>302 - 375</td>
</tr>
<tr>
<td>3</td>
<td>1200 / 175</td>
<td>850 / 125</td>
<td>4</td>
<td>60 / 45</td>
<td>341 - 444</td>
</tr>
<tr>
<td>4</td>
<td>1400 / 200</td>
<td>1100 / 155</td>
<td>2</td>
<td>35 / 25</td>
<td>388 - 477</td>
</tr>
<tr>
<td>5</td>
<td>1600 / 230</td>
<td>1300 / 185</td>
<td>1</td>
<td>20 / 15</td>
<td>402 - 512</td>
</tr>
</tbody>
</table>
Abrasion Resistance of ADI

Pin Abrasion Test Results

From Section IV
Ductile Iron Databook for Design Engineers
www.ductile.org/didata
Applications of ADI
ADI Drive Wheel

- ADI replaces an 84 piece assembly that was welded and bolted together.
- Advantages of casting:
  - Fillets – ½ inch radius
  - Cores – center mass reduction
  - 15% reduction in weight;
  - Eliminate 30 minutes of assembly time.
ADI Bumper Block

- Component tightens slack when an implement is attached to back of a tractor;
- Good wear resistance is desired along with moderate impact properties.
• Part function to distribute seeds during revegetation of arid sites;
• Weldment wears out after 500 acres and doesn’t allow for a smooth seed delivery;
• ADI component is 15% lighter and costs 65% less to produce;
• No significant wear reported for these components.
Harvester Grain Deflector

- Ductile iron casting for complex shapes;
- Wear resistance of ADI imparts ability to stand up to abrasive grain.
ADI Agri-Speed Hitch

- Allows operator to hitch and disconnect wagon without leaving their seat.
- 5 ductile iron components – 4 are ADI.
- Reverse engineered from a customer’s weldment.
- Must withstand impact force of a tractor (13 tons) into a grain wagon (21 tons).
ADI Flail for Agricultural Mower-Conditioner

- Component must withstand impact loading and abrasive wear of sandy and/or wet grass, stalks and organic material.
ADI Plow Points - Tips

Typical ADI Plow Point

ADI Mitch Tips
ADI Actuating Lever (from Europe)

- Low cost replacement for a steel forging;
- Cast as ferritic/pearlitic ductile iron, machined and austempered
ADI Adjuster Sprocket

- Sprocket is used on a John Deere harvester;
- ADI replaces a steel sprocket machined from bar stock;
- Results in a cost savings for the end user.
Carbidic ADI - CADI
Methods of Carbide Introduction

- **As-Cast**
  - By alloying with carbide stabilizers (Mo and Cr)
  - Chill Carbides – cool very fast (surface, directional)

- **Mechanically Introduced**
  - Cast-in, crushed $M_XC_Y$ carbides
  - Cast-in, engineered carbides (shapes)

- **Welded**
  - Hard face weldment
  - Weldment with $M_XC_Y$ grains
Pin Abrasion Results

![Graph showing abrasion results](image)

- As-Cast Irons
- Q&T Ductile Iron
- ADI
- ADI - interrupted quench
- IADI
- Ni-Hard
- Carbidic ADI
- Abrasion Resistant Irons
- Austempered Steel
- Q&T Steel
- Q&T 4140
- Manganese Steel
- AGI
- As-cast Gray Iron

**Volume Loss, mm³** vs **Hardness, HRC**

Hardness values range from 20 to 65 HRC.
Pin Abrasion Test Comparison for CADI and AR Irons

![Graph showing the comparison of Pin Abrasion Test between CADI and AR Irons. The graph plots volume loss against hardness, with different markers for CADI, AR, 5% Carbide, 18% Carbide, and ADI.]
CADI Plow Point

- 1st commercial CADI application;
- Material has adequate toughness to survive the initial dropping of the plow and impact events with stones.
John Deere LaserRip™ CADI Ripper Points

• Better wear resistance than standard steel points;
• Better wear resistance than high-chrome, AR irons;
• Produced using a patented method developed by TK Waupaca.
Components for Harvesting Equipment

- bucket
- flight
- thrashing tine
- scraper blade
Austempered Gray Iron
Why AGI?

- AGI is relatively inexpensive with excellent castability.
- Take advantage of superior as-cast machinability;
- Noise damping improved over as-cast gray iron;
- Useful for applications that:
  - Have a complex shape;
  - Require reasonable strength;
  - Need good wear resistance.
Tensile Strength of AGI

The graph shows the tensile strength of AGI at different temperatures and classes:
- **AS-CAST**
- **AGI 700**
- **AGI 600**
- **AGI 500**

The strength is plotted in KSI (Kilopounds per Square Inch) and MPa (Megapascals). The graph includes data points for:
- Red squares: **CLASS 20**
- Light blue squares: **CLASS 30**
- Green triangles: **CLASS 40**

The data suggests an increase in tensile strength with temperature and class.
Internal Damping of AGI
Pin Abrasion Results for AGI

As-Cast Irons
Q&T DI
Gr 750 ADI
Ni-Hard
CADI - 5%
CADI - 18%
Ni-Hard
Abrasion Resistant Irons
As-cast Gray Iron
AGI
AGI Cam Wheel for a Forage Harvester

- Complex shape is easily cast;
- Critical shape is maintained during heat treatment
- Component has good wear resistance and good noise damping.
Final Comments

- ADI is a cost effective, durable alternative to steel and aluminum castings, forgings, weldments and assemblies.
- CADI offers excellent wear resistance with a modicum of toughness that gives it performance and cost advantages over conventional AR irons.
- AGI combines good wear resistance and noise damping at a total manufacturing cost less than ADI, steel or aluminum.
Thank you!
Questions?
www.appliedprocess.com
Effective Metallurgical Interpretation of Ductile Iron at Neenah Foundry Link

Michael A. Riabov

Mike graduated from the Moscow Institute of Steel and Alloys in 1995 with his Bachelor’s Degree in Metallurgical Engineering. Mike then moved to the United States and continued his education by graduating from the University of Northern Iowa in 1999 with his Masters Degree in Industrial Engineering. Mike then was employed by Citation Corporation in Brownstown, WI in the position of Plant Metallurgist from 1999 to 2005. In August of 2005 Mike then moved to Neenah Foundry Company serving as the Plant Metallurgist and since December 2006 as the Manager of Technical Services.

The DIS welcomes Mike who is here to talk about “Effective Metallurgical Interpretation of Ductile Iron at Neenah Foundry”
Effective Metallurgical Interpretation of Ductile Iron at Neenah Foundry

Mike Riabov
Neenah Foundry Co., Neenah, WI

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
Neenah Foundry Co. Today

- Total number of employees: 855 hourly & salary
- Manufacturing Area: 440,000 sq. ft.
- Two manufacturing plants located in Neenah, WI:
  -- Plant 2 – mostly Gray Iron
  -- Plant 3 – Ductile Iron
- Fully equipped pattern shop
DUCTILE IRON PRODUCTION AT NEENAH FOUNDRY

DJS 2009 Annual Conference
Lancaster, PA – June 3-5, 2009
MELTING

- Melt with a 84" water-cooled cupola (refractory lined down to 66"), with hot blast and oxygen injection
MELTING

- Melt with a 84" water-cooled cupola (refractory lined down to 66"), with hot blast and oxygen injection
- Melt rate – up to 35 tons per hour
MELTING

• Melt with a 84" water-cooled cupola (refractory lined down to 66"), with hot blast and oxygen injection
• Melt rate – up to 35 tons per hour
• Desulfurization with Limespar
MOLTEN METAL PROCESSING

• After the desulfurization, the iron is duplexed into one of two 60 ton holding furnaces using a 5-ton transfer ladle.
MOLTEN METAL PROCESSING

- Magnesium treatment in 7500 lbs. Mod-Tundish ladle
MOLTEN METAL PROCESSING

- Treated iron is delivered to one of two 10-ton Junker autopours
- Ladles are cleaned out after each treatment

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
PROCESS MONITORING AND CONTROL THROUGH THERMAL ANALYSIS

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
THERMAL ANALYSIS EQUIPMENT AND PRACTICES

- Use ATAS Verifier version 6.0
- Each DISA line has its own dedicated unit
- Use square non-tellurium cups
- Control parameters are set up for Mg treated but uninoculated iron
- Samples are obtained from the pouring trough of pouring furnaces prior to the in-stream inoculation at least once each hour
THE ANATOMY OF THE COOLING CURVE

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
EXAMPLES OF THERMAL ANALYSIS APPLICATION AT NEENAH FOUNDRY

DIS 2009 Annual Conference
Lancaster, PA – June 3-5, 2009
THERMAL ANALYSIS AT NEENAH FOUNDRY

- Everyday tests: main parameters to note are S1, TL, ACEL, GRF1 and GRF2
- Usage in metallurgical projects:
  ✓ Alloys and inoculants trials
TA at Neenah Foundry – New Mg alloy trial

- Standard MgFeSi alloy
- Trial MgFeSi alloy
TA at Neenah Foundry – New Mg alloy trial

- Standard MgFeSi alloy
- Trial MgFeSi alloy

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
TA at Neenah Foundry – New Mg alloy trial

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
TA at Neenah Foundry – New inoculant trial

- Standard inoculant
- Trial inoculant

DIS 2009 Annual Conference
Lancaster, PA – June 3-5, 2009
TA at Neenah Foundry – New inoculant trial

- Standard inoculant
- Trial inoculant

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
THERMAL ANALYSIS AT NEENAH FOUNDRY

• Everyday tests: main parameters to note are S1, TL, ACEL, GRF1 and GRF2
• Usage in metallurgical projects:
  ✔ Alloys and inoculants trials
  ✔ Scrap troubleshooting (proved to be a very useful tool for shrinkage troubleshooting)
TA at Neenah Foundry – Scrap Troubleshooting, Part 1

- Intermittent shrink porosity opening up during machining;
- Testing protocol:
  -- Pour ATAS several times during the production run;
  -- Pull 3 castings at the beginning, middle and the end of the run;
  -- Castings sent to X-Ray and results correlated with ATAS;

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
TA at Neenah Foundry – Scrap Troubleshooting, Part 1

DIS 2009 Annual Conference
Lancaster, PA – June 3-5, 2009
TA at Neenah Foundry – Scrap Troubleshooting, Part 2

- Intermittent porosity complaints from the customer.

DJS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
TA at Neenah Foundry – Scrap Troubleshooting, Part 2

- Intermittent porosity complaints from the customer
- For the long time the porosity was believed to be a gas defect from a core...

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
TA at Neenah Foundry – Scrap Troubleshooting, Part 2

- Intermittent porosity complaints from the customer;
- For the long time the porosity was believed to be a gas defect from a core... until we looked at ATAR curves;

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
TA at Neenah Foundry – Scrap Troubleshooting, Part 2

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
ANY QUESTIONS?

DIS 2009 Annual Conference
Lancaster, PA – June 3-6, 2009
JIM MAJSK RECEIVING HIS SPEAKER GIFT FROM CHAIRMAN GENE MURATORE

JIM IS CURRENTLY EMPLOYED AT POWERIT SOLUTIONS AS THE EAST COAST BUSINESS DEVELOPMENT ENGINEER. JIM IS RESPONSIBLE FOR SALES AND SUPPORT OF POWERIT’S SPARA EMS PRODUCT LINE, WHICH IS USED FOR DEMAND CONTROL, DEMAND RESPONSE AND REALTIME PRICE RESPONSE APPLICATIONS. JIM BRINGS OVER 2 DECADES OF EXPERIENCE AND KNOWLEDGE OF INDUSTRIAL AUTOMATION SYSTEMS INTEGRATOR HELPING CUSTOMERS STREAMLINE THEIR MANUFACTURING PROCESSES AND PRODUCTION SYSTEMS. JIM HAS MOST RECENTLY SPOKEN AT THE 13th ANNUAL OHIO ENERGY CONFERENCE HELD IN COLUMBUS, OH IN FEBRUARY 2009.

LARRY COLLINS
LARRY IS CURRENTLY EMPLOYED AT ENERNOC AS THEIR BUSINESS DEVELOPMENT MANAGER, SPECIALIZING IN DEMAND RESPONSE SOLUTIONS FOR COMMERCIAL AND INDUSTRIAL CONSUMERS IN THE PJM INTERCONNECTION TERRITORY. BEFORE JOINING ENERNOC, LARRY WAS A KEY ACCOUNT MANAGER FOR PPL UTILITIES AND SELECT ENERGY COMPANY. PRIOR TO THOSE SALES AND MARKETING POSITIONS, LARRY SERVED AS A PLANT ENGINEER WITH AMERICAN ELECTRIC POWER COMPANY. LARRY IS A MEMBER OF THE ASSOCIATION OF ENERGY ENGINEERS AND HOLDS THE CERTIFIED ENERGY MANAGER DESIGNATION FROM AEE.

THE DIS WELCOMES BOTH JIM AND LARRY WHO ARE HERE TO TALK ABOUT “INTELLIGENT DEMAND CONTROL AND AUTOMATED DEMAND RESPONSE”

"EnerNOC Presentation Synopsis for Ductile Iron Society Newsletter"

We all know that better energy management makes good business sense, particularly in an energy-intensive industry that faces competition from abroad. We also know that efficient use of energy will benefit our environment and community. Yet methods for implementing simple, verifiable energy cost savings elude many business operators and plant managers. Demand response presents a unique opportunity for businesses to access cutting-edge energy data to drive efficiency in the plant at no cost, and earn revenues from their electric utility or grid operator by reducing reliance on peaking power generation.

Demand response programs exist across the United States with the goal to reduce peak demand for electricity, and are open to foundries and other commercial and industrial operations. Utilities and grid operators pay commercial and industrial organizations who agree to standby to reduce electricity consumption when called upon, to prevent the need to use peaking power generation or resort to rolling blackouts. Demand response is an improvement over interruptible programs/rates because it is voluntary, flexible, and backed with high technology.

The information technology that supports demand response participation not only makes it simple for businesses to participate, it also gives them access to energy data. For example, EnerNOC’s PowerTrak® software is available free to all businesses in its demand response network and is an easy-to-use, web-based application that provides real-time electricity consumption information you need to better manage your energy costs. Viewing energy data in real time allows you to reduce peak demand charges, detect inefficient equipment, and verify energy reduction and cost saving strategies.

For more information on demand response, visit www.enernoc.com.
Intelligent Electric Demand Control

Ohio Energy Management & Restructuring Conference
February 24, 2009

WARNING!
Do Not Attempt.
Grabbing bolts of electricity does not control energy cost.

Powerit Solutions
Demand more from the energy you use.
How Are You Charged For Power?

- **Consumption (kilowatt-hours, kWh)**

  1,000 watt loads

  (10) 1,000 watt loads running for 1 hour = 10 kWh

- **Demand (kilowatts, kW)**

  Highest Demand = (6) 1,000 watt loads = 6 kW Peak
How Are You Charged For Power?

Peak Demand Is An Interval Average

No matter how it is distributed during the interval…

the interval with the highest *average* kW is your peak interval

---

3 kW Interval Average

3 kW Interval Average
How Are You Charged For Power?

Electric Demand

The rate at which electric energy is delivered to a facility, averaged over a designated period of time.

**Peak = 5,299kW**

**Demand Charge = 5,299kW @ $8.00/kW = $42,392**
How Are You Charged For Power?

Know Your Tariff

Understand how your bill is calculated!

Utility Rate Schedules:

- Straight Demand
- Time Of Day
- Ratcheted
- Any Combination Of The Above
- Other Creative Ideas
Straight Demand Tariff

One charge based on the highest kW value during the month

Electric & Water Plant Board, Frankfort, KY

```
LP - LARGE POWER (RATE 20)       $ 4.17
ALL KW

ENERGY CHARGE:
0-500,000 KWH                    .03470
500,001-2,000,000 KWH             .03220
OVER 2,000,000 KWH               .03100

POWER FACTOR CLAUSE APPLIES

MINIMUM BILL: $ 4.17 x 25% OF THE HIGHEST KW IN
THE PRECEDING 11 MONTHS BUT
NOT LESS THAN 2 KW

FUEL ADJUSTMENT – ALL RATES WILL INCLUDE A
PROVISION FOR FUEL ADJUSTMENT AT A MONTHLY
RATE PER KWH AS DETERMINED FROM KU’S BILLING
```
Time Of Day Tariff

One or more charges based on the highest kW values during daily time periods throughout the month

PPL Electric Utilities - Rate Schedule LP-4

BILLING KW
The Billing KW is the average number of kilowatts supplied during the 15-minute period of maximum use during the current billing period. The Billing KW applicable to the charges under this Rate Schedule for customers with onpeak hours for billing purposes is the average number of kilowatts supplied during the 15-minute period of maximum use during the on-peak hours of the current billing period. No new applications will be accepted after January 1, 2000. This provision will terminate on January 1, 2010.

ON-PEAK HOURS
On-peak hours for billing purposes are 7 a.m. to 3 p.m., 8 a.m. to 4 p.m., or 9 a.m. to 5 p.m., local time, at the option of the customer, Mondays to Fridays inclusive except, New Year’s Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day and Christmas Day.
Ratcheted Demand Tariff

Peak demand is based on the highest kW value during a number of months

Connecticut Light & Power - Rate 057

DETERMINATION OF PRODUCTION/TRANSMISSION DEMAND:

The production/transmission demand shall be the highest average 30-minute kilovolt-ampere (kVA) demand recorded during the billing month in the on-peak hours as defined above.

DETERMINATION OF DISTRIBUTION DEMAND:

The distribution demand shall be the highest average 30-minute kilovolt-ampere (kVA) demand in the current month or the preceding eleven (11) months.

The customer may, upon not less than three (3) months' prior written notice to the Company, decrease the Distribution Demand ratchet solely to reflect lower load levels resulting from demonstrable conservation and load management.
Combination Tariff

Peak demand is based on the highest result of multiple types of calculations

NIPSCO Rate 825 For Electric Melting

DETERMINATION OF MAXIMUM DEMAND
The Customer’s demand of electric energy supplied shall be determined for each half-hour interval of the month. The phrase "half-hour interval" shall mean a thirty (30) minute period beginning or ending on a numbered clock hour as indicated by the clock controlling the metering equipment.

DETERMINATION OF BILLING DEMAND
The Billing Demand for the month shall be the greatest of the following demands:

• The maximum metered On-Peak half-hour demand, adjusted for Power Factor.
• 30% of the maximum metered Off-Peak half-hour demand, adjusted for Power Factor.
• 75% of the highest Billing Demand established in the preceding eleven (11) months.
• 500 kilowatts.
Other Creative Tariffs

The key term is “KW”......

Peak kW extended into kWh charges:

Capacity and Energy Charge (Effective 1-1-08 through 12-31-08)
$5.624 per kilowatt for all kilowatts of the Billing KW.
4.011 cts. per KWH for the first 400 hours use of Billing KW.
2.553 cts. per KWH for all additional KWH.

Capacity and Energy Charge (Effective 1-1-09 through 12-31-09)
$5.736 per kilowatt for all kilowatts of the Billing KW.
4.082 cts. per KWH for the first 400 hours use of Billing KW.
2.604 cts. per KWH for all additional KWH.

EXAMPLE: With peak demand of 1,000kW, you would be charged
4.082cts For the first 400,000kwH (400 * 1,000kW = 400,000 kWh)

Custom calculation of peak kW value:

BILLING KW

The monthly Billing KW is calculated as:

Billing KW = Firm Power + [Interruptible Power X (1 - Average On-peak Load Factor)]
“Controlling” peak load sounds risky... but it doesn’t have to be

- Peak demand savings is about managing your loads efficiently
- Energy bill savings can be realized without using less energy or doing less work
- Load performance can be protected
- Analyzing your energy usage can be educational
Demand Control

**Definition**
- Understanding where, when and why spikes in demand occur and taking ongoing measures to reduce them with a minimal impact on facility operations.

- **Manual Procedures** – Operators follow defined rules.
- **Demand Limiting** – Limit output of high-demand loads.
- **Intelligent Demand Control** – Predict peak usage, take coordinated action and provide data for event analysis.
Intelligent Demand Control

Prediction
• Predictive algorithm identifies pending peaks
• Calculates specific action necessary to avoid highest peak

Action
• System directly modifies equipment run status
• Uses embedded Operator intelligence to protect process

Information
• Real-time & archived report of savings performance
• Real-time & archived energy and load data

Intelligent Demand Control (IDC)
Where Do We Start?

• Analyze energy usage data (interval data)
• Identify load shedding candidates
  – How much in total load is available?
• Identify rules/conditions for load reductions
  – How do we protect production, quality and/or comfort?
• Estimate Demand Control savings
Analyze Energy Usage Data

Utility Bills:

Interval Data:

<table>
<thead>
<tr>
<th>RECORDER ID</th>
<th>DATE</th>
<th>HOUR</th>
<th>KW</th>
<th>KVAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>56150001</td>
<td>80107</td>
<td>15</td>
<td>8455.68</td>
<td>1186.56</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>30</td>
<td>8536.32</td>
<td>1152</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>45</td>
<td>8847.36</td>
<td>1296</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>100</td>
<td>8841.6</td>
<td>1255.68</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>115</td>
<td>8772.48</td>
<td>1200.96</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>130</td>
<td>8691.84</td>
<td>1128.96</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>145</td>
<td>7750.08</td>
<td>1028.16</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>200</td>
<td>7767.36</td>
<td>1039.68</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>215</td>
<td>7655.04</td>
<td>984.96</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>230</td>
<td>7300.8</td>
<td>984.96</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>245</td>
<td>6805.44</td>
<td>1036.8</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>300</td>
<td>6791.04</td>
<td>1028.16</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>315</td>
<td>6756.48</td>
<td>1028.16</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>330</td>
<td>6600.96</td>
<td>1094.4</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>345</td>
<td>6252.48</td>
<td>1094.4</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>400</td>
<td>6114.24</td>
<td>996.48</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>415</td>
<td>6174.72</td>
<td>984.96</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>430</td>
<td>5040</td>
<td>1080</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>445</td>
<td>4389.12</td>
<td>1143.36</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>500</td>
<td>4380.48</td>
<td>1131.84</td>
</tr>
<tr>
<td>56150001</td>
<td>80107</td>
<td>515</td>
<td>4265.28</td>
<td>1077.12</td>
</tr>
</tbody>
</table>
Analyze Monthly Interval Data

Identify Peaks And Process Events

Daily Peak Demand Values - 1 Month

Lone Peak? Why?

Process Starts?

Half-hour Period
Analyze Daily Interval Data

Manual Procedures Not working?

Two Load Profiles: With and Without Energy Director

Facility Demand (kW)

Fifteen-Minute Interval Data (Peak Day)

- Uncontrolled
- With Energy Director
Identify Load Shedding Candidates

Equipment to Evaluate:

- Electric Melting
- Holding Furnaces
- Wheelabrators
- Electric heating
- Chillers
- Waste Water pumps
- Shredders
- Any other non-production-critical loads
Protecting The Process; Creating The Rules

Ask the questions:

• Under what conditions can I implement load shedding? (time, other load operations)

• Are there specific situations that could make this load unavailable?

• Can we use the true key production criteria to protect the process? (ex: temperature, pressure)

• How and when should I communicate load shedding to the operators?
Next Steps …

• Develop project costs
  – Hardware & Software
  – Commissioning/Training
  – Installation

• Calculate ROI

• Identify any additional system benefits
  – Sub metering
  – Data logging
  – Load monitoring
  – Load cycling for kWh savings

• Contact utility for possible incentives
- Energy Cost Forecasting
  - Instant access to real-time data
  - Historical access to archived data
- Utility Bill Authentication
  - Data comes from meter, should match bills
- Load Status & Monitoring
  - Real time and historical load status
- kWh Savings Opportunities
  - Look at load shifting
- Demand Response Automation
  - Take advantage of additional cost savings through demand response programs
Selecting A Product

An Intelligent Energy Management Tool Should Have …

- Sophisticated communications for integrating a wide variety of control systems
- Proven algorithms for predicting and managing savings actions
- Application-specific rule-sets for prioritizing loads & protecting productivity
- Flexible scheduling of energy savings & demand management actions
- Automatic setpoint adjustment to maximize efficiency
- Relational database for data archive & reporting
System Expectations

Before Intelligent Demand Control

Daily kW Graph - July 2005

All reductions, except for two intervals, are less than 2000kW
System Expectations

After Intelligent Demand Control

Foundry in Indiana w/Energy Director

Setpoint = 16,000kW
Leverage your investment in technology to take advantage of other cost saving opportunities

- **Real-Time Price Response** – Response to peak price periods as well as peak KW periods.

- **Intelligent Efficiency** - Use automation with “Embedded Operator Intelligence”™ to make continuous adjustments to an energy consuming loads.

- **Intelligent Demand Response** - Use automation with “Embedded Operator Intelligence”™ to reduce facility electric usage when the electric grid is overly stressed and facing failure.
Thank You

Powerit Solutions, LLC
114 Alaskan Way South Suite 201, Seattle, WA 98104
Phone: 206.467.3030
Fax: 206.621.8545
Toll Free: 1.866.499.3030
info@poweritsolutions.com
www.poweritsolutions.com

Demand more from the energy you use.
Demand Response for Foundries
Ductile Iron Society Annual Meeting
June 4, 2009
Introductions

• Larry Collins, Business Development Manager
• EnerNOC, Inc. is a leading developer and provider of clean and intelligent energy solutions. Our technology-enabled demand response and energy management solutions help optimize the balance of electric supply and demand.
• EnerNOC, Inc. is certified to provide demand response services to the commercial and industrial sector in utility markets across the United States
Agenda

- Electricity Issues & Solutions
- Demand Response Overview
- How to Participate
- Case Study
- Questions & Answers
Common Energy Issues

• Consumption rate is high and one of the leading operating costs
• Little or no transparency into consumption patterns or ways to cut demand
• Electric reliability is critical and risk must be minimized
• No energy expert on staff
An Innovative Solution

- **Demand response** is the reduction of electrical consumption at the end-use customer level in response to system reliability events, system resource capacity needs, or high wholesale electricity prices.
The Case for Demand Response

Better system management with DEMAND RESPONSE

Office
- Reduce common space lighting
- Change temperature set points

Retail
- Cut back lighting levels
- Restrict elevator use

Hospitality
- Increase/decrease temperature set points
- Reduce laundry volume

Education
- Raise/lower temperature and ventilation set points

Healthcare
- Combine backup generation with HVAC control

Grocery
- Reduce lighting
- Anti-terror heater curtailment

Manufacturing
- Reschedule lines and processes
- Curtail compressor

Agriculture
- Pump, fan adjustment
- Disconnect truck plugs

Energy Supplier

Peak Demand

Demand Response

Demand Response is an important component of a modern electric power grid. Instead of increasing supply to meet system needs, demand response programs reduce demand. Demand response can be cleaner than renewable resources, and reliable and quick to dispatch like a peaking power plant. State-of-the-art companies like EnerNOC use advanced, internet-based technology to ensure your demand response program is reliable, measurable and verifiable.
The Benefits of Demand Response

- Earn revenues that go straight to the bottom line
- Protect operations from grid instability
- Access and manage energy data
- Improve electric reliability in the community
- Reduce the need for peaking power generation
- Become a leader in the industry and community
Demand Response Aids Energy Management

- Minimize risk: Receive notice of grid emergencies and prepare to protect critical systems from voltage reductions
- Cost center turned revenue center: Earn revenues from utility/grid operator for participating, and fund capital upgrades or offset energy costs
- Verify efficiency: Advanced metering infrastructure shows real-time energy consumption so you can quantify efficiency or reduce peaks
- Easy green initiative: Reduce the need for peaking power plants in your community

Demand response should have no costs, no investments, and no financial penalties for non-performance
How A Demand Response Event Works

**EVENT BEGINS**

Peak capacity

Send out a curtailment notification.

When demand is at its peak, your energy provider will notify EnerNOC to trigger a demand response event. EnerNOC will send a curtailment notification to all participants.

**TAKE ACTION**

Notify

Curtail

Verify

Restore

When you’ve received the notification, curtailment can be carried out manually or automatically. EnerNOC monitors your performance during the event from its Network Operations Center (NOC).

1:50 PM
Start generator and shift load

4:00 PM
Restore load to grid and shut off generator

Demand response is simplest for you when fully backed by high technology
Potential Curtailment Strategies

• Reduce temperature on some or all furnaces
• Shut off some or all compressors
• Reduce HVAC and chiller set points
• Shut off other motors and machining
• Shut down entire plant for maximum revenues
• Transfer load to generator (where permitted)
Demand Response Networks

- Commercial & industrial demand response is available in many regions across North America
Case Study: AB&I Foundry

- Largest manufacturer of cast iron soil pipe and fittings in the western United States: 60,000 tons/year
- Spends more than $3 million/year on electricity
- Operation includes electric melt furnaces, 4 pouring furnaces, and 60 holding furnaces
- Curtails 300 kW of load by reducing furnace and compressor settings via Spara EMS™ integrated with PowerTrak®
- Most employees don’t notice the curtailment at all
- Uses program revenues to pay for efficiency upgrades
- Relies on engineering innovation to reduce cost and stay competitive with producers in India and China

“Demand response doesn’t affect our operations, since many of the changes are behind the scenes. The iron in our furnaces may be a little cooler at times, but overall, it has very little impact on production.”

- Dave Robinson, Engineering Manager, AB&I Foundry
Some of Our Valued Partners

- Somerset Foundries
- FJ Frazer & Jones
- Noranda
- MF
- U.S. Pipe
- JWE Industries
- Nichols Aluminum
- Clarksville Foundry, Inc.
Questions & Answers

- Thank you for your attention. Now for your questions.
The Ductile Iron Society/Iron Casting Research Institute Fall Meeting will be held September 30-October 2, 2009 at the Radisson Hotel in West Middlesex, PA. There will be a visit to Hodge Foundry in Greenville, PA.

*****

BUSINESS

PEOPLE