Ductile Iron News

Ductile Iron Society

To Promote the production and application of ductile iron castings

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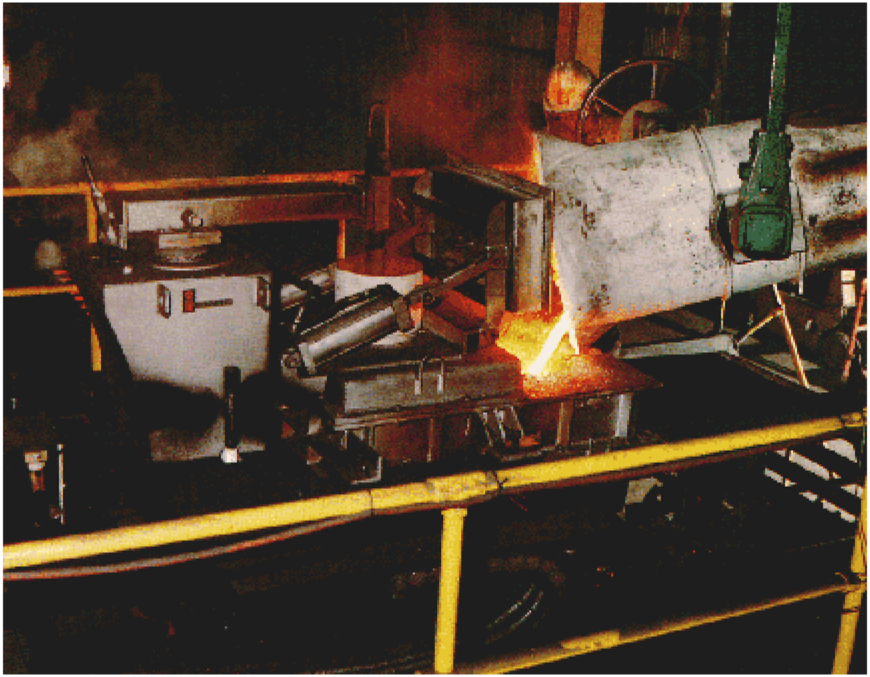
Automatic Pouring of Molten Metal by Utiliziing Real Time Vision-Based Control System



Automatic Pouring of Molten Metal by Utilizing Real Time Vision Based Control System

by; E. Tabatabaei, Inductotherm Corporation; Rancocas, New Jersey

ABSTRACT

A closed-loop automatic molten metal dispensing system based on vision technology is presented. Vision technology and its effects on industrial automation and reasons for selecting vision sensor as opposed to other sensing devices such as X-ray and laser is discussed.

The control is self-compensating and utilizes automatic learning schemes to repeatedly and accurately fill the molds.

The level in the sprue cup is sensed by a vision camera and compared to a predetermined level profile. The difference is then used to drive a servo-driven actuator. The control calculates the flow of molten metal into the mold to learn the gating system characteristics. This information is used to improve the future pours, which may be affected by the change in the orifice diameter and the level of molten metal in the tundish.

In case of a flaskless mold line, the pour tundish is automatically positioned over the sprue cup.

The system has been successfully tested both in the laboratory and on the production lilne.

The rising cost of material and labor has forced today's foundries to automate the various aspects of their operation to increase efficiency and productivity. The extent of this automation has also reached the casting process. The modern delivery systems and high speed molding machines have necessitated the need for an automatic pouring system to produce high-quality castings as a high throughput, while eliminating costly overpours.

This paper will discuss a closed-loop automatic pouring system based on Vision Technology for non-contact measurement of the molten metal level in the sprue cup.

After a brief discussion of the vision sensing, the control scheme will be introduced.

VISION SENSING

A typical vision system is comprised of a camera, lens, and image-processing electronics. The object is viewed by the camera and a live picture is sent to the image-processing electronics at a rate of 30 frames or samples per second. Each point of the picture is converted to an element called the pixel with a value representing the brightness of the original picture. The collection of the pixels form an image, which can be processed by a computer for feature extraction (Fig. 1).

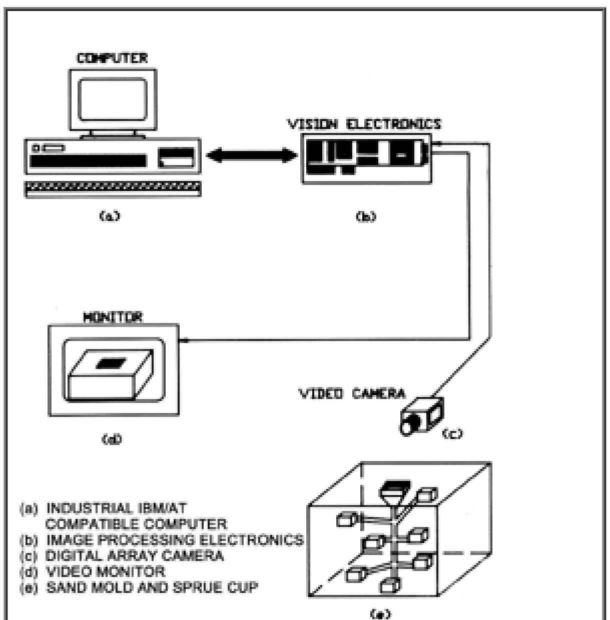


Figure 1. A typical vision system.

Level Measurement
To measure the level of the molten metal in the sprue cup, it is essential to distinguish between the molten metal and the sprue cup. This is accomplished by optical filters and electronic thresholding of the image.

The brightness of the molten metal provides an excellent contract between the sand mold and the metal in the sprue cup, and, therefore, a crisp image of the molten metal represented by white pixels can be obtained without utilizing any special lighting. Since the camera looks at a large area and not only one point of the sprue cup, it is necessary to reach the area of the sprue cup or the region of interest (Fig. 2a). The region of interest has two functions, it is used in metal level calculation (Fig. 2b) and in the elimination of the stream contribution in the total image area. By looking directly at the sprue cup and electronically blocking the stream, the need for special sprue cup design is eliminated (Figs. 2c and 2d).

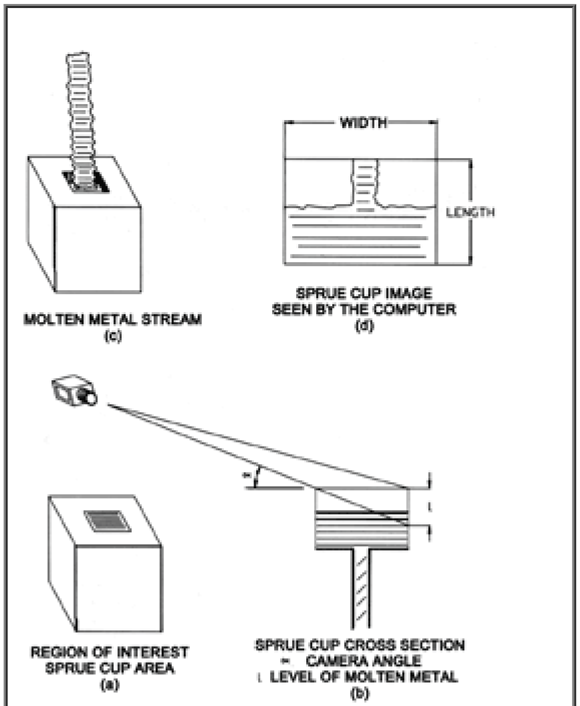


Fig. 2. Sprue cup area (region of interest).

The molten metal level is calculated by counting complete lines of white pixel, filtering the stream out, and normalizing the total count to the cup area.

Why Vision?
The technological advancement of the past 10 years in the areas of computer and sensor technology has made a tremendous impact on automating industrial process control. The increased productivity, reliability, and safety is what this automation has offered.

Vision systems, being a part of this advancement, are being widely used to automate industrial quality control, process control, and gauging, to name a few.

The advantages of a vision system in the automatic pouring process are:

- Availability and relatively low cost of the components
- Safety
- Visual feedback

The availability and low cost of the vision components, plus the fact that -- unlike other measuring devices such as X-ray and laser -- there is no need for any sort of radiation, makes this system attractive. Another feature is that, with the vision system, the process of positioning and pouring can be viewed live on a video monitor. The camera, in conjunction with a VCR, can provide a valuable tool to analyze the pouring process.

VISIPOUR AUTOMATICE CONTROL SYSTEM
The Visipour System consists of a power enclosure that houses the servo amplifier, power supplies, and line conditioner; a control station that contains the computer, vision electronics, servo controller, the input-output interface, control software, and a video monitor; two air-cooled camera housings; and a servo-driven stopper rod mechanism (Fig. 3).

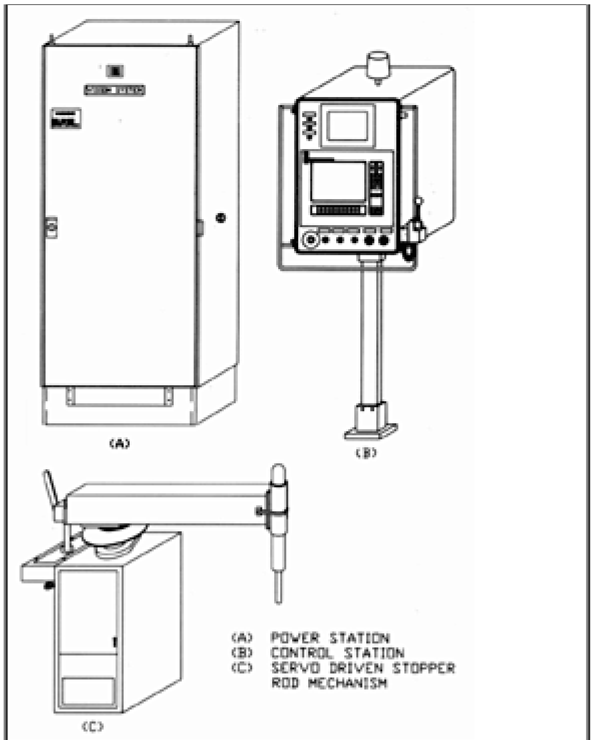


Figure 3. Vision system equipment.

The operator interfaces with the system via a set of user-friendly menus through a front panel membrane keypad.

The stopper rod mechanism is a servo-driven computer-controlled actuator, which provides fast response and accurate positioning of the stopper rod for quality pouring of molten metal. The quick response of a servo actuator, as opposed to a pneumatic one, which is slow in response for today's fast sampling sensors, is vital to automatic control of the stopper rod during opening, closing, and throttling.

The servo closed-loop control system offers accurate positioning of the stopper rod and provides the means to automatically adjust the seating force of the rod into the nozzle.

The vision system performs two functions: it automatically positions the tundish over the sprue cup, and it fills the mold according to its filling requirement.

Tundish Tracking
In the flaskless molding operation -- such as Disamatic line -- because of the change in the sand compactibility, the thickness of a given volume of green sand will vary from mold to mold. This variation in the mold thickness offsets the sprue cup in relation to the pouring nozzle, and, therefore, the pour stream will not fall in the center of the sprue cup. This causes splashing and sand erosion, and may increase the pour time.

Another reason for the tracing is that the vision system requires the sprue cup (region of interest) to always be in the same position.

The tracking is done by aligning the tundish over a mold and acquiring a picture of a notch formed on the side of the sand mold (Fig. 4). The ideal notch location to be used as a position reference is calculated by the vision system.

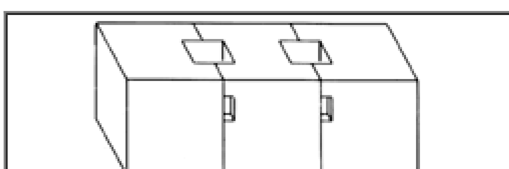


Fig. 4. A typical flaskless mold line.

The automatic positioning program will use this location to position the tundish by acquiring an image of the new mold's notch and comparing it to the ideal one. The system is moved according to the difference between the present notch location and the desired one.

Automatic Pouring Control
To produce quality castings, it is essential to fill the sand mold quickly and continuously, without interruption in the flow of the molten metal in the gating system. To assure this continuity, the sprue cup should be kept full during the pour to eliminate air entry into the gating system, which will result in unacceptable casting quality.

The vision system is a closed-loop, computer-controlled, molten-metal-dispensing system designed to fill sand molds with varying metal intake characteristics at a high throughput.

Due to the variation in the gating system, which determines the flow characteristic in the mold, the level of molten metal in the metal holding container, and the diameter of the orifice (which changes over time), the control system should be self-compensating. To assure repeatability and accuracy of the pours over time, a powerful adaptive scheme is incorporated, which learns the characteristic of each pour and uses the acquired information to provide the controls with prior knowledge for the succeeding pours.

The control system (Fig. 5) requires a tracking profile to use the guidance in controlling the level of molten metal in the sprue cup. This profile is based on the total time of pour and the desired levels of the molten metal in the sprue cup, during filling and at the end of the pour (Fig. 6).

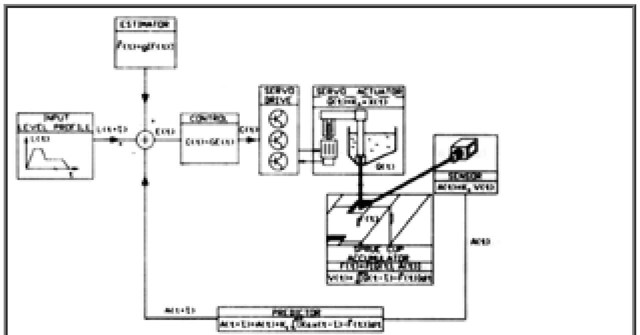


Figure 5. Vision system control loop.

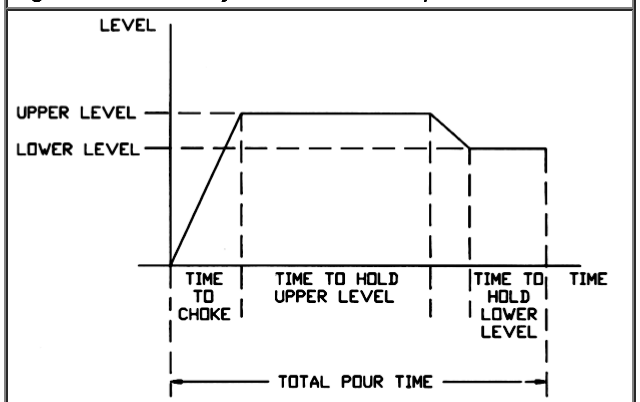


Figure 6. Level profile.

The vision camera measures the level of molten metal in the sprue cup, which is directly proportional to the difference between the flow out of the orifice and the flow into the mold (Eq.1). This information is then used to predict the future level in the sprue cup (Eq. 2) due to metal in transition and also to calculate the mold intake (Eq. 3).

(1) $$A(t) = K_c \int_t^{t+\tau} \left[Q(t-\tau) - \hat{F}(t) \right] dt$$

(2) $$A(t+\tau) = A(t) + K_c \int_t^{t+\tau} \left[K_a \times (t-\tau) - \hat{F}(t) \right] dt$$

(3) $$F(t) = f\,[Q(t), A(t)]$$

It takes a certain amount of time for the molten metal released from the orifice to reach the sprue cup (metal in transition). This time delay is directly related to the distance between the orifice and the sprue cup and must be accounted for in the control scheme.

The comparison of predicted level to desired level, in conjunction with the estimated mold intake (Eq. 4), produces a process error (Eq. 5). The error is then fed to a proportional control (Eq. 6) to drive the servo actuator to correct the level of the molten metal in the sprue cup and eliminate the error.

(4) $$\hat{F}(t) = g\,[F(t)]$$

(5) $\hat{F}$

$$E(t) = L(t + t) - A(t + t) + \quad (t)$$

$$C(t) = G\,E\,(t) \tag{6}$$

where:

Kc = calculated gain
Ka = a measured gain
G = the control gain
t = the measured time for metal in transition
L(t) = the desired level of molten metal in the sprue cup
Q(t) = the flow out of the orifice

The learning process takes place after a pour is finished. While the next mold is being indexed into position, the calculated mold intake (Eq. 3) is analyzed, and the estimated mold intake (Eq. 4) is updated based on the result of the analysis (Fig. 7).

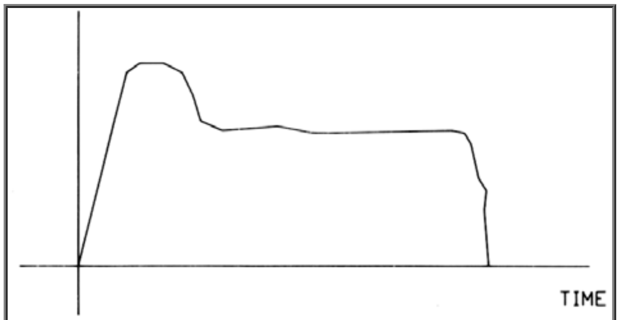


Figure 7. Mold intake profile.

The learning process is essential to the proper operation of the control system in order to keep the pour time in the acceptable time window without short pouring, due to gradual changes in the level of molten metal in the tundish and diameter of the orifice.

CONCLUSION

The vision system as a closed-loop, self-compensating automatic pouring system increases the productivity and reliability of the casting process by eliminating the costly over pours and short pours. The utilization of a vision camera, which directly views the sprue cup, eliminates the need for oversized sprue cup design, which may hold more molten metal than needed.

The control system adapts itself to the changes in the pour process caused by variation in the molten metal level in the tundish and diameter of the orifice.

Ductile Iron Castings Made to Specification GGG 40.3

A DIS presentation given by: *Mark J. Fields, Cast-Fab Technologies*

Cast-Fab Technologies produces ductile iron castings which range in size from just a few pounds up to about 40,000 pounds. We have produced larger ductile iron castings, in my own experience at Cast-Fab, even up to 1 63,000 pound shipping weight. On a regular basis we produce castings weighing 40,000 pounds.

In regard to the 40.3 specification, we first began shipping castings made to this specification in 1996. However, we laid the groundwork for this as early as 1994.

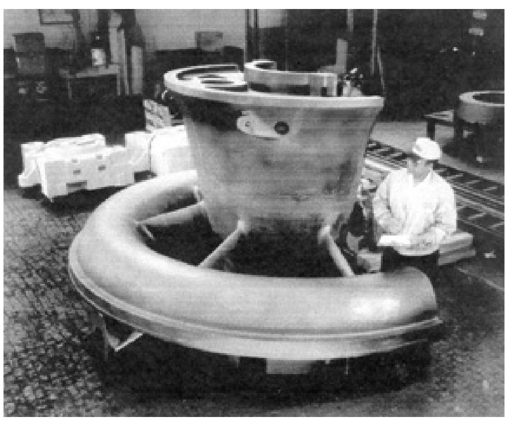
To start this discussion on the castings made to the specification 40.3, I would like to talk for a bit about the historical beginnings of the specifications themselves.

The so-called "DIN" specifications actually refers to the issuing authority for the specifications, which is much like ASTM (American Society for Testing Materials) in the United States. In Germany a similar organization exists, known as "Deutshe Industrie Norman," or the initials DIN.

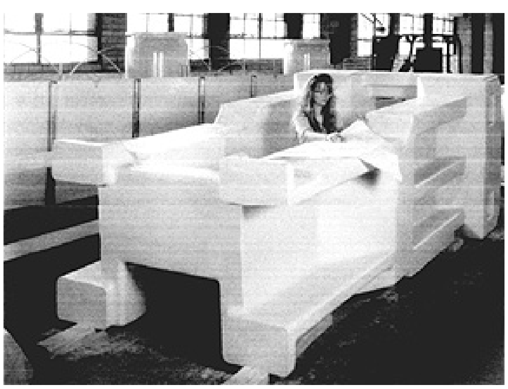
DIN 1693, Part 1, was first issued in September 1961. I have not studied the 1961 issue, but I understand it cam about from research in Germany from about 1955 through 1959. The specification is similar to ASTM specification A536, in that this one specification number covers several grades of combinations of tensile strengths. Similar to A536 the grades in DIN 1693 are ranked according to their mechanical properties. Also like A536 the numbers used to designate the grades are a type of shorthand indicating the strength of the grade. Of course the measuring units are in metric, instead of Imperial units.

The original specification I referred to DIN 1693 which was issued in September 1961 had sever lower tensile grades classified within the specification, namely GGG-38, GGG-42 and GGG-45. For example GGG-42 would refer to a ductile iron with a tensile strength of 420 N/mm. So the number in the grade is multiplied by 10 and the result is the minimum tensile strength, in N/mm^2.

In 1973 the DIN 1693 specification was revised again. Two ferritic grades were combined - GGG-38, and GGG-42 into the GGG-45. Also, the increasing importance of guaranteed impact values led to the conclusion of the 40.3 grade in DIN 1693 Part 1.



Here's an example of a 40.3 type casting - an inlet housing (26,956 pounds)



This is another example - a press frame (62,310 pounds)

Molding Practice
To produce the large castings normally associated with the 40.3 specification, rigid sand molds and cores are necessary. Chemically bonded sands, mixed correctly and well rammed, are necessary. Without good practice, mold wall movement can occur which introduces microporosity in the attached test bars.

Test bars should be positioned vertically in the mold. In doing so, any dross or slag will normally be on one end of the bar, instead of the area where the test pieces will be removed. The length of the bar is a good item to discuss with the customer before starting production. The length will be dependent on the gage length of machined tensile test bars, including the gripping method. It is best to allow an extra 15 to 25 mm if possible.

Positioning bars in the cope should not be done. The drag is the best area to place test bars.

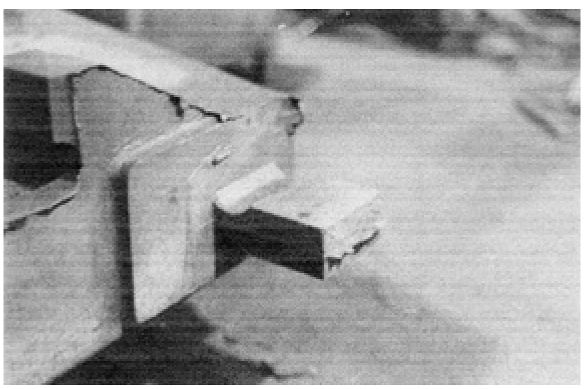
If a bar must be placed horizontally, the test pieces should be cut from the lower two-thirds of the bar only.

Attached bars can be made as part of the pattern, or ram-up cores can be used to make the bars. Each method has an advantage. With pattern made bars the position is controlled, the location is controlled, and the cost to make the bar itself is minimal. With ram-up cores the bars can be placed lower in the mold, but the possibility now exists for leaving the bars out during molding, or variation in location and position from casting to casting. Also the costs go up since an extra operation is needed to make the core. We consider the advantages of both in our placement decision.

I think it is important to attach two bars on very large castings. This provides more material for all the tests, and extra material to be used in case of a problem in testing.

Test bars must be made of sand of the same type as the casting. Avoid locations also where cooling rates will be influenced by gating systems, risers or chills.

Lastly, the bars should not be removed until the heat treating is concluded. Some customers want to witness bar removals.



Here is a Form 2 bar attached to a large casting.

In our experience we have never had a purchaser specify where the bar is to be placed. Some purchasers do like sketches or photos of bar placement for their records, however. So usually it is the manufacturers choice to attach the bar in a suitable location.

Although the bar thickness is specified exactly, there is some latitude in design of bar width. We have always opted for a wider bar. This represents large castings better and gives more raw material to machine test bars out of.

Metallurgical Considerations
Silicon may be the most important element to control for producing to the GGG-40.3 specification. It is a strong graphitizer, to assist in obtaining a fully ferritic matrix. It is also a ferrite strengthener. In strengthening the ferrite the impact transition temperature is increased. GGG-40.3 testing is performed at a specific temperature. In producing the grade we are not measuring the transition temperature, we are just interested in assuring the Impact Energy absorbed by the specimens meets the minimum. Since lower shelf temperatures are typically in the 4 to 7 joules range, the key is to keep the silicon low enough that the transition temperature is shifted lower than -20 degrees C.

Naturally lowering the silicon content will lower the carbon equivalent. This makes for a dilemma. In order to avoid shrink defects, carbon equivalent needs to be maintained near the eutectic. Micro shrinkage as a result of too low CE can occur in the test pieces. This will certainly lower the absorbed energy during the test. Pouring temperature now becomes a concern for shrink control.

Phosphorus must be kept low, since the phosphide eutectic lowers ductile iron toughness. This should be kept as low as possible, certainly below 0.025%. The key is raw material control.

In lowering the silicon to assist in lowering the transition temperature, yield strength suffers. Yield strength in GGG-40.3 must be maintained to the same degree as in the standard or non impact grade GGG-40. Nickel can be added to increase yield without increasing the ductile/brittle transition temperature. Care should be exercised, as too much nickel will cause nodule shape changes.

Almost all other elements, besides the ones mentioned, harm the metal in some way for the production of GGG-40.3 impact grades. Carbide stabilizers lower toughness, and many other elements will cause graphite formation or shape control problems.

Treatment and Pouring
Good inoculation is essential to produce good nodularity. The aim should be to maximize the number of Type 1 nodules. However, you should avoid raising the silicon content too much with the inoculation since this will affect the transition temperature. Solid mold inoculants are a good idea, since fade is minimized. Correct pouring temperature must be maintained. This will reduce shrink in the casting or the test bar.

Heat Treating
In producing 40.3 castings, a heat treatment is normally required. This is a full anneal which is done to completely transform any remaining non ferritic structure into ferrite.

One thing to remember is the strong influence silicon has as a graphitizing element. Since one metallurgical aim for transition temperature control is to lower the silicon content, the iron will tend to form more pearlite in the as cast condition. Then, through annealing, the pearlite can be decomposed into ferrite with the carbon migrating to existing graphite nodules or interstitial sites.

Nodule spacing becomes important. The smaller the nodule spacing, the shorter the migration path for the carbon. It should be controlled so that your heat treatment can be standardized. At the very least it should be measured, so some remedial action can be taken if the first heat treat is unsuccessful.

Micros should be taken from the impact specimens themselves until you can be certain your heat treatment cycle is producing a fully ferritic material.

Removal of specimens from an attached bar
I think it is a good idea to specify how the samples will be taken from the bar. We usually mark the bars before having the sectioning done. The actual testing is done at an outside laboratory. We require that the laboratory maintain traceability of the three specimens. We also request that the specimens for Charpy test be returned to us. That way if there is a low result, we can examine the bar to determine why the result is low. That is why marking the bar is important.

Specifying test methods
The most important part of meeting the 40.3 specification is the actual impact test.

DIN 1693, Parts 1&2 both specify that the test specimen be machined to a DVM shape. This DVM shape is described in DIN 50015. The test coupons are 55mm long and 10mm x 10mm rectangular bars. A notch which is 3mm deep by 2mm wide is cut into the bar. The bottom of the notch is fully radiused. The uncut cross section remaining is 7mm x 10mm.

Other shapes are sometimes specified, by customers, but this U shaped notch is the standard in DIN 1693 Part 1. Good machining of the notch is important to the test.

Make sure that the lab knows what the test temperature is to be. This must be absolutely clear. Minus 20 degrees centigrade is the GGG-40.3 requirement. When we first began producing to GGG-40.3 the lab would sometimes test at the wrong temperature or test at Fahrenheit temperatures.

Test results are preferably reported in Joules. Ask the lab to report to as much precision as possible. Accuracy is of course a given requirement.

Notch Styles
Now we talked about how other notch designs are sometimes specified. The V notch is 2mm deep, comes to a point at a 45 degree angle, and the bottom has a .25mm radius. The DVM notch is

U-shaped. Although the notch is 3mm deep, the sides are parallel and there is a relatively large 1mm radius at the bottom. The DVM notch is the requirement for DIN 1693, 40.3 grades.

Investigations of the specimens
After testing, the fracture surface should be examined. Look for percentage of crystalline fracture vs non-crystalline. Micros can be made of one half of the two notch pieces. This is especially important if test requirements are not met.

The future of DIN 1693, Parts 1 & 2, GGG-40.3
At this time we have been talking about 40.3, but the DIN standards of the 1970's were superseded almost two years ago. EN 1563 is the replacement specification. It was issued in August 1997. The old material designations are obsolete. There are no longer two parts to the specification, they are now combined. 32 new grades have been added and grades based on hardness are now available. They are not in wide use yet, but some inquiries have been made. Is 40.3 equal to the new standard? Maybe yes and maybe no.

Environmental Compliance Considerations & Strategies for Foundries

Abstract of Presentation at DIS Ft. Worth Meeting

by: Daniel Longbrake, August Mack Environmental, Inc.

Recent Regulatory Developments

1. Lawsuit filed against utilities for violations of the clean air act.
The law suit alleges that the utilities have made major modifications that would have required the controls to be put in place. If this law suit is successful, one could expect to see the USEPA targeting other title V facilities.

2. Phase II storm water rule.
According to this rule, a separate storm water system must be in place for construction sites greater than five acres and/or if the population is greater than 100,000.

3. MACT (Maximum Allowable Compliance Target) for iron and steel industry is scheduled to be promulgated prior to 11/00.
This is about twelve months behind schedule and 600 MACT long forms have been submitted by the industry. Foundries with cupola operations will be asked to complete another questionnaire (bag house vs scrubber for MACT). This will come from the MACT task force.

4. Risk management plans.
The plans were due by June 21, 1999. On August 5, 1999 Clinton signed the chemical safety information, site security and fuels regulatory act, that provided an exemption for all hydrocarbon fuels that are used on site as fuel. (Example - propane) The propane exemption is still in the US Court of Appeals.

Summary of Environmental Regulations Affecting the Foundry Industry

1. Clean air act and amendments
2. Clean water act
3. Resource conservation and recovery act (RCRA)
4. Superfund amendments and reauthorization act of 1986 (SARA Title III)
5. Toxic substance control act (TSCA)
6. Oil pollution prevention
7. OSHA

Compliance Strategies - General principles

1. Get Buy-In from management
2. Establish relationship with regulators
3. Plan ahead
4. Participate in capital planning
5. Conduct training
6. Recognize that any program is dynamic: anticipate and account for change
7. Utilize resources that are available (E.G., regulators, web pages, associations, consultants)

Specific Compliance Strategies

Develop and Implement

1. Compliance audit program

- Continually update and track progress
- Establish responsibility and accountability

2. Integrated contingency plan

- Address the issues of storm water pollution
- Prevention plans: OSHA Emergency Action Plan; RCRA Contingency Plan

3. Emergency health and safety tracking system

- Develop electronic record keeping
- Utilize software available in the market
- Utilize graphics (facility layouts, plans)

4. Environmental liability assessments

- Determine or update liabilities
- Account for changes in regulations/technology
- Free up capital for expansion/growth

Globe Metallurgical's "Challenge Scholarship Program"

Globe Metallurgical Inc., the world's leading manufacturer of foundry alloys and the country's largest producer of silicon metal, is again this year sponsoring the "Globe Challenge High School Scholarship Program."

Now entering its eighth year, the program recognizes outstanding high school students who have overcome unique challenges or helped others to do so. High school seniors in the four communities in which Globe has production facilities are eligible: Beverly/Waterford, OH; Niagara Falls, NY; Selma, AL; and Springfield, OR. Fifty-one scholarships have been awarded to date. "The scholarship theme is in line with Globe's corporate motto, 'The Challenge Never Ends'," said Arden Sims, president and CEO. "It reminds us that we must constantly strive to reach new heights in quality improvement. Through the Scholarship program, we challenge students to reach new heights in their academic and personal endeavors."

Winners are judged by an independent panel based on their submission of a 500 word essay in which they describe a challenge they have overcome, or helped someone else overcome. In addition to their essays, applicants are evaluated on their academic performance, participation in extracurricular activities and letters of reference.

"Last year, our essays described how students overcame a variety of challenges - from helping parents get a home of their own to reuniting broken families", said Sims. "It is gratifying to see the ingenuity and maturity of these students. We are proud to help support them as they pursue their higher education."

The award consists of a one-time $1,250.00 tuition payment to the student's college, trade or technical school of choice. Winners also have their names engraved on a plaque placed at Globe's plant and the participating school.

For complete details and scholarship application, eligible students in **aforementioned participating school districts** should contact their high school guidance counselor.

In addition to its Challenge Scholarship Program, Globe offers scholarships specifically for the children of Globe employees. Applications for these scholarships are available directly through the company.

Globe Metallurgical Inc. is a privately held company, with headquarters in Cleveland, OH. In addition to four domestic production facilities and one in Norway, Globe owns a subsidiary in West Sussex, England, and is the major shareholder in Fesil, a leading Norwegian Alloy producer. Recognized internationally for its high quality products, Globe has received numerous awards, including the 1988 Malcolm Baldridge National Quality Award and the 1989 Shiego Shingo Award for Manufacturing Excellence.

Deep Cryogenic Tempering - One of Metalworking's Best Kept Secrets

An abstract of a presentation given at the DIS Ft. Worth meeting

by: John Koucky, 300 Below, Inc.

What is Deep Cryogenic Tempering?

It is -

1. Freezing the material at -300^{o}F to modify the microstructure and improve the properties.
2. A "dry" process.
3. A "one time" treatment.
4. A "through" treatment.
5. A treatment to improve properties - particularly the wear properties.

What are the benefits of Deep Cryogenic Tempering?

Deep Cryogenic Treatment at -300^{o}F can make a major contribution to solving these problems:

1. HIGH ABRASIVE WEAR in cutting tools, molds, dies, bearings, etc.
2. HIGH CORROSIVE WEAR in chemical, food and oil equipment applications.
3. HIGH EROSIVE WEAR from wind, water and other abrasive grit carriers.
4. DISTORTIONS induced by design, forming, machining or environment.
5. STRESS RELIEF in complex tools, components and welds.
6. STRESS RELIEF CRACKING in weld zones in corrosive atmospheres.
7. SURFACE FINISH in any applications where long life is needed.
8. STABILIZATION in parts and components as a result of stresses.
9. MACHINABILITY in aluminum and copper parts.
10. ELECTRODE LIFE in copper resistance welding electrodes.

What happens during Deep Cryogenic Tempering? (Ferrous components)

1. Most of the retained austenite is transformed into martensite. The martensite is then tempered to change it into tempered martensite.
2. Small complex carbides called eta carbides are precipitated out.
3. Residual stresses are greatly reduced.

Alloys with greater than 0.40% carbon REQUIRE Cryogenic Tempering to finish martensite transformation.

Deep Cryogenic Tempering is performed in batch type Cryo Processors using primarily liquid nitrogen. The tempering process is fully automated with computer controls to offer maximum benefits.

What materials are favorably affected by Deep Cryogenic Tempering?

Ferrous Materials:

1. Tool steels
2. Higher carbon, higher alloy materials
3. Martensitic stainless steels
4. Gray cast iron

Aluminum

Brass

Tungsten carbide

Other applications of the process are

1. Musical instruments
2. Motor sport applications
3. Gun barrels
4. Sporting goods
5. Disc brake rotors
6. Others such as composites, etc.

Deep Cryogenic Tempering at -300^{o}F vastly improves the wear properties compared to 'cold treatment' at -100^{o}F. (See table 1.)

TABLE 1. Test Results (% Wear Increase after Cryogenic Tempering)			
Type of Steel		**% Improvement**	
AISI #	**Description**	**(-110^{o}F)**	**(-310^{o}F)**
D-2	High carbon/chromium die	316	817
A-2	Chromium cold work die	204	560
S-7	Silicon tool steel	241	503
52100	Bearing steel	195	420
0-1	Oil hardening cold work die	221	418
A-10	Graphite tool steel	230	264
M-1	Molybdenum high speed	145	225
H-13	Chromium/moly hot die	164	209
M-2	Tungsten/moly high speed	117	203
T-1	Tungsten high speed	141	176
CPM-10V	Alloy steel	94	131
P-20	Mold steel	123	130
440	Martensitic stainless	128	121
430	Ferritic stainless	116	119
303	Austenitic stainless	105	110
8620	Nickel-chromium-moly steel	112	104
C1020	Carbon steel	97	98
AQS	Graphitic cast iron	96	97
A-6	Manganese, air, cold work die	73	97
T-2	Tungsten high speed steel	72	92

Field test results with Deep Cryogenic Tempering. (See table 2.)

Our expert computer-controlled patented systems which enable

CONSISTENCY AND MAXIMIZED GAIN in the following areas:

Reduced: Abrasive Wear, Corrosive Wear, Erosive Wear, Distortion

Increased: Stress Relief, Stabilization, Machinability

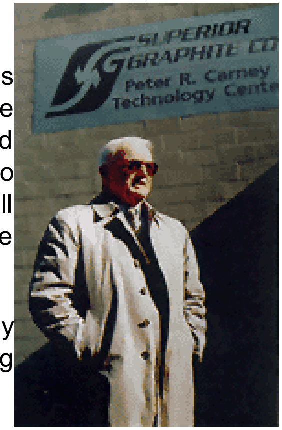
Significantly Increased: Useful Life

Table 2

Tool Type	Company	Tool Material	% Improvement
Drills	Aircraft Manufacturer	M42, M7, C2	300
Milling	Aircraft Manufacturer	M7	250
Deburring	University Study	Inconel	400
Gear Cutter	Major Manufacturer	Ti-N Coated	350
Broach	Metal Milling Co.	Carbide	300
Punching	Major Manufacturer	M7	600
End Mill	Aerospace Mfg.	M42	450
Hob	Turbine Mfg.	M2-M7	300
Face Mill	Aerospace	C2 Carbide	400
Key Cutter	Aircraft Mfg.	M2-M7	250
Slicer	Plastics Mfg.	M7	600
Chipper	Box Mfg.	Carbide	500
Shredder	Paper Mfg.	M7	400
Tap	Tool Maker	C2 Carbide	600
Die	Casting Company	Hi Ni Alloy	300
Dentistry	Dentist	400 Stainless	500
Broach	Auto Mfg.	Hi Nickel	250
Logging	Logging Company	Saw Chain	400
Milling	Machine Shop	347 Stainless	375
Woodcutting	Pro Woodworker	HSS	500
Stamping Die	Steel Furniture	D2	1000
Corrosion	University Study	S2, M2, 4142, 316	Red. All Corrosion
Machinability	Machine Shop	Thin Wall Alum.	50% Time Savings
Electrode	7 Studies	Welding	600% Average

Superior Graphite New R&D Center

Superior Graphite Co. dedicated its new research and development center in honor of company Chairman and CEO Peter R. Carney.



"The Peter R. Carney Technology Center will complement the company's development work, now and in the future, serving as a constant reminder that we need to pursue the limits of our capacity," said Superior Graphite President Edward Carney. "Peter Carney is committed to product innovation and invention. Thanks to his resolve, Superior Graphite has long been a leader in this area. This center will be the foundation where we will continue to develop technologies that will set the industry standard for years to come."

Surrounded by Superior Graphite employees and numerous guests, Peter R. Carney thanked the company's employees for all of their hard work and dedication, saying the center would not be possible without them.

"This state-of-the-art facility is really a tribute to all of you," he said. "I encourage everyone to continue to find new applications that will keep us on top of emerging industry processes and open up new markets for the company."

Significant resources have been dedicated to the center at 4201 W. 36th Place, Chicago, Illinois, 60632. Cutting-edge research, development of new products, and quality assurance of finished products are all performed at the facility.

The center has a lab that contains state-of-the-art equipment including a Carl Fisher K.F. analyzer, which measures moisture in graphite in parts per million; a B.E.T. surface area analyzer, a laser particle size analyzer; and an inert atmosphere glove box used for lithium-ion battery research.

The center also houses a Quality Assurance Department where finished products are tested to make sure they meet stringent customer specifications.

Here, sophisticated equipment including an emission spectrometer measures trace metals in the graphite. These contaminants are kept to a minimum to assure Superior Graphite's customers receive the highest quality, customized products.

Superior Graphite is a high-temperature technology manufacturing company that uses unique technologies to add value to carbons and graphites, developing high-quality solutions for numerous industries.

Based in Chicago, the company has eight manufacturing centers in the United States, Europe and Mexico, and sales and distribution resources worldwide.

NEWS BRIEFS

MEETINGS

The next meeting of the Ductile Iron Society will be held on **June 14-16, 2000** at the Hyatt Regency Hotel in Wichita, Kansas. There will be a visit to Farrar Corporation in Norwich, Kansas. Call (440) 734-8040 or email the Ductile Iron Society jhall@ductile.org to make your reservations. You may also call the hotel directly for your room reservations at 1-800-233-1234. Please mention the Ductile Iron Society Meeting to receive your group rate.

The Fall T&O meeting of the Ductile Iron Society will be held on October 4-6, 2000 at the Orleans Hotel in Las Vegas, Nevada. Room rates are $54 per night and reservations can be made by calling 1-800-675-3267.

On Friday morning, October 6, Dotson Company, Plymouth Foundry, and St. Mary's Foundry will present "Virtual Tours" of their foundries.

PEOPLE IN THE NEWS

Edward D. Gesdorf Named Vice President Sales - Northern Division. **Edward D. Gesdorf** has been named Vice President Sales - Northern Division for Miller and Company, a Chicago-based supplier to the metal casting and steel industries. Mr. Gesdorf has over 30 years experience in the metals industries, most recently serving as Vice President for Pickands Mather Sales, Incorporate. He started his career as a plant metallurgist for Alcoa and later moved into sales. Thereafter, he continued in a sales capacity for Foote Minerals for twelve years.

Ashland Specialty Chemical has announced that **Michael W. Swartzlander** has been named to the newly created position of director of business development. The announcement made by James A. Duquin, president of Ashland. In his new position, Swartzlander will facilitate the company's growth goals to add significant new specialty chemical businesses via technology development, alliances, and strategic partnerships. He will be based in Dublin, Ohio, and reports to Duquin.

Ashland Specialty Chemical Company's Foundry Products Division has named **Jiang Fu** general manager of its operations in the People's Republic of China at Ashland (Changzhou) Chemical Company. The announcement was made by Michael D. Killian, vice president and general manager of the division.

Grede Foundries, Inc. has named **Robert A. Wermuth**, Vice President and Chief Financial Officer of Grede Foundries, Inc. Wermuth received a BA in economics in 1977 from Lawrence University and an MBA in 1979 from the University of Chicago Graduate School of Business. He comes to Grede from Snap-On Inc. where he served as International Business and Finance Director. Previous to that, the major portion of his career has been with the Coca-Cola Company, where he served in various finance roles. Wermuth currently serves as a director on the board for the Milwaukee Symphony Orchestra.

Ashland Distribution and Specialty Chemical Companies have named **David H. Armstrong** vice president of Planning and Development according to D. S. Boston, Jr., administrative group vice president. Armstrong is now responsible for managing the merger and acquisitions activity and strategic planning process, including major capital project analysis, special studies and new business development, for both Ashland Distribution Company and Ashland Specialty Chemical Company. Armstrong will remain in Dublin, Ohio and report to Boston.

AMCOL International Corporation announced that **Tony Tomlin** has been named vice president of technology. Tomlin will oversee research and product development for all AMCOL companies, including Chemdal, a supplier of super absorbent polymer, American Colloid Company and Volclay International, suppliers of bentonite clay and related products, CETO, an environmental company, and Nanocor, a supplier of plastic additives.

AMCOL International Corporation has elected **Larry Washow**, president and chief executive officer, effective in May 2000. Currently he is president and chief operating officer. In his new capacity, Washow will be responsible for AMCOL's strategic direction and operational leadership.

Intermet Corporation announced in February that **Doretha J. Christoph** has resigned as Chief Financial Officer, to accept a CFO position with a large west coast company.

American Colloid Co., a specialty minerals operation of AMCOL International Corp. announced in February the promotion of **Gary Morrison** to the position of president. Morrison assumes the responsibility for American Colloid's North American operations from **Frank B. Wright, Jr.**, who continues to spearhead AMCOL's international mineral market development and serve as president of Volclay International Corp., a sister operation to American Colloid.

John Doddridge, INTERMET Chairman and CEO, announced today that **Michael J. Ryan** is joining INTERMET as Executive Vice President responsible for manufacturing operations and as a member of the Corporate Operating Committee. John Doddridge said, "We are excited to have an individual of Mike's caliber and impressive background join the INTERMET senior management team."

Jen Meier has joined Superior Graphite Co. as product manager-Slip-Plate®. In her new position, she oversees marketing, planning, promotion and distribution of Slip-Plate products, including aerosol and quick-dry films, and penetrating oils made in Chicago.

Grede Foundries, Inc. has named **Kristin Z. Reilly** Vice President - Business Engineering of Grede Foundries, Inc.

Foseco Promotes **Hugh Kind**. Foseco Metallurgical, Inc., a leading provider of proprietary products and systems designed to enhance quality and efficiency in aluminum, iron and steel foundries has promoted Hugh Kind to Vice President of Marketing.

Kind has been with Foseco since 1976 and has previously held various product management and application engineering positions. Most recently, he was Marketing Director. In his new position, Kind will oversee all Marketing, Product Management, Application Engineering and Product Development groups. He will continue to be based in Foseco corporate headquarters in Cleveland, Ohio.

Currently serving on the Board of Directors of the Casting Industry Suppliers Association (CSIA), Kind also serves as Treasurer of the Ductile Iron Society and on the Board of Trustees of the Foundry Education Foundation.

Kind received his B.S. in Metallurgical Engineering from the University of Missouri-Rolla, and then earned his M.B.A. from Baldwin Wallace College in 1992.

Foseco Promotes **Hal Clarke.** Foseco Metallurgical, Inc., a leading provider of proprietary products and systems designed to enhance quality and efficiency in aluminum, iron and steel foundries has promoted Hal Clarke to Vice President, Sales.

OBITUARY

Victaulic mourns the passing of longtime employee Tom Healy.

Thomas E. Healy, 54 of Tinton Falls, passed away at home on Wednesday, February 2, 2000. Mr. Healy completed 22 years of dedicated service to Victaulic. He began in 1978 as a Line Sales Representative for the New York City area, in 1983 he was promoted to the title of HVAC Market Manager. Since 1984 Tom fulfilled the duties of Northeast Regional Sales Manager. His commitment to excellence earned him the honor of participating in the President's Club, an award bestowed upon outstanding salesmen. He was a participating member of the New York Sprinkler Contractor Association, American Society of Heating, Refrigerating and Air Conditioning Engineers, American Society of Plumbing Engineers, as well as an alumni of Alpha Kappa Psi, a professional business fraternity.

Upon completing his education at Bloomfield College, where he received his degree in marketing and economics, Tom served his country in the New Jersey Army National Guard for six years.

Surviving him are his wife, Deanne and his daughter Jaime Lyn Healy of Tinton Falls, and sister Barbara Kelly of Fort Myers, FL. Victaulic mourns the loss of Tom Healy, a dedicated salesman and friend.

BUSINESS BRIEFS

Superior Graphite Co. has selected **CMC Australia Proprietary Ltd.** To be the exclusive distributor in Australia for Superior's Desulco high purity carbon additive. CMC Australia, a subsidiary of Commercial Metals Co., is a leading supplier of products to the steel, aluminum and foundry industries in Australia and New Zealand. "Because CMC Australia has salespeople located throughout the country, the company provides excellent personal attention and service to our customers", says Michael Castro, Superior's marketing manager. "In addition, CMC Australia has multiple warehouses, enabling the company to provide customers with same-day delivery."

American Colloid Co., a wholly owned subsidiary of AMCOL International Corp., plans to build a foundry compounds blending plant in the southeast region of the United States. Pending completion of site selection, contracts and additional government and developmental authority arrangements, construction is slated to begin by Spring, 2000. The project cost is estimated at three to four million dollars. American Colloid President Frank B. Wright, Jr. said that the finished plant will employ up to 12 people. Wright says construction is targeted for completion by year-end 2000.

Grede Foundries, Inc., of Milwaukee, Wisconsin and Proeza, S.A. de C.V. of Monterrey, Mexico, announce their decision to create a 50-50 joint venture company to construct and operate a state-of-the-art ductile iron foundry. Located on a 32-acre site near Monterrey, construction of the world-class foundry was scheduled to commence by March 30, 2000, and take 18 months to complete. The facility is being planned to produce 80,000 tons of castings on an annual basis for automotive, agricultural, and construction customers in an effort to address the needs of a global market. Proeza, a highly recognized industrial group, participates in the automotive, citrus processing and ductile iron casting industries with operations in Mexico, selling on a worldwide basis.

Superior Graphite Co. is pleased to announce it has entered into an agreement with Cambridge, Ontario based Kalexa Inc. that makes Kalexa the exclusive distributor in Canada for Superior's matallurgical products. David Sproat, who previously was the Canada based sales manager for Superior Graphite's markets in Canada, Latin America and Mexico, owns Kalexa Inc. Superior Graphite is pleased to continue its working relationship with Sproat as an agent for the company, and assures its customers that their service will not be interrupted. "One advantage of this relationship is that there will be a seamless transition for our Canadian customer base", says Edward Carney, president of Superior Graphite. "At the same time, the move will lead to a more focused effort to enhance the contact and product leadership in the Canadian market." Superior Graphite closed its Canadian office on December 31, 1999, to consolidate its business structure.

Foseco Metallurgical, Inc. announced that **Corning Incorporated's Specialty Cellular Ceramics Plant** celebrated its tenth anniversary in 1999 with impressive growth statistics and a roster of innovative new products including a major new filter introduced for the foundry industry in 1997. Corning's Erwin, NY, facility, which manufactures cellular ceramic metal filters used to remove impurities from molten metal while it is being cast, has nearly tripled its sales in the past decade. Over this period, the use of molten metal filters demonstrated solid growth as foundries sought to increase product quality and yields. Another reason for its growth is the success of the Corning Delta CELTEX filter, an extruded ceramic filter with triangular shaped cells that provide more effective filtration for foundries. In developing the filter, Corning partnered with Foseco Metallurgical, Inc., a leading provider of proprietary products and systems that enhance quality and efficiency in aluminum, iron and steel foundries.

Ashland Distribution Company announced that it has formed a new division called **Service Business Division**. This new division will be charged with managing and growing businesses that provide a wide range of services to Ashland's customers. This business unit will report directly to Michael J. Portland who has been named vice president and general manager of the new division. Portland will report to Peter M. Bokach, president, Ashland Distribution Company.

Intermet Corporation reported on January 27, 2000 an all time record sales of $957 million for 1999, keeping pace with record auto sales. Compared to 1998, sales were up $115 million, or 14%, over the previous annual record 1998 sales of $842 million. 1999 and 1998 included sales of $57 million and $55 million, respectively, for the Ironton facility that will be closed in 2000. Net income for the year was $36.4 million, or $1.42 per diluted share, compared with $41.0 million, or $1.58 per diluted share, in 1998. Earnings per diluted share, excluding one time events, were $1.59. 1999 earnings were impacted by manufacturing facilities operating at over capacity levels to meet customer demands. The earnings also include several one time events: recognition of a $0.47 per diluted share charge for the closure of a foundry in Ohio, a tax benefit of $0.33 per diluted share resulting from non recurring tax events, and a $0.03 per diluted share cost associated with the acquisitions to two light metal companies.

Intermet Corporation announced on February 4, 2000 that its entire cast metal product line will be manufactured and marketed under the Intermet name. All facilities previously identified as Diemakers, Ganton Technologies or Tool Products will be identified as Intermet. "The name changes were made to better reflect our role as a single source supplier for all cast metal automotive components," said David L. Neilson, Intermet vice president of sales and marketing. "With the recent acquisitions of Diemakers, Ganton Technologies, and Tool Products, we are uniquely positioned as a company with full service supplier capabilities across a broad spectrum of materials. Our customers know us as the premier manufacturer of ductile iron components. Now we are able to provide solutions to our customers' challenges in ductile iron, aluminum, magnesium and zinc."

The **General Casting Company**, headquartered in Grafton, Ohio announces the formation of a new lost foam jobbing foundry, MetFoam Casting, LLC. The new venture is a subsidiary of General Casting, and is located in Columbus, Ohio. MetFoam Casting will be in production by July.

MetFoam will pour all grades of gray and ductile iron, serving a variety of industrial markets. The foundry can produce castings in weights from 50 to 1,000 pounds, and has a capacity of 6,000 net good tons per year. The foundry has an automated production line with twenty-six flasks 38" dia. x 58" tall.

Mr. Jeff Vogel is Vice President and General Manager of the new foundry. Mr. Vogel has 17 year experience in the foundry industry.

General Casting operates eight foundries in OH, PA, and IN. The company produces a wide variety of gray and ductile iron castings ranging in size form 1-30,000 pounds. General Casting is privately owned and employs approximately 900 people.

Ashland Specialty Chemical Company Names Gilbreath Project Manager.
Dublin, Ohio (USA) -- Ashland Specialty Chemical Company's Foundry Products Division has named Timothy J. Gilbreath project manager. The announcement was made by Michael D. Killian, vice president and general manager of the division.

Foseco Builds New Foam Filter Manufacturing Facility. Foseco Metallurgical, Inc., a leading provider of proprietary products designed to enhance quality and efficiency in aluminum, iron and steel foundries has announced that it is constructing a new facility at its Cleveland, Ohio manufacturing plant. This new, state-of-the-art facility is expected to begin production this fall. It will produce foam filters under the SIVEX® FC filter trademark for aluminum castings and the SEDEX® filter trademark for iron castings.

Associate Member Profile

MAGMA Foundry Technologies, Inc.

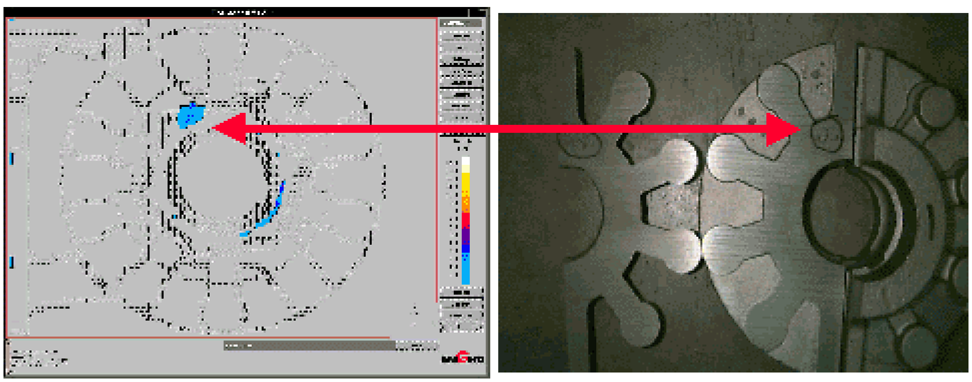
Type of Business: Provider of casting design/optimization engineering and process simulation software.

Company Profile: Started in the U.S. in 1991, MAGMA has been the pacesetter in defining a new direction for the Foundry Industry. Its development and use of casting process simulation has provided the opportunity for metal casters to improve quality while concurrently reducing the lead times for sound, cost effective castings. Both foundries and OEM's call on MAGMA to assist in the engineering of improved castings. Our Engineering Services Group is always available to problem solve or optimize casting designs.

Product Information: In addition to providing casting engineering expertise, MAGMA sells and supports its casting simulation software, MAGMASOFT®, for use in both production and research environments. Most every facet of the casting process can be investigated using this simulation tool.

More recent developments have led to a greater understanding of such aspects as; alloy segregation, microstructure and mechanical property prediction, new casting processes such as counter pressure and thixo, and much more.

With today's computer hardware our simulation tools can be used on virtually any major operating system. And what's more, simulations today often take just hours to complete. This provides the user with quick answers for more successful up-front engineering, quality improvement, process development, and investigation of new casting designs.



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