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To Promote the production and application of ductile iron castings *Issue 1, 2005*

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Ductile Iron Society Opens Membership Globally

Beginning in late 2004, the Ductile Iron Society has changed their bylaws to allow membership for companies around the world. In the past, the membership was restricted to companies on the North American continent.

It is the feeling of the Ductile Iron Society Board of Directors that offshore companies would be able to participate fully in our activities using email and our website discussion site. These new members would enjoy all the benefits of the Society.

For those who would become "Associate Members," (those who supply goods and services for our foundry members) the dues structure is the same for all and is $880 per half year.

For those foundries that join the society, the fee is $2,500 per year, paid annually.

Membership has been sought by many companies is the past and was denied due to the past policy. We hope that those companies will contact us again in the near future.

To obtain more information, please contact:

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Coping with Higher Molybdenum Prices in Iron Foundries

by George D. Haley
Metallurgical Consultant

Coping with higher molybdenum prices requires using the minimum amount of alloy effectively. While molybdenum is added to cast iron for a variety of reasons, its most common foundry use is to increase the tensile strength. Its single function in this application is to refine the pearlite spacing. The difference in tensile strength between coarse and fine pearlite has been reported to be as much as 15,000 psi. This improvement in strength can only be achieved by adding molybdenum to a 100% pearlitic matrix. As the amount of pearlite decreases so does the strengthening effect. Molybdenum has little to no effect on the ferrite present in the matrix. Adding molybdenum to a mixed ferrite and pearlite iron is wasting money.

This leads us to **Rule No. 1: When using molybdenum make sure the structure is completely pearlitic before making the addition.** Adjust the chemistry of the base alloy to achieve the desired structure. The first approach to increasing the pearlite content is to lower the silicon content. Do this in small steps. Lower silicons promote more pearlite and finer (stronger) pearlite. At a certain silicon level chill carbides will begin to occur in the thinner sections. Small additions of copper and/or nickel will counter the chilling tendency while promoting more pearlite.

Rule No. 2: Proper addition of molybdenum is critical to achieving good recovery. The recovery of molybdenum depends on the addition practice. The melting temperature of FeMo is over 3000°F. Time and temperature are critical to achieving good recovery. Every effort should be made to alloy in the furnace. Add 2” x 1” or 1” x ½” into a clean molten iron bath in the furnace a minimum of 10 minutes before tapping. If ferromolybdenum must be added to the ladle, the recovery will not be as good as when adding it into the furnace. Do not add more than 0.50% FeMo to the ladle. Mix the FeMo with any other addition such as copper or inoculant. Add fine ferromolybdenum sized 8 mesh x down to the stream as the ladle fills. The stirring is critical for it to go into solution. The tap temperature should be a minimum of 2700°F. Do not add FeMo to a small ladle as the metal will cool too fast to achieve good recovery.

ADDITIONAL COMMENTS

There is no substitute for proper inoculation of the iron. Type “A” graphite is required to achieve the maximum tensile properties. The base metal should have a high potential for nucleation prior to inoculation and alloying. If the base metal is overheated, the charge is full of rusted scrap and there is no graphite added to the charge then alloy additions will not be as effective and will be wasteful.

If the molybdenum containing returns are not segregated, half the alloy is lost and the addition cost is doubled!

SUMMARY

Efficient use of molybdenum as ferromolybdenum to increase tensile strength depends on Rule No. 1 (an all pearlitic structure) and Rule No. 2 (proper addition of FeMo to the base metal). Achieving anticipated results requires proper preparation of the base metal and good inoculation practice. Lastly, do not throw molybdenum away in the returns.

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A Study of the Machinability of an ASTM Grade 3 Austempered Ductile Iron

2002 World Conference on ADI

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*Southampton Institute, Southampton, UK
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ABSTRACT

The paper discusses a comprehensive investigation of the machinability of an ASTM Grade 3 Austempered Ductile Iron utilizing four high grade cutting tools. The machining process selected was a turning operation, conducted under conditions associated with both a roughing cut and a finishing cut. Tool forces, surface finish and tool wear were examined in the investigation. The paper concludes with a benchmarking comparison between the tools.

INTRODUCTION

Throughout the last three decades, Austempered Ductile Iron (ADI) has been rapidly adopted and exploited world wide for manufacturing primarily automotive products. ADI (Austempered Ductile Iron) was first commercially applied in 1972 and by the mid 1970's was employed in Chinese military trucks and commercial truck applications among European industries. Towards the end of the 70's ADI had been utilized for light cars and trucks and was favorably looked upon by the US automotive industries. At the turn of the last century, the world wide consumption of ADI was estimated at 150,000 tons per year, with a projection forecast of 20% annual growth. [1, 2, 3,4]

ADI exhibits remarkable properties, such as high toughness, relatively light weight, good heat conductivity and good vibration damping, as well as a high level of ductility, recyclability and wear resistance. These useful mechanical properties are arrived at via a unique process of heat treatment that provides designers with further manufacturing flexibility and effective cost reduction compared to comparative forged steel components. Austempered Ductile Iron is continuously being incorporated into the ferrous application market. [4,5,6] Further information on the ADI distribution of applications and production capacity is illustrated in Figure 1 and Figure 2.

This paper describes a study of the machinability of ADI using four individual cutting tools. It describes the experiments conducted and the results obtained. The paper concludes with a benchmarking comparison between the tools, which highlights the most suitable tools for machining ADI.

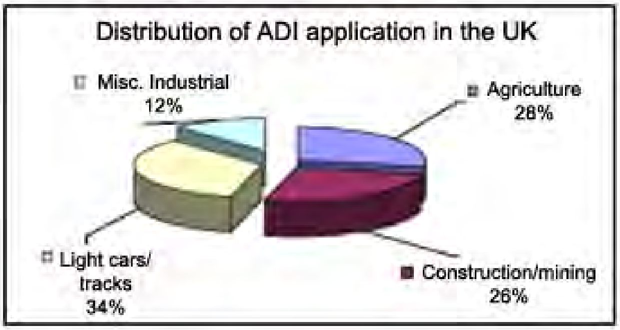


Figure 1 - Distribution of ADI application in the UK

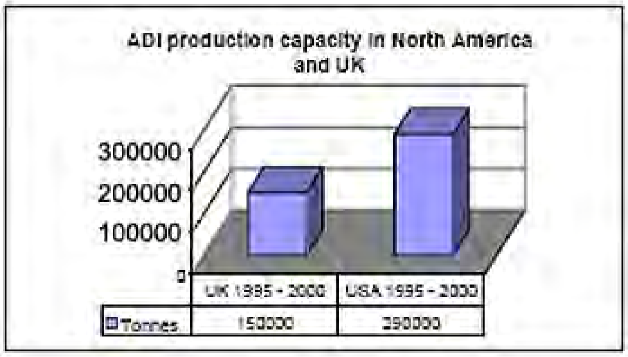


Figure 2 - ADI production capacity in North America and UK

BACKGROUND

Austempered Ductile Iron is a specially heat-treated ductile cast iron. The iron is subjected to an isothermal heat treatment called "Austempering". [3,7,8,9] In contrast to conventional "as cast" ductile irons, ADI gains its mechanical properties by the heat treatment process and not by a specific alloy combination. Thus, the only condition for obtaining a desirable ADI component is a good quality ductile iron material. [9] The typical microstructure of ADI consists of ferrite; austenite and graphite nodules as depicted in Figure 3. [2,6,7,8,10]
The ferrite in the microstructure exists as needle-like arrangement and the white pattern between the ferrite represents the retained austenite. Thus, the metallurgical composition of the two, forms an Ausferrite structure. Furthermore, the dark spheres are the graphite nodules. [5,7,8,9] The austempering procedure is conducted in two stages; namely the Austenitising process and the Austempering process. Details of such treatments appear elsewhere [3,5,7,9] as well as in other papers at this conference.

Figure 3 – microstructure of ADI presenting a common ausferritic matrix of ADI casting grade 1 (500 X

photomicrograph).[5]

The Five ASTM standard ADI Grades ASTM 897-90 (ASTM 897M-90)					
ADI Grade	Tensile Strength MPa (1)	Yield Strength MPa	Elong. %	Impact Energy Joules (2)	Typical Hardness BHN
1 850/550/10	850	550	10	100	269-321
2 1050/700/7	1050	700	7	80	302-321
3 1200/850/4	1200	850	4	60	341-444
4 1400/1100/1	1400	1100	1	35	388-447
5 1600/1300/-	1600	1300	N/A	N/A	444-555
(1) minimum values (2) Un-notched charpy bars tested at 22 +/- 4°C (72+/- 7°F)					

Table 1 - test results obtained by American Society of Testing Material. [5]

Regarding mechanical properties, Kovacs [5] reported that among many beneficial features, ADI has the advantage of offering manufacturing flexibility presenting the designer the option to alter significantly the casting mechanical properties by applying various modes of heat treatment. The ASTM standard grades covering the various strength levels are shown in Table 1, above. The mechanical properties developed through the austempering process are considered broadly as a consequence of either low or high austempering temperature. With a high austempered temperature, features such as high ductility, high fatigue and impact strengths could be acquired. Thus, high austempered temperature would produce relatively low yield and tensile strengths. In contrast, a low austempered temperature will produce high yield and tensile strengths with remarkable wear resistance, though lower ductility and impact strength would be the trade off. [5,7,9]

MACHINABILITY OF ADI

There has been considerable debate concerning the machinability of ADI and whether rough machining should be undertaken before or after the austempering treatment [11,12]

Consequently, an investigation was conceived which would examine the various aspects of machinability as they pertain to a particular grade of ADI, utilizing cutting tools recommended by a number of leading manufacturers.

The term machinability itself may be interpreted in a variety of ways. It generally implies that for a given set of cutting conditions a particular workpiece material may affect:

a. tool life – in example, flank wear

b. HP required in cutting

c. tool forces experienced

d. workpiece surface finish.

TESTING PROCEDURE

The experimental objectives were to assess the machinability characteristic of grade 3 austempered ductile cast iron using four individual cutting tool media and consequently to compare the machining performances. To achieve a comprehensive overview of the cutting characteristics, the experiment incorporated the examination of both roughing and finishing turning operations. The turning operations were performed dry. These two machining conditions were established to assess the machinability of the ADI component under extreme and moderate conditions. The roughing condition comprised a predetermined cutting speed of 425 m/min coupled with 2mm depth of cut and the finishing condition consisted a chosen cutting speed of 700 m/min together with 0.5 mm depth of cut. In an attempt to formulate a thorough comparison between the four cutting tool materials, a diverse range of feed rate parameters were utilized, ranging from 0.1 to 0.4 mm/rev. The PCBN tools, associated with this experiment, approached the workpiece in a 6° negative rake angle, and the ceramic tools approach rake angle was neutral (0°).

The machinability assessment performed in this experiment incorporated three common industrial criteria, namely force analysis, tool wear evaluation, and surface texture assessment.

The force analysis and tool wear evaluation criteria are related to the machining process and reflect its qualities. The surface texture assessment, however, is related to the machined surface, hence such measurements were conducted at the post machining stage. Furthermore, the results are described for each individual tool. These results were used as reference data for comparison of these four tool material compositions.

Figure 4 illustrates the experimental design in a form of a flowchart. The flowchart indicates the finishing operation in green color and the flow of operation for the roughing in blue color.

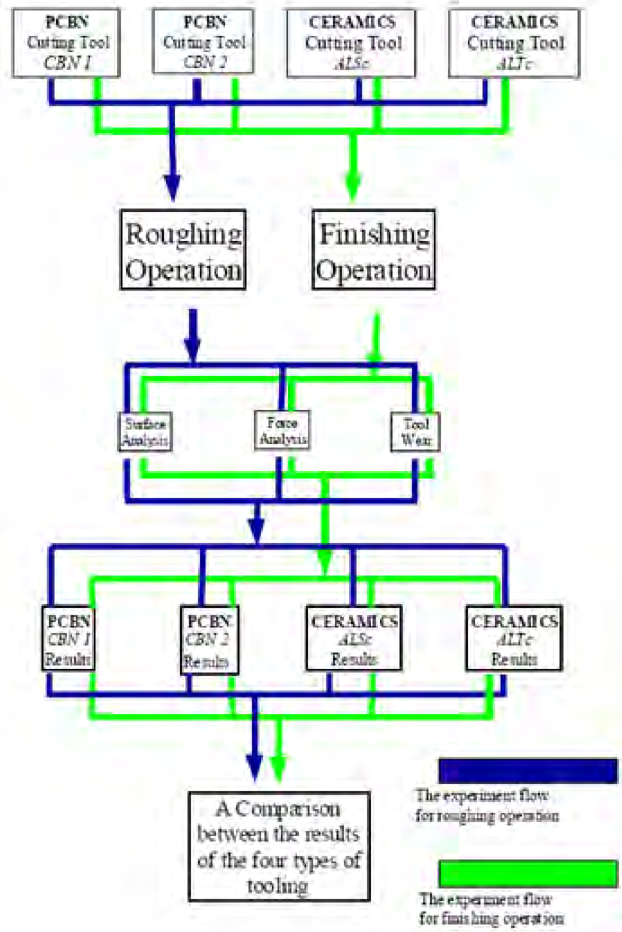


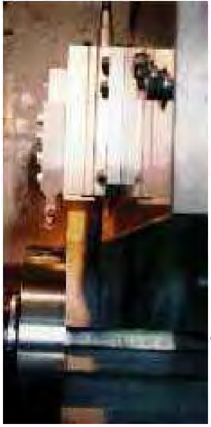
Figure 4 – The experiment design flowchart

The machining trials were performed on a CNC machine programmed with finishing and roughing operations that comprised one continuous pass of "metal removal". One pass of metal removal incorporated removing material from an ADI casting of 250mm diameter with 40mm material thickness. The metal removal process was repeated four times with various feed rates. This array of machining conditions was then applied four times, each time using a different cutting tool, producing in total sixteen discrete trials. The machining trials, were undertaken on a Cincinnati Turning Centre (Cincinnati 200/15), equipped with a Kistler Dynamometer (Model 9257B), as displayed in Figure 5, to provide data that relates to the force experienced on the tool edge while engaged in machining.

At the completion of each machining trial, the cutting inserts were examined under an optical microscope with a measuring device in order to evaluate and record the VBmax tool wear inflicted on the flank (i.e. lower) faces. The cutting tool insert was replaced each time in order to provide a fresh cut edge.

Figure 5 – turning ADI on a lathe, using PCBN cutting tool and a Kistler dynamometer for recording cutting forces.

The surface texture assessment was conducted using a cut off length of 0.8 mm at right angles to the lay, as it depicted in Fig. 6. The sampling length, also known as "Meter Cut Off", constitutes a reliable reference line when comparing the results with



other surface texture parameters which taken in the same fashion. The sampling length, therefore, is sufficiently long to include a reliable amount of roughness and yet short enough to exclude waviness from the measurement.[13,14,15] The specimen used for the turning trials was mounted on a flat “V” fixture jig standing on top of a granite flat surface. The roughness value, known as the prime surface texture, can be arithmetically defined by Equation 1. [14,15]

$$Ra(\mu m) = \frac{\sum areas \cdot r + \sum areas \cdot s}{L} \times \frac{1000}{V}$$

Equation 1
Where:
L = sampling length
V = vertical length
Areas R + S = as illustrated in Figure 6

The parameter Ra refers to a numerical value. The higher the Ra values the rougher the surface texture. The Ra values obtained for the experiment were measured automatically by the Talysurf instrument (manufactured by Taylor – Hobson). The measurements were obtained via stylus probe type instruments which moves over the surface equipped with a skid. The probe direction motion is vertical relative to the skid with an aim to identify the roughness of the surface. The electronic surface texture instrument was calibrated before the assessment was performed, ensuring repeatability and confidence in the results. All stylus-based instruments, however, equipped with a finite radius at the tip of the stylus, which fail to produce a true trace of the surface texture. The stylus is physically unable to penetrate the deepest valleys of the profile, resulting in accumulated truncation of any narrow deep valleys. [14,15]

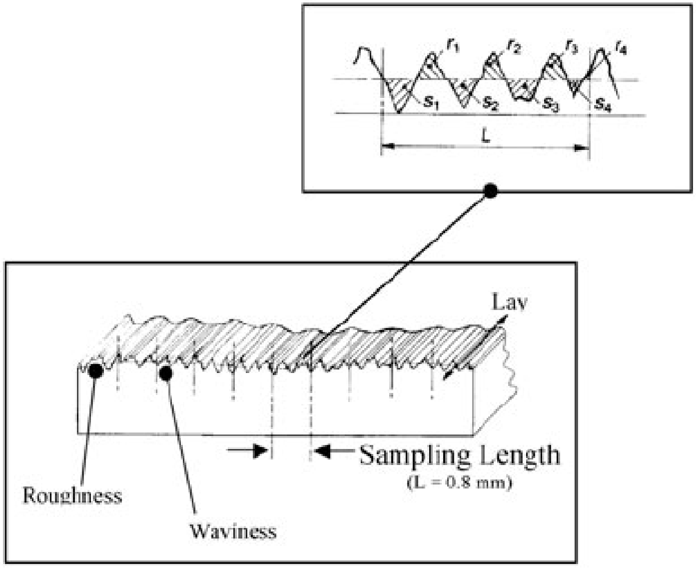


Figure 6 - the fundamental parameters of surface texture [13]

WORKPIECE MATERIAL

The workpiece specimen used was a casting of ADI grade 3, as depicted in Figure 7. The cast shape was designed to cater for both plane and interrupted turning and facing operations. The chemical composition and the mechanical properties of the workpiece are detailed below. (note – this design had been used in previous studies on the machinability of grey irons, elsewhere).

C	Si	Mn	S	P	Cu	Ni	Mg
3.65	2.85	0.18	0.005	0.027	0.97	0.04	0.041

Hardness : 388 HBN
Ultimate Tensile stress: 1221 N/mm2
Elongation : 7.2 %

Figure 7– Photo of the ADI specimen

CUTTING TOOLS

Tool grade	Tool characteristic specification [16,17]
CBN 1	Polycrystalline cutting tool material with high Cubic Boron Nitride (CBN) content and relatively coarse grains structure. The industry applications for CBN 1 tool include primarily, heavy stock removal of hard ferrous materials.
	Polycrystalline cutting tool material with reduced CBN content and fine grain structure. The industry

CBN 2	applications for CBN 2 tool include low stock removal and finish machining of hard ferrous material.
ALSc	The cutting tool material composition includes silicon carbide whiskers, which re-inforce an Aluminum oxide matrix. The composition exhibits a unique material that holds advantageous properties such as higher hardness, remarkable wear resistance, chemical inertness, high thermal shock resistance and high melting point.
ALTc	The cutting tool material composition includes Aluminum Oxide (Al_2O_3) + Titanium carbide (TiC). The industry applications for ALTc tool include machining of cast iron and steels which exceeding 32 Rockwell, at high elevated temperature. This composite material exhibits remarkable features such as the ability to sustain interrupted cutting and milling, as well as, heavy roll turning.

Table 2 - cutting tool used in the experiment

The roughing and finishing operations, associated with the experiment, were repeated several times. Each trial investigated a different grade of PCBN or Ceramic based button insert as defined in Table 2:

RESULTS

Tool wear results

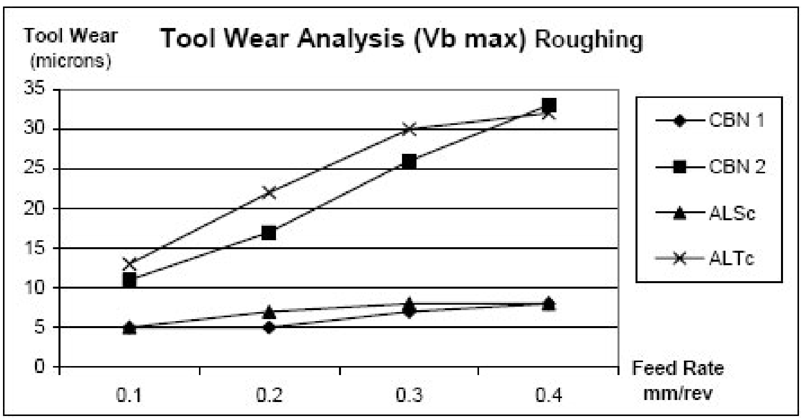


Figure 8 Tool wear results for Roughing operation

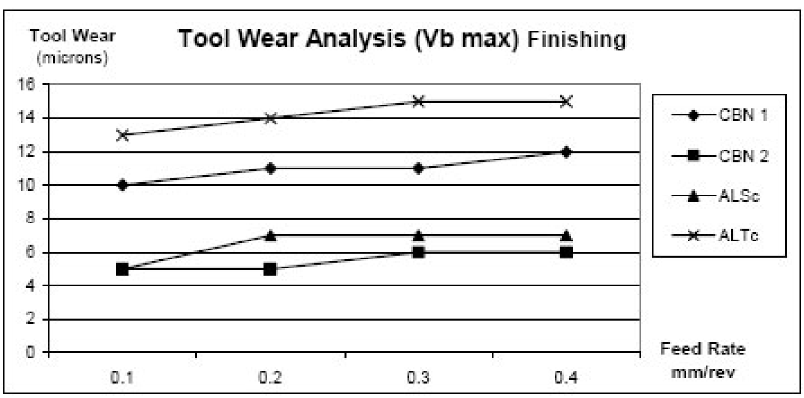


Figure 9 Tool wear results for Finishing operation

Force analysis results

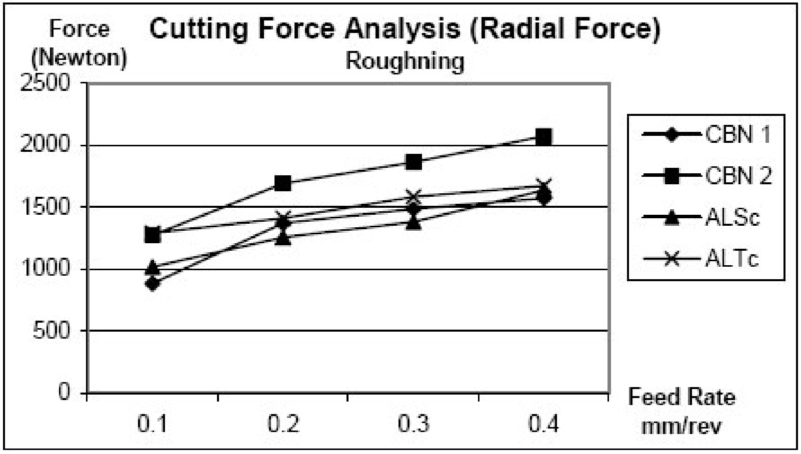


Figure 10 cutting forces results for Roughing operation

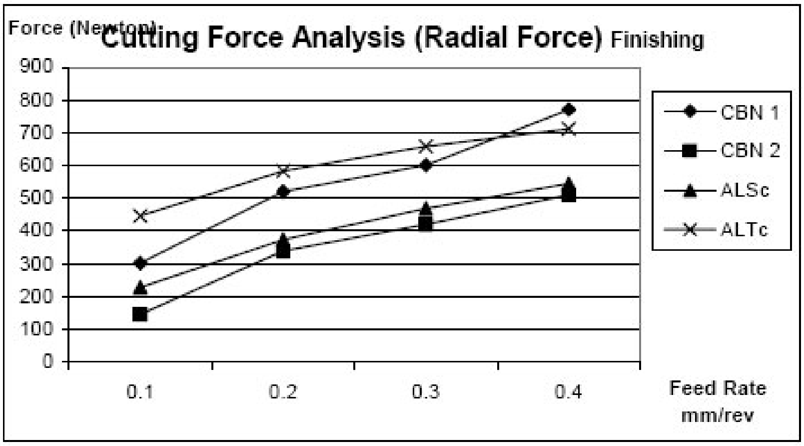


Figure 11 cutting forces results for Finishing operation

Surface Finish results

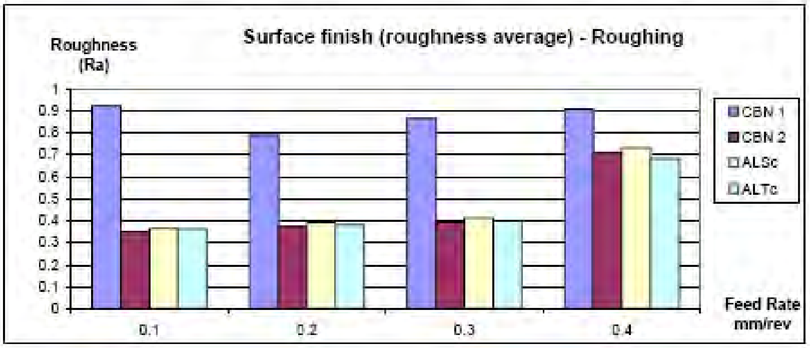


Figure 12 Surface Finish results for Roughing operation

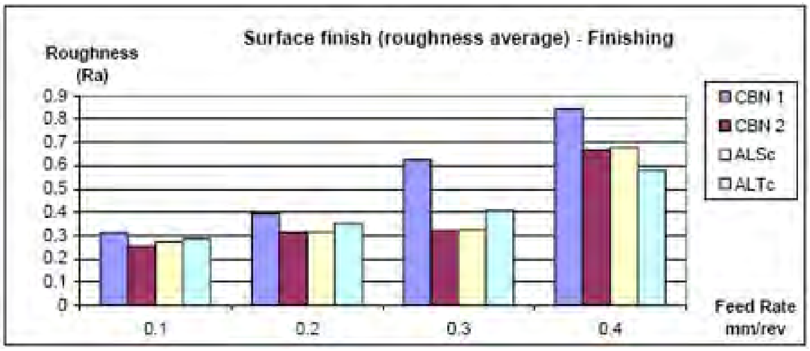


Figure 13 Surface Finish results for Finishing operation

ANALYSIS OF RESULTS

Tool wear

The tool wear developed on the flank (underside) plane of the cutting tool during roughing machining can be classified as either natural low wear or accelerated tool deterioration. Both cutting tool ALSc and CBN 1 exhibited satisfying wear resistance during the roughing machining whilst the other two experienced excessive tool deterioration, as it depicted in Figure 8. In contrast, the analysis of tool wear developed during finishing machining condition indicates that ALSc and CBN 2 were most durable when compared to their counterparts, hence enduring least tool damage, as it exhibited in Figure 9.

The cutting tool grade of ALTc exhibited the poorest tool wear with comparison to the other three tools, as it displayed in Figure 8 and Figure 9. In general, the tool wear characteristic was exclusively flank wear which was a direct consequence of adhesive / abrasive wear mechanism. The tool wear tended to grow as a result of increasing the depth of cut parameters, and even more significantly, by elevating the feed rate. The tool wear, experienced by each cutting tool, reflected a much lower level of deterioration in finishing machining condition, compared to the level of damage inflicted upon the tool during the roughing condition.

Cutting forces

The cutting forces, captured by the dynamometer, indicated that the dominant cutting force was in the radial direction, hence the radial force was exclusively considered. This phenomenon is inherited from the geometry of the insert. The cutting forces were relatively greater in roughing operation when compared with those obtained at the finishing operation. The decrease in cutting forces that occurred during the finishing machining condition, is a consequence of the generated heat that tended to evolve and concentrate at the interface between the workpiece and the cutting tool. This generated heat appeared to be much more profound during machining at the finishing condition with high cutting speed, and thus a thermo-softening effect was created within the vicinity of the cutting point, assisting the shearing mechanism. Further, the lowest cutting forces, which are most desirable, were obtained generally at the lowest feed rate of 0.1 mm/rev. The cutting force analysis at the roughing operation indicated that the two best tool performances were achieved by ALSc and CBN 1, as it exhibited in Figure 10. Conversely, the tool that exhibited the least satisfactory performance in terms of cutting forces were the CBN 2. When considering the finishing machining condition, the cutting tools that excel in terms of producing lower cutting forces were the CBN 2 and ALSc, as it depicted from Figure 11. In contrast, CBN 1 and ALTc exhibited unsatisfactory performances.

Surface finish

Invariably, the surface finish characteristic, displayed in Figure 12 and Figure 13, deteriorated as the feed rate increased. The most adequate surface finish was associated with the combination of 700 m/min cutting speed coupled with 0.5 mm depth of cut and 0.1 mm/rev feed rate. This produced a satisfactory surface finish for ADI casting when engaged with either CBN 2 or ALSc. The cutting tool ALTc produced similar, and occasionally even improved, surface finish characteristic compared to ALSc. In contrast CBN 1 consistently produced the least desirable surface finish, due to its relatively coarse grains structure.

CONCLUSIONS

The paper has described a machinability study of Grade 3 Austempered Ductile Iron with two grades of PCBN cutting tools and two grades of ceramics. The emphasis was placed on the machinability evaluation of these four individual cutting tool materials based on three machining criteria and the comparison between their performances.

The machining of ADI dictates the use of a cutting tool with high toughness and good thermal conductivity, with an aim to assist in dissipating some of the heat generated during the machining operation, whilst retaining some heat to develop the thermo-softening effect on the material (more details are given in reference 18).

The experimental results indicated strong correlation between tool wear, cutting forces and subsequently, surface finish. That correlation is demonstrated throughout these machining trials where a condition of excessive tool wear coupled with poor surface finish, is tied in with high levels of cutting force. The results obtained indicated that cutting tools such as ALSc and CBN 2 are most suitable for light cut high speed machining operations, whilst ALSc and CBN 1 adequately sustained roughing machining operations that incorporated large metal removal volumes.

The cutting tool ALSc constantly offers the versatile solution, which accommodates both finishing and roughing operations, producing satisfying machining characteristic with regards to assessment criteria, such as tool wear, surface finish or cutting forces.

ACKNOWLEDGEMENTS
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Environmentally Assisted Embrittlement of ADI - Current Understanding

2002 World Conference on ADI
Environmentally Assisted Embrittlement of ADI - Current Understanding
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ABSTRACT

An unusual environmentally assisted embrittlement effect has been reported to affect ADI when it is tested in tension with its surface in contact with water and other fluids. This effect has been verified by several laboratories, but the embrittlement mechanism has not been fully explained yet. A thorough understanding of the causes and preventive actions is necessary to ensure that the steadily increasing number of applications of ADI continue to be safe.

This work gives an updated view of the current understanding of the environmentally assisted embrittlement of ADI. The influence of the environment (different liquids) and of different ADI grades is discussed. The features of the fracture surfaces are also detailed. Recent results of testing under applied potential are presented. An explanation of the fracture mechanism is proposed, based on the recent identification of cracks developed at the last to freeze portions as a result of plastic deformation.

INTRODUCTION

Effects on Mechanical Properties Austempered ductile iron (ADI) is being increasingly used in the fabrication of cast parts for a number of industries, such as railroad, automotive, agricultural and others. ADI combines excellent strength and good ductility with low cost and the ability to produce nearly finished parts through casting. It has been used to replace parts traditionally made of cast, forged or machined steels of different grades. ADI can be produced in different grades [1], reaching minimum properties ranging from 850 MPa to 1600 MPa of tensile strength, and minimum elongation between 10 and 0% respectively.

Shibutani et al [2], and Komatsu et al [3] reported that ADI suffers an uncommon environmentally assisted embrittlement (EAE) effect when it is tested in tension with the sample's surface in contact with water. Later,
Martínez et al. [4], obtained similar results in an independent laboratory, using different base ductile iron and several ADI grades. These investigations showed that ADI suffers significant reductions in UTS and elongation, that can reach up to 30% and 70% respectively, when tested in tension, as shown in Figure 1. This EAE takes place almost instantaneously, and it reverses immediately when the surface of the sample is dried [2]. On the

other hand, impact properties are not affected by contact with water. This suggests that the EAE does not act under high loading rate. The effect shows no dependency with the time of exposition to water, acting almost instantaneously.

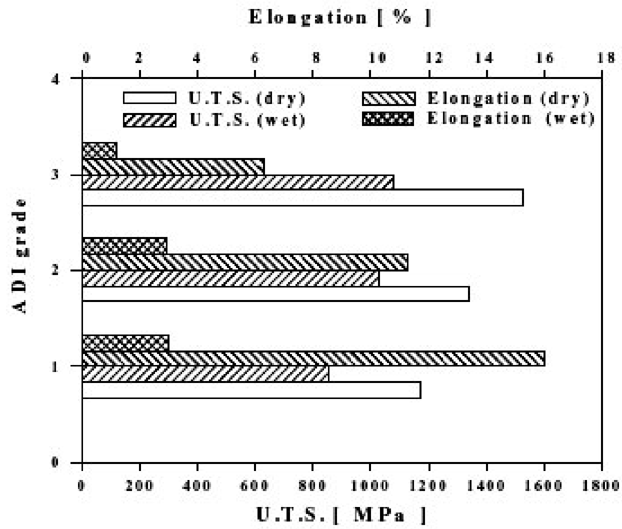

Figure 1: Change in UTS and elongation as a result of tensile testing of ADI grades 1, 2 and 3 in contact with water.

Martínez et al. [4] found that EAE of ADI is also caused by contact with other liquids, such as isopropyl alcohol and SAE 30 mineral lubricant oil, as shown in Figure 2. The effect of these liquid fluids is not as marked as that caused by water. They also reported that the effect of water is independent from its pH, and remains unchanged when water based solutions of pH ranging from 5.5 to 11.9 are used.

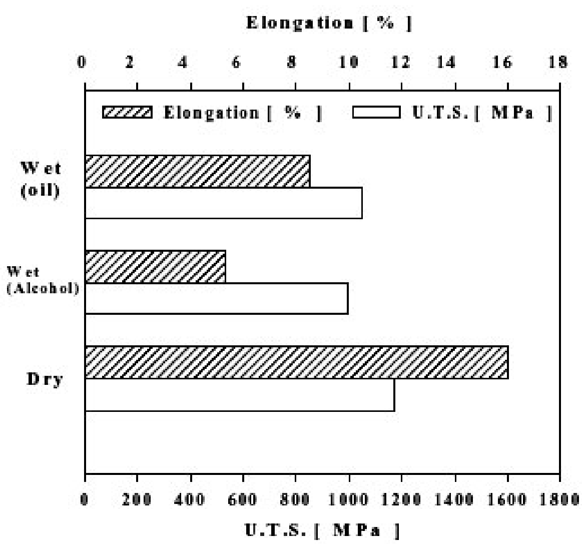

Figure 2: Change of UTS and elongation caused by contact with lubricant oil and isopropyl alcohol.

Role of Microstructure

The EAE not only affects ADI, but also ductile irons (DI) of other microstructures, such as those having martensitic and pearlitic matrices. All investigations showed that the higher the strength of the DI, the greater the embrittlement effect. Only ferritic matrix ductile iron

has been found to be immune to the contact with water [2,3]. It is known that a given ductile iron alloy can be heat treated to show ausferritic, martensitic, pearlitic or ferritic matrix. Only the first three matrices will suffer EAE. Therefore, the embrittlement mechanism has to be primarily related to the microstructure, and not to the chemical composition of the alloy. Martínez et al.[4] have discussed the role of the different microconstituents of the matrix on the EAE effect. They pointed out that EAE has so far been identified on DI of matrices composed of ferrite and austenite (ADI), ferrite and cementite (pearlite) and tempered martensite (fine dispersion of carbides in a ferritic matrix). Furthermore, in high silicon steels having a bulk composition similar to that of the chemical composition of the ductile iron matrix (0.55-0.65C; 1.8-2.2Si; 0.7-1Mn), embrittlement is also present in the bainitic microstructure, but only causes a reduction in elongation [3]. It is clear that the microstructure affects EAE, but the nature of the effect is uncertain.
The presence of graphite spheroids does not seem to be responsible for the effect, since EAE is also detected in steels of similar composition that are free from graphite, and it is not detected in ferritic ductile iron, in which plenty of graphite exists. The presence of austenite in the matrix cannot be the cause of embrittlement, since it is only present in ADI matrix, and other microstructures not showing austenite are also affected.

Cementite and carbides are present in pearlite and tempered martensite. Some investigations show that very small transition carbides are present in the microstructure of ADI. Carbides are certainly not present in the ferritic matrix. Therefore, there is no definite base to disregard a possible effect of the presence of carbides on EAE.

The presence of ferrite, on the other hand, cannot be considered to be able to prevent EAE, since even though ferritic matrices have been found not to be susceptible to embrittlement, all other embrittled matrices have large amounts of ferrite.
Other factors, not just the phases forming the matrix, could affect EAE, such as the presence of interphases and chemical or microstructural inhomogeneity. Interfaces are favorable paths for diffusion and are also highly reactive sites. Ausferritic and pearlitic matrices, that are very susceptible to embrittlement, both have a large amount of interfacial area. Low tempering temperature martensites show incomplete recrystallization of ferrite and carbides, and also have a large amount of interface area. On the other hand, ferritic matrix microstructures only show the ferrite-ferrite grain boundary and ferrite-graphite interfaces. The smaller contribution of preferential diffusion paths, or the lower matrix reactivity could then
be preventing the embrittlement of the ferritic matrix. [4].
A new insight into the effect of the matrix inhomogeneity on EAE has been given recently by Laine [5], who aimed to identify the fracture initiation site in ADI embrittled by

contact with water. He examined the surface of the tensile samples during the fracture process. Square section tensile samples were used. Sample faces were polished metallographicaly before testing. It has been shown that microsegregated regions of the ADI microstructure, usually referred to as Last To Freeze (LTF), cracked during testing after plastic deformation starts, as shown in Figure 3. The microstructure of LTF regions after austempering may show, depending on the chemical composition of the DI and the heat treatment practice, different amounts of unreacted austenite, martensite and even small carbides precipitated during solidification or heat treatment. With this microstructure, LTF regions are usually harder and more brittle than the matrix. This may account for the cracking of LTF when the plastic deformation of the surrounding austempered matrix imposes relatively large stresses on them, as observed by Laine [5]. It is known that the degree of inhomogeneity at the LTF and its extent is affected by the chemical composition of the iron, by the solidification rate, and possibly by the nodule count. Additionally, austempering heat treatment variables also influence the microstructure of the LTF. This suggests that the quality of ADI may affect the EAE intensity. The validity of this speculation has not been verified yet.

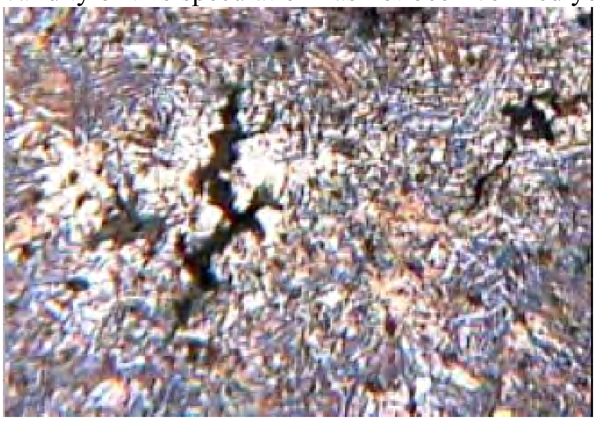

Figure 3: Typical cracking of LTF regions of ADI samples after plastic deformation.

Examination of the Fracture Surface

The fracture surface of the embrittled samples has been examined by Komatsu et al.[3] and by Martinez et al.[4]. Small regions of cleavage fracture are present in most ADI fracture surfaces, conforming a fracture mechanism called quasi-cleavage. The fracture surfaces of tensile test samples tested in contact with embrittling liquids show a larger proportion of cleavage facets than the fracture surface of samples tested in air. Both Komatsu and Martínez identified flat bright portions covering a fraction of the fracture surface of the tensile samples tested in water. These bright portions were characterized primarily by cleavage fracture. Masud et al. [6] investigated the link between the flat fracture regions on the fracture surface of tensile testing samples, and the fracture initiation site. In an attempt to localize the initiation of the fracture, the tensile sample surface was put in contact with water only at a very small location, by using a hyssop previously wet with water. This was done during the test, at a constant stress level higher than the tensile strength in contact with an aqueous solution, but lower than the dry tensile strength. Under this stress condition, contact of the wet hyssop with the sample surface caused instantaneous fracture. Figure 4 shows a macrography of the fracture surface. The arrow points the location at which the sample surface has been wet. A nearly round, bright and flat fracture area, of approximately 1mm diameter, originates from the point of contact of the hyssop. The examination of the fracture surface by scanning electron microscopy showed that the fracture mechanism characteristic of the flat region is cleavage, as shown in Figure 5. The fracture surface out from the flat portion, Figure 6, shows a predominantly ductile fracture, characterized by dimples. The marked difference in the brittleness of both fracture types is also emphasized by the extent of plastic deformation around the graphite nodules, which is much greater on the predominantly ductile fracture. The results proved that water induces brittle cleavage fracture of ADI. It is also suggested that when flat brittle portions are observed on the fracture surface of tensile samples tested in contact with water, they show the location of the fracture initiation

The work of Laine [5] also gives some very recent views on the fracture initiation and propagation. Laine used similar methodology to that of Masud et al., but worked on square section tensile samples of polished surfaces. The surface metallography of the whole sample was photographed before testing. After the sample is broken in contact with water, the surface fracture path can be observed. Laine found that fracture initiates at the LTF regions of the sample, which became cracked during the test, at stress levels surpassing the yield strength of this ADI. The observation of the fracture surface by Scanning Electron Microscopy showed that LTF regions fractured by cleavage.

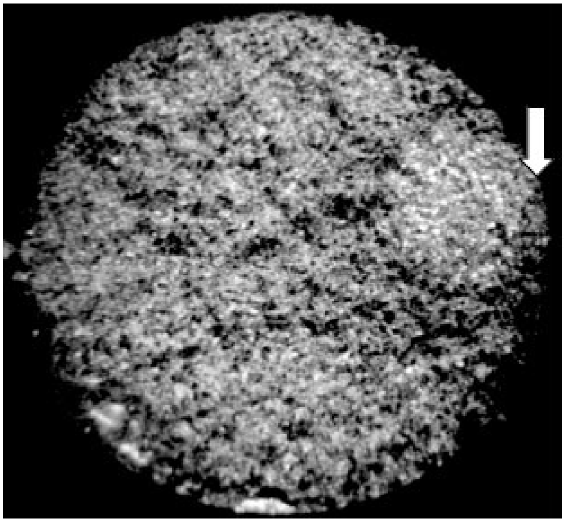

Figure 4: fracture surface of a tensile test specimen. The arrow points the location at which a water impregnated hyssop has been put in contact with the sample surface. Note the approximately round, bright area of about 1.5 mm diameter that originates from the contact point. Total sample diameter is 6.5mm.

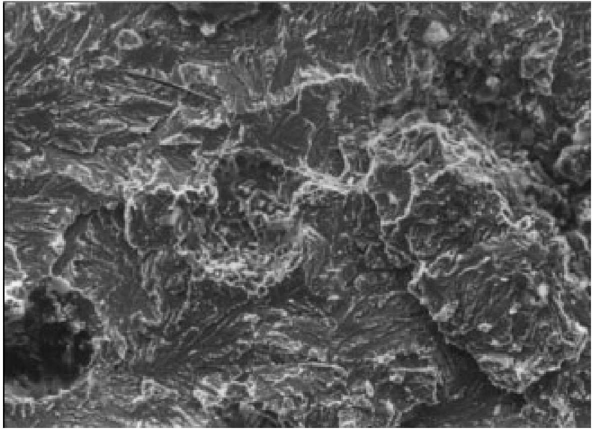

Figure 5: Fracture surface of ADI embrittled by water (500x).

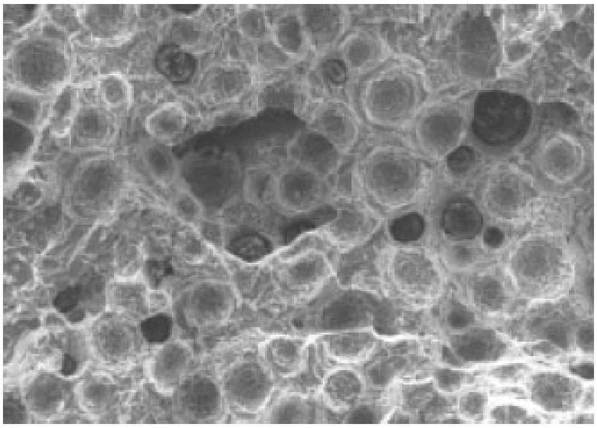

Figure 6: Predominantly ductile fracture surface of ADI broke in contact with water, shown at a location far from the fracture initiation site (200x).

Cause of Embrittlement

The cause of embrittlement remains unexplained. Shibutani [2] and Komatsu [3] found similarities between the embrittlement of ADI and the
behavior of hydrogen embrittled materials, and concluded that this effect is induced by the generation of hydrogen atoms from water on the ductile iron surface under plastic deformation. Hydrogen atoms would then diffuse into the ductile iron matrix, causing the embrittlement. This affirmation was further supported by their results of tension testing in H2 atmosphere, which caused an embrittlement similar to that caused by water. Nevertheless, the mechanism by which the protons will reduce at the water/ADI interface and cause an almost instantaneous effect has not been explained by the authors. Furthermore, the little dependency of the phenomena with the time of exposition to water, and its fast reversibility, do not precisely suit the usual characteristics of the hydrogen embrittlement effect. The results of Martínez et al.[4] and Masud et al. [6] do not support the role of hydrogen as proposed by Shibutani and Komatsu, since the concentration of protons in the embrittlement media does not affect the degree of embrittlement. Furthermore, the fact that other liquids, such as mineral oil and alcohol, cause embrittlement, suggest that the explanation of the effect should be based on the influence of some other factors. Hydrogen embrittlement (HE), together with stress corrosion cracking (SCC) and liquid metal embrittlement (LME) are the most extensively studied environmentally induced cracking (EIC) processes [7]. EIC failures are characterized by brittle failures in

which cracks propagate at stress intensity (K) levels lower than the critical values in air or vacuum, as a result of the combined effect of a tensile stress field and the presence of a corrosive media. Corrosion rates are usually quite low. The mechanisms involved in this type of failure are very complex and remain under discussion. In consequence the occurrence of EIC failures in service is still difficult to predict.

HE involves brittle fracture caused by penetration and diffusion of atomic hydrogen into the crystal structure of an alloy. The kinetics of hydrogen generation is accelerated by an increase in the cathodic polarization. Thus, cathodic polarization should enhance HE, while anodic polarization should have the opposite effect.

Recent work by Masud et al [6] investigated the behavior of ADI on tensile testing in aqueous media under controlled electrochemical conditions, aiming to identify whether the loss of ductility can be either inhibited or enhanced by stimulating or avoiding the reduction of protons on the sample's surface. They used ADI grade 2 (ASTM A 897M–90) tensile test samples, and tested them in contact with aqueous solutions at controlled potential The values of controlled potential applied during tensile testing were chosen based on the results of polarization curves. A potential of –1.45 V (SCE) was used to induce cathodic conditions, in which the generation of hydrogen on the surface is stimulated, and a potential of –0.55 V (SCE) was used to inhibit hydrogen generation. Their results showed that the magnitude of the embrittlement effect caused by water was not affected by the application of potential. The results suggest that the EIC of ADI is not an electrochemical phenomenon, since neither cathodic nor anodic applied potentials have been able to inhibit or enhance embrittlement.

The characteristics of the embrittling effect caused by water on contact with ADI are quite unique, showing no complete similarity with any other EIC reported for metals. The velocity of the process and its fast reversibility resemble LME. 2002 World Conference on ADI LME causes the catastrophic brittle failure of normally ductile metal alloys when coated by liquid metal and stressed in tension. The fracture mode changes from a ductile to a brittle intergranular or brittle transgranular (cleavage) mode. It has been shown that the stress needed to propagate a sharp crack or a flaw in liquid is significantly lower than that necessary to initiate a crack in the liquid metal environment. In most cases, the initiation of the propagation of cracks appears to occur instantaneously, with the fracture propagating through the entire test specimen. The velocity of crack or fracture propagation has been estimated to be 10 to 100 cm/s. LME is not a corrosion, dissolution or diffusion–controlled intergranular penetration process. The embrittlement is severe, and the propagation of fracture in the case of LME is very fast as compared to that in stress corrosion cracking [7].

PROPOSED OF FRACTURE MECHANISM

On the basis of the existing knowledge, and given the similarities with LME, the authors propose that the fracture of ductile iron in contact with water proceeds as follows: upon stressing ADI at a certain level above its yield strength, it develops cracks at the LTF regions, as shown by Laine [5]. When this takes place in contact with water or other liquids, the liquid penetrates the crack, the A-A atomic bonds at the crack tip are weakened by the chemisorption of an atom or molecule B, as shown schematically in Figure 7

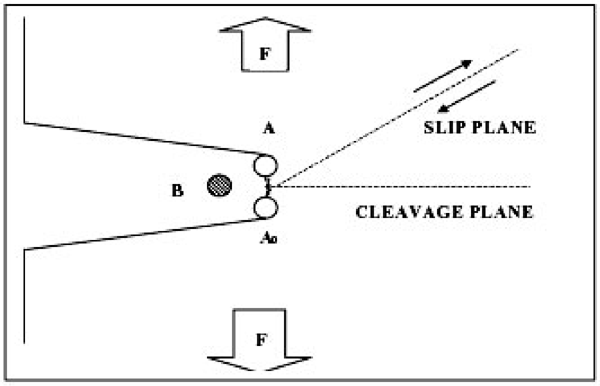

Figure 7: schematic representation of the weakening of A-A atom bonds at a surface crack tip as a result of the interaction with an atom or molecule B supplied by the surrounding liquid.

The chemisorption process presumably takes place spontaneously or only after the A-A bonds have been strained to some critical value. In any event, electronic rearrangement takes place because of adsorption, and weakens the bonds at the crack tip. When the applied remote stress is increased so that local stress at the crack tip exceeds the reduced breaking strength of A-A bonds, then the crack becomes unstable and grows rapidly. The crack grows initially in a brittle manner, by cleavage, but changes to a ductile mechanism, as it grows far from the fracture initiation site. Taking into account the load conditions in tensile testing, the stress levels, and the sample dimensions, and assuming a semieliptical surface defect and a K1C value of 90 MPa m1/2, the size of the critical defect can be estimated to be 0.8 mm. This would indicate that if the presence of water activates the rapid growth of a crack, and such crack extends beyond the critical defect size, then, even when the fracture mode changes to a higher energy consuming mechanism, the remaining ligament will not be able to stop fracture, and the sample will collapse. The size of the cleavage fracture surface observed in tensile specimens fractured in contact with water, as shown in Figure 4, is usually of approximately 1.5mm. This size is greater than the critical defect size, supporting the proposed mechanism.

SUMMARY AND CONCLUDING REMARKS

Water and other liquids cause the embrittlement of ADI. The characteristics of this environmentally assisted cracking effect are quite unique, and share some of the features of liquid metal embrittlement. The effect of the environment is not understood. Recent experiments do not support hydrogen embrittlement as the cause of fracture. An explanation of the fracture mechanism has been proposed by the authors, based on the recent observation of cracking of last to freeze portions of the ADI microstructure upon straining. Future work should be aimed to clarify the mechanism of EIC responsible for the embrittlement of ADI. In particular, it is necessary to identify the role of the different liquids on fracture. Additionally, the influence of the ADI microstructure on EIC should be investigated.

ACKNOWLEDGMENT

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Reticulated Filtration of Large Ferrous Casts and Castings

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Introduction

Metal filtration in the ferrous industry is not new. Utilizing silicon carbide filters with iron and zirconia filters with steel applications, metal filtration has been available for many years. These filters make it possible to remove slag, inclusions, and other melt contaminants that cause defects, while creating a more laminar flow of metal throughout the mold cavity. Yet, the size of these filtered castings has been limited to the smaller end of the spectrum (< 1000 pounds).

Application of these materials to larger castings may now be accomplished in a variety of ways. First, manufacturing advancements have been made enabling an increase in the overall dimensions of these products. This increase in size can lead to an increase in the metal volume a single filter can accommodate. Secondly, filters are now available with an undulating surface to increase surface area. This increase in surface area can lead to increased capacities and flow rates for a fixed cross sectional area. And lastly two methods utilizing precast refractory shapes are being used to filter large volumes of metal. These precast shapes, known as the spider gate and carousel filter systems, enable the use of multiple filters in a space efficient manner.

This paper will describe the techniques to apply filtration systems to large ferrous pours. The benefits including reduction in rework and lead times involved with the manufacture of these castings will also be discussed.

Filter Description

Reticulated Zirconia Filters

Reticulated zirconia filters are comprised of zirconia utilizing magnesium oxide as its stabilizing agent. The ability to make this ceramic structure from high performance oxides has allowed these materials to be optimized for the filtration of ferrous alloys up to and including temperatures of 3200 degrees F (1). The benefits associated with partially stabilized zirconia are temperature capability, chemical inertness, mechanical strength, and thermal shock resistance.

In the past products were limited to a size range of up to 6 inch round and square filters. This equates to recommended capacities of approximately 700 to 1000 pounds and 900 to 1250 pounds, respectively. With recent manufacturing advancements, zirconia filters are now being produced to 10 inch round and square sizes, with large rectangular filters also being realized (see figure 1).

These filters equate to recommended capacities of approximately 2150 to 3000 pounds and 2750 to 3850 pounds for steel and twice that for iron, respectively.

As a general rule, ferrous filtration applications start from 10 ppi and increase for more desired filtration.

While these materials have benefit for many different ferrous alloys, more cost-effective materials have been employed with iron castings.

Reticulated Silicon Carbide Filters

Reticulated silicon carbide filters allow the filtration of ferrous alloys up to 2650 degrees F. Utilizing an oxide bonded silicon carbide, mechanical / thermal strengths have increased to produce larger filters. This provides an increase in the resistance to thermal creep, allowing to these filters to withstand the longer pour times associated with large ferrous casts.

High Surface Area Filters

Reticulated filters are now available with an undulating surface geometry (see figure 2). This configuration allows more metal to pass before the flow rate is restricted, resulting in an increased capacity. Improvements realized in pour time and capacity have been up to 30%.

These filters have been found to provide exceptional benefit to extremely drossy metal pours that have a tendency to blind off the surface of the filter, and can be produced in any filter chemistry desired.

*Fig. 1 – Reticulated ceramic Filters

*Fig. 2 – High Surface Area Filters

Carousel Filtration System

The carousel filtration system is a precast mullite shape, containing a hexagonal arrangement of filters and is implemented with the standard hollowware utilized in large bottom fed castings. The concept of the invention is to allow tangential flow of metal into the ring/channel in front of the reticulated ceramic filters. A convexity is incorporated at the top and bottom of the channel to promote the segregation of the low-density particles allowing the filters more deep-bed-filtration. Also, this tangential flow facilitates the prevention of coarse impurities approaching the filter surface. The metal then finally penetrates the filter and exits the carousel entering into a refractory gating system or directly into the mold cavity. (See figure 3)

* Fig. 3 – Carousel Filtration system

These products can be used in singular or multiple configurations, with a linear increase of pouring rate and capacity. For these applications, the carousel can be provided in a left and right version, allowing a symmetric installation of the gating system. Different carousel sizes may also be chosen.

Filter Selection

Filter selection is made on a casting by casting basis. Variables, such as pouring temperature, casting size, gating system, desired pouring rate, pouring equipment, deoxidization practice and alloy will influence the filter application.

Typical drossy metal capacity recommendations are 25 pounds per square inch, with flow rates of 2.2 pounds per second per square inch. More fluid alloy capacities may range up to 50 pounds per square inch, with flow rates of 3.0 pounds per second per square inch. These recommendations vary and change with alloy chemistry and metal cleanliness.

Carousel filters are currently produced in three sizes. The smaller utilizes six 3x3x1 inch filters, has a flow rate of 65 –100 pounds per second, and a capacity of 2200 pounds. The medium utilizes six 4x4x1.25 inch filters, has a flow rate of 130 – 260 pounds per second, and a capacity of 4400 pounds. The larger carousel utilizes six 6x6x1.25 filters, has a flow rate of 220 – 400 pounds per second, and a capacity of 8800 pounds. These recommendations are for fluid alloys. Again, changes in metal chemistry will result in changes to the above recommendations.

Low Range Pours (1000 pounds – 5000 pounds)

Pours in this size range can show extreme benefit from the large reticulated filters produced today. Horizontal and vertical orientation in the gating system provides the most productive means of filtering these casting. Strategic filter placement in conjunction with a sound gating system will allow for the best combination of yield and quality.

When looking at the gating system, the number of contacts to the casting in conjunction with the runner system will provide the most influence over the location of filters and the number of filters applied. After location is selected, pour rate and capacity influences the filter size selected for the casting (see figure 4).

When a higher flow rate or higher capacity is desired, without gating alteration, the high surface area filter may be applied. These filters are applied in the same manner as the regular reticulated filters.

Carousel filtration may also be a cost-effective way of producing a profitable low range casting. The ability to tie into existing hollowware systems make it an excellent choice for bottom fed castings. These systems may also be implemented vertically or horizontally. (Further description of the carousel will take place in the carousel implementation section)

*Fig 4 – Gating systems implementing numerous filters

Midrange Pours (5000 pounds – 10000 pounds)

With increasing pour rates and capacities, there is an increased necessity to move toward the high surface area and carousel filters. Multiple high surface area filters may be used near the lower end of the spectrum, but the carousel filter is most applicable in this range. The carousel filtration system again will tie into hollowware gating systems easily, providing an effective mode of filtration for this range.

The spider gate filtration system may also be applied to ingot pours or **castings with multiple contact points.**

Highrange Pours (10000 pounds +)

These large pours, will require the use of the spider gate and/or carousel filtration systems. As the amount increases, multiple systems may be required to comply with the expected pour rates and capacities. Systems have seen up to 76,000 pounds of metal poured, and are not limited with multiple units.

Filter Implementation

Reticulated Filters and High Capacity Filters

These filters are typically implemented in a vertical or horizontal fashion. In either case a blank, a removable object to mimic the filter size, is used to insert the filters. This may be accomplished by adjusting the pattern for sand systems. The blank placement should be near the parting line to assist with installation. Filters should be placed as near to finished product as possible.

Vertically placed filters are inserted perpendicular to the parting line. Choosing a filter with 4 times the surface area to the cross sectional area of the initial runner system will allow the proper flow of metal without choking. Care should be taken to blow out all passageways with an air hose before assembling the cope and drag.

Horizontally placed filters are also best implemented at the parting line with a blank system. In conjunction with a filter, placement of an overhead reservoir can assist with the trapment of slag and larger oxide inclusions. Less dense oxides collect in the reservoir, assisting the filter to maintain a more consistent flow and capacity throughout the pour. (See figure 5).

*Fig 5 – Horizontal implementation of Reticulated Ceramic Filters

Carousel Filters

The carousel filters are implemented along with the hollowware system of a bottom fed casting. Male and female ends match existing hollowware to allow easy implementation. The assembly of the carousel unit completes with filters and spacers placed in the interior chamber and sealing the unit (see figure 6). During the assembly process sand must be packed carefully around the extremities of the carousel to allow for external support (see figure 7). If the carousel is not supported properly, a failure in the casting process may occur.

*Fig 6 – Attachment of carousel filters

* Fig 7 – Sand compaction with two carousel filters

Oxide Inclusion Removal

On further examination of the reticulated filters after pouring, one can inspect for the oxide inclusions that have been removed. The findings can be produced with the use of X-Ray Diffraction, Electron Microscopy, and Spectroscopy (Fig. 8 & 9). With this information, one can make determination on where inclusion development may begin and take steps to reduce these occurrences. This, along with the cooperative efforts of filtration, will lead to the most cost-effective production of ferrous castings.

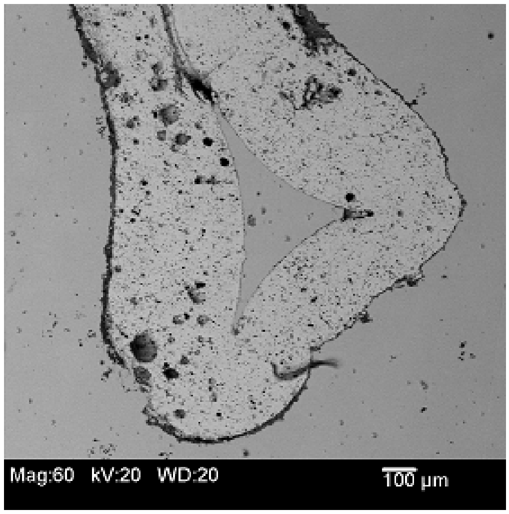

*Figure 8 – Electron Microscope Photo of Ceramic Filter material with oxide inclusions sintered on

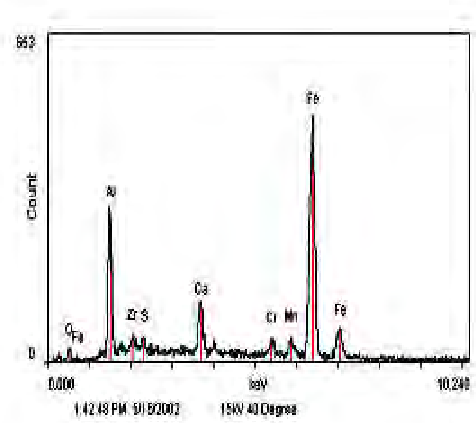

*Figure 9 – EDS Analysis of oxide inclusions

Conclusions

No longer are the benefits of filtration restricted to casting sizes smaller than 1000 pounds. The use of reticulated ceramic filters provides a cost-effective way to produce large steel castings, while offering the ability to shorten turn around time.

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Saint-Gobain Advanced Ceramics Hamilton

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Saint-Gobain Advanced Ceramics Hamilton manufactures Flow-Rite™ ceramic foundry filters. These filters have a cellular design of perfectly round cells which unite with the ceramic material to withstand thermal shocks and extreme pouring temperatures, to provide an engineered balance between flow rate and strength. They are able to remove dross, slag and impurities from the melt, resulting in outstanding machinability, an improved surface finish, greater yields and reduced foundry operating costs.

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By involvement with several leading foundry research laboratories, and by making use of the extensive testing equipment at the Saint-Gobain central research facilities, Saint-Gobain Advanced Ceramics Hamilton is constantly increasing its understanding of materials and processes related to foundry filtration. This knowledge is then applied in support of manufacturing and quality control and to provide application and engineering support for customers, whenever required.

Flow-Rite™ filters are available in a broad range of standard sizes or, on request, can be custom engineered and built to customer specifications.

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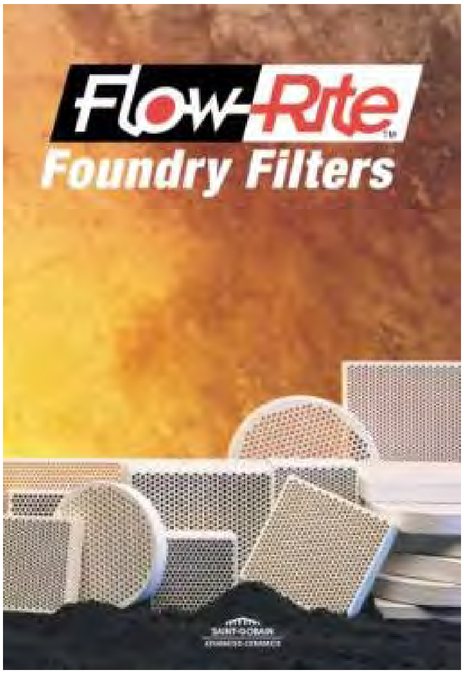

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Ductile Iron News
To Promote the production and application of ductile iron castings
Ductile Iron Society
Issue 1, 2005

News Briefs

MEETINGS - BUSINESS

MEETINGS

The **Ductile Iron Society 2005 Fall Meeting** will be held on October 25-26, 2005 in Cleveland, Ohio.

BUSINESS

Ashland and SinterCast Announce Global Alliance

DUBLIN, Ohio (USA) and STOCKHOLM (Sweden) - **Ashland Casting Solutions**, a business group within Ashland Specialty Chemical, a division of Ashland Inc. (NYSE:ASH), and **SinterCast AB** (publ) (Stockholmsbörsen O-List:SINT) have agreed to a global marketing and technical alliance.

Through their technical alliance, Ashland and SinterCast will collaborate to develop novel mold coatings, binders, resins and core materials to optimize the structure and properties of Compacted Graphite Iron (CGI) at the immediate mold/metal interface. The combined efforts will also be designed to strategically alter the thermal balance within the mold to optimize castability. The collaboration is designed to further improve the thinwall design flexibility of CGI in complex lightweight castings and expand the overall market potential of CGI.

Under the global marketing alliance, the parties will combine their products, services, engineering know-how and contact lists to introduce reliable CGI production technology to new markets and to deliver complete CGI production solutions to the world foundry industry.

Ashland’s technology strengths in mold/metal interactions, and SinterCast’s knowledge of CGI, will be brought together at Ashland’s advanced facilities for research and development studies in Dublin.

“This alliance creates an industry leading initiative to expand CGI into other casting markets,” said Mike Swartzlander, vice president, Ashland Specialty Chemical, and general manager, Ashland Casting Solutions. “With the unified expertise and innovation power of Ashland and SinterCast, we are confident that we can further improve our industry’s capabilities to make the most of CGI’s outstanding mechanical properties and true potential.”

“SinterCast is enthusiastic about the technical and commercial possibilities presented by this alliance,” said Steve Dawson, president and chief executive officer, SinterCast. “Working together with Ashland will help us grow the overall CGI market potential and also provides us with an established and respected partner as we bring the SinterCast process control technology to new products and new geographical markets."

For more information about this alliance, contact Ashland Casting Solutions at (800) 848-7485 or SinterCast at +44 20 8891 8900.

About SinterCast
SinterCast AB (publ) is the world's leading supplier of online process control technology for the reliable high volume production of Compacted Graphite Iron. SinterCast's production agreements encompass a total of 25 foundries in 14 different countries that account for approximately 40 percent of the world production capacity for cast iron cylinder blocks and heads. SinterCast's foundry customers also produce a variety of other automotive and non-automotive components that range from 8 kg to 17 tons. To learn more about SinterCast, visit www.sintercast.com

About Ashland
Ashland Casting Solutions, a business group of Ashland Specialty Chemical, is a leader in supplying products, processes and technologies to the global metal casting marketplace. The group has operations (including licensees and joint ventures) in 21 countries.

Ashland Specialty Chemical, a division of Ashland Inc., is a leading, worldwide supplier of specialty chemicals serving industries including adhesives, automotive, composites, metal casting, merchant marine, paint, paper, plastics, watercraft and water treatment. Visit www.ashspec.com to learn more about these operations.

Ashland Inc. (NYSE:ASH) is a Fortune 500 transportation construction, chemicals and petroleum company providing products, services and customer solutions throughout the world. To learn more about Ashland, visit www.ashland.com.

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Ashland builds strong Arena-flow™ software technology user base in key geographies

Dublin, Ohio (USA) -- Ashland Casting Solutions, a business group of Ashland Specialty Chemical, a division of Ashland Inc. (NYSE: ASH), recently added three companies to the list of licensed clients now using Arena-flow computer-aided engineering software. Ashland is the exclusive worldwide sales, marketing and service supplier for Arena-flow software in the sand casting industry.

Mazda Motor Corp., Toyota Motor Corp. and Yonetani Die & Mold Co. have all agreed to license the Arena-flow software from Ashland. Representatives from these companies recently completed a four-day training session held at the Arena LLC headquarters in Albuquerque, New Mexico.

Arena-flow software offers an intuitive, easy-to-use graphical interface for tooling and core-making process design in the metal casting industry. The software delivers a complete picture of the entire core-making process including the blowing, gassing and purging cycles, as well as the capability to analyze the virtual cores before investing significant time, money and material in the core-making process. Arena-flow software also allows tooling

manufacturers to validate optimum designs in virtual space to ensure that cold box tooling is optimized the first time.
Arena-flow technology was developed by Arena LLC of Albuquerque, N.M., in conjunction with General Motors, NASA, the Department of Energy and most recently, Ashland Casting Solutions. Arena-flow computer-aided engineering software technology can be accessed by software license agreements as well as contract engineering projects conducted in Ashland Casting Solution's Design Services Center.

"The addition of these valued customers to our user list is quite significant," said Mike Swartzlander, vice president, Ashland Specialty Chemical, and general manager, Ashland Casting Solutions. "We now have a strong user base in the Americas, Europe and Asia. Additionally, our license agreements and engineering contracts now span all segments of the metal casting market including large automotive original equipment manufacturers, Tier I and II metal casting suppliers and strategic tooling manufacturers," added Swartzlander.

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Ashland's PEP SET QUANTUM™ binder provides a quantum leap in no-bake performance

DUBLIN Ohio – Foundry mold and core making performance is being raised to a new level with the newly introduced PEP SET QUANTUM resin binder technology from Ashland Casting Solutions, a business group of Ashland Specialty Chemical, a division of Ashland Inc. (NYSE:ASH).

Designed to provide superior performance in a variety of ambient weather conditions, PEP SET QUANTUM binder provides more operational consistency in mold and core making. The resin also is lower in viscosity, thus increasing sand flowability and improving casting surface finish. Other benefits include an increase in strength and odor reduction.

PEP SET® resin binders were introduced in 1970 and are considered by many as the industry standard for no-bake technology. With the PEP SET QUANTUM technology innovation, Ashland Casting Solutions continues to drive performance gains for the metal casting industry.

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Ashland QUICKPADTM technology boosts casting industry productivity

DUBLIN, Ohio – QUICKPAD™ release and wear films, an innovative yet simple solution to excessive tooling wear and core-making productivity losses, are the latest innovation from Ashland Casting Solutions, a business group of Ashland Specialty Chemical, a division of Ashland Inc. (NYSE:ASH).

For many years the casting industry has suffered from excessive wear, resin build-up and "core stickers" caused by the abrasive nature of sand as it is blown into cold box tooling. This ongoing problem results in excessive down time and operator safety issues due to cleaning, as well as extensive tooling repair costs. Ashland's QUICKPAD release and wear films are focused on solving those problems.

QUICKPAD release and wear films are made from a unique polymer film and feature a pressure sensitive adhesive that allows it to be applied to the area of the tooling requiring the most wear protection and core release properties. Wear protection and release properties can last for up to eight hours of production depending on process conditions and film thickness.

QUICKPAD films are customizable to allow for unusual shape production conforming to unique tool geometries and contours. Ashland's QUICKPAD release and wear films range in size equivalent to a penny to about a silver dollar or larger. QUICKPAD film material is also available in 8.5" X 11" sheets for custom cut applications. Die-cut QUICKPAD films are sized to cover only the critical areas on a tool to achieve optimum protection from the abrasive nature of blown sand.

Originally designed to be applied to cold box tooling, their use has expanded to greensand molding patterns, wooden or synthetic patterns for conventional no-bake sand molding, and even to the inside of hoppers and mixers where large sheets of film can be applied to minimize cleaning.

"We are very excited about this product," said Mark Adamovits, Ashland senior product manager. "It is a simple solution, but sometimes the simple solutions are the best."

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Ashland's sand additive technology puts control into casting

DUBLIN, Ohio – Adding control to the sand casting process is the idea behind EXACTHERM® sand additive technology introduced by Ashland Casting Solutions, a business group of Ashland Specialty Chemical, a division of Ashland Inc. (NYSE: ASH).

Being able to control the cooling rate of the metal in critical areas of a casting can have numerous benefits. EXACTHERM sand additive contains unique characteristics that allow the foundry to custom tailor the thermal properties of a mold or core to meet critical casting sections needs. The result is better control of the casting process; elimination of misrun defects, blows and hot tears; and an overall improvement of the casting's surface finish.

Challenges in casting thin sections have existed for many years, but with EXACTHERM sand additive, casting thin-wall metal sections is achievable. The total amount of EXACTHERM additive that is in contact with a casting section determines how fast or slow the metal in that section will cool. It is compatible with all traditional mold and core-making processes, including green sand, cold box, no-bake and others. Ashland Casting Solutions, a business group of Ashland Specialty Chemical, is a leader in supplying products, processes and technologies to the global metal casting marketplace. The group has operations (including licensees and joint ventures) in 21 countries.

Dramatic color change featured in Ashland's VELVAPLAST® ZW FDI refractory coating

Dublin, Ohio – Foundries wishing to maximize productivity by reducing oven drying time for molds and cores need only apply VELVAPLAST ZW FDI refractory coating and watch the color change. This new technology, introduced by Ashland Casting Solutions, a business group of Ashland Specialty Chemical, a division of Ashland, Inc. (NYSE: ASH), provides the most dramatic color change of any refractory coating currently used.

"Our new VELVAPLAST ZW FDI refractory coating helps foundries not only reduce costs by optimizing oven drying times, but also by allowing core or mold density problems to be more readily seen," said Joe Muniza, global marketing manager – metal casting specialties, Ashland Casting Solutions.

VELVAPLAST ZW FDI refractory coating can be brush, spray, dip or flowcoat applied and changes from a bright purple color to yellow when dry. The dramatic color change is very easy to observe and assists foundry personnel in determining when cores and molds are dry so that multiple layers can be applied, or pouring can begin.

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