OUTLOOK

Wah Chang
An Allegheny Technologies Company

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INNOVATION

Nitinol Technologies Innovator Redefining the Cutting Edge

By **Kirk Richardson, Editor**

Jerry Julien, founder of Nitinol Technologies Inc., leans back in his office chair and chuckles. It's a beautiful day outside his Puyallup, Washington manufacturing facility, nothing but blue skies. But fair weather isn't all that has him smiling today. It's the bright future of Julien's nickel-titanium- (NiTiNOL-) focused business that has him in good spirits this morning.

The super-elastic, and super tough alloy NiTiNOL (from Nickel Titanium Naval Ordinance Laboratory) was developed in 1959 by William J. Buehler, a metallurgist working on metallic materials for the U.S. Navy Polaris reentry vehicle's nose cone. In 1962, a colleague of Buehler's, Dr. Fredrick Wang, discovered the shape memory property of the alloy. In simple terms, shape memory NiTiNOL alloy can be deformed, held in a contorted shape, then returned to its original form by changing its temperature (usually by applying heat).

NiTiNOL paper slitter

In subsequent years, the alloy's unique properties led to new applications, ranging from super-elastic medical devices to shape memory couplings for joining hydraulic tubing in aerospace industry applications. That's where Julien, a retired Boeing Mechanical Engineer and Air Force veteran, first learned about nickel-titanium, working with the material at the Seattle-based aircraft manufacturer's R&D facility in the 1980s and '90s. He eventually left Boeing, he says, "because I wanted more freedom to innovate. I come down here and work on what I want, when I want."

Since his start-up opened its doors in 1997, Julien has done just that, logging long hours inventing uses for nickel-titanium alloys and refining the processes to manufacture his ideas. In fact, he's filed 20 patents covering processing and applications of Grades 55 and 60 NiTiNOL alloy. Of the 12

60 NiTiNOL bearings showed no corrosion in salt fog tests.

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Murdy Named ATI President/CEO

Pittsburgh, PA, June 26, 2001—Allegheny Technologies Incorporated (NYSE:ATI) announced today that James L. Murdy, 63, currently Executive Vice President and a member of the Board of Directors, has been elected President and Chief Executive Officer by the company's Board of Directors effective July 1, 2001. Mr. Murdy succeeds Robert P. Bozzone, who remains Chairman of the Board.

James L. Murdy

Mr. Bozzone said, "Jim Murdy is exceptionally well qualified to lead

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Corrosion Solutions Conference Update

Wah Chang is pleased to announce that Brian Fitzgerald of Exxon-Mobil Chemical, will present a keynote speech, Monday, September 10, at the Corrosion Solutions Conference in Sunriver, Oregon. The third in a series of biennial conferences, "Corrosion

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Innovation

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patents allowed to-date, most are applications oriented. These include NiTiNOL alloys for high security locks, shape memory rotary actuators, gun barrels, reusable metallic seals, cutting instruments, and bearings. The potential for the alloy is enormous, according to Julien, with new ideas churning out almost daily… more patents in the works.

He rattles off potential uses for the material, with no end in sight "bearings… cutting instruments for food processing, pulp and paper, cutlery… lock washers… serpentine coils for seals… heater elements… impact absorbers for sporting goods and automobiles… fasteners… wood rasps and files… ski and snowboard structures… even horse shoes" for pity's sake (the alloy is light weight, corrosion/erosion resistant, impact dampening, and has low thermal conductivity—good news for the ponies). Jerry's list goes on… ad infinitum.

What makes nickel-titanium so special? "It has so many attractive properties," says Julien. For instance, 60 NiTiNOL alloy is extremely tough and very corrosion resistant. When a well-known aircraft manufacturer tested steel type 52100 bearings and NiTiNOL in salt fog, the steel showed corrosion after eight minutes. 60 NiTiNOL alloy showed no erosion or corrosion after several hundred hours of testing. Similar experiments performed by the U.S. Navy showed no corrosion after 500 hours of testing. According to Julien, the Navy has stated that the potential exists that 60 NiTiNOL bearings can be operated in salt water, without the use of lubricants. He goes so far as to say that "salt water may actually act as a lubricant with this material."

Innovators Larry Baker (left) and Jerry Julien (right) say that 60 NiTiNol's hardness and corrosion resistance make it ideal for cutting instruments.

Testing of Nitinol Technologies' prototype ball bearings and roller elements continues at several companies, including Boeing.

Larry Baker, Vice President of Operations for the company, says in 31 years of metal fabrication, he's never worked with anything like this alloy. Baker, an expert in laser cutting of metals, points out that 60 NiTiNOL alloy is extremely tough. "Normal manufacturing processes do not apply with this material," he says. "We use a 3000-watt laser to cut it."

Julien is quick to add that most drills and saws (even those made of tungsten) are no match for 60 NiTiNOL alloy. "The oxide layer won't even come off with diamond paste," he states. While cutting the alloy is no easy task, the same properties that make it so tough to shape also make it an attractive material for cutting instruments. With a Rockwell hardness value of 60-62 and superior corrosion resistance, the alloy is being evaluated for use in everything from cutlery to slitter blades for food processing and pulp and paper mill applications. Initial tests have determined 60 NiTiNOL alloy to be corrosion resistant to selected acids in both applications.

It's also worth noting that the alloy can be cast and welded, opening the door to many more potential applications. Julien mentions that cast-part applications might include salt-water resistant components for boats, like deck hardware. "The slick,

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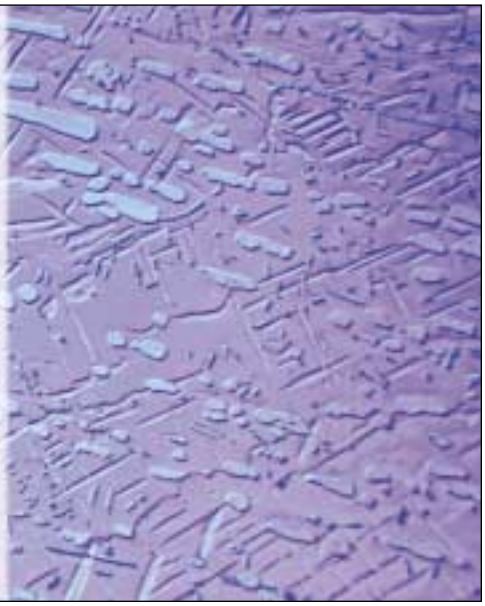
NiTi Production Challenges

According to Wah Chang Research Metallurgist Craig Wojcik, the most challenging aspect of working with 60 NiTiNOL alloy is casting and fabricating production in scale quantities. "This alloy is made up of intermetallic compounds NiTi and $TiNi_3$, both of which can be notoriously brittle in nature," he says.

In fact, early work on this composition was given up due to the apparent lack of sufficient ductility to fabricate even simple shapes such as bar or rolled plate. "This is where Wah Chang expertise has achieved major milestones recently," says Wojcik. Through proprietary processing methods, large ingots weighing several thousand pounds have been melted and processed into plates.

"We have come a long way since the first large ingot was cast at Wah Chang," he continues. "That ingot spontaneously fractured while cooling down to room temperature."



60 Nitinol hot rolled sheet showing primary and secondary precipitates of $TiNi_3$ in a NiTi matrix.

ATI President/CEO

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Allegheny Technologies to new levels of growth with improved financial performance. He has a strong knowledge of our company, its businesses, people and markets, and he has a wealth of experience in executive level positions with several global business organizations. The Board of Directors is confident that Jim has the skills and capabilities to lead the company in its strategic vision of being the world's leading provider of specialty materials. As Chairman, I look forward to working with Jim and the rest of his management team in achieving this vision."

Mr. Murdy has been with Allegheny Technologies and Allegheny Ludlum Corporation, a predecessor company, for 13 years. He has been an Executive Vice President since 1996 and was Chief Financial Officer from June 1988 through August 2000. Mr. Murdy has served as a Director of the company for most of this period.

Prior to joining the company in 1988, Mr. Murdy served as Executive Vice President and Chief Financial Officer of Gulf Oil Corporation. His earlier experiences include various positions with Occidental Petroleum Corporation and the public accounting firm Deloitte & Touche LLP.

Allegheny Technologies Incorporated (NYSE:ATI) is one of the largest and most diversified specialty materials producers in the world. The company's talented people use innovative technologies to offer growing global markets a wide range of specialty materials. High-value products include nickel-based and cobalt-based alloys and superalloys, titanium and titanium alloys, specialty steels, super stainless steel, exotic alloys, which include zirconium, hafnium and niobium, tungsten materials, and highly engineered strip and Precision Rolled Strip® products. In addition, the company produces general purpose specialty materials such as stainless steel sheet and plate, silicon and tool steels, and forgings and castings. Allegheny Technologies website can be found at www.alleghenytechnologies.com. ■

Wah Chang Strengthens Sales/Technical Services Groups

Ms. Susan Huse recently joined Wah Chang as an Account Manager in the Nuclear Sales Group. Ms. Huse worked at Wah Chang from 1991-95 as a Sales Representative for various product lines, including Zirconium 702 and 705, Titanium, Hafnium wire, and Niobium for jewelry applications.

Susan Huse

Her strong background includes stints with Oremet Titanium, selling rotor and non-rotor Ti billet, castings, sponge, scrap and chemicals, and at Allvac, selling titanium, specialty steels and nickel based alloys.

"In my new position, I will be selling nuclear grade zirconium with a focus on customers in Japan, Korea, China and several domestic accounts," she said. Contact Ms. Huse by phone at 541-917-6746, by fax at 541-967-6994, or by e-mail at susan.huse@wahchang.com.

Mr. Mike Abraham is a recent addition to Wah Chang's Technical Services Group. Mr. Abraham served as Nuclear Propulsion Engineering Officer in U.S. Navy from 1990-94. From 1996-2001 he worked at HMT Technology/Komag, Inc. (a computer disk manufacturer) in process engineering. Mr. Abraham has a degree in Chemical Engineering.

Mike Abraham

In his new position, Mr. Abraham will be assisting with technical inquiries, helping with applications engineering, performing failure analyses, making technical services calls, and presenting at Wah Chang's Corrosion Seminars. He can be reached by phone at 541-926-4211 ext: 6521, by fax at 541-924-6892, or by e-mail at mike.abraham@wahchang.com.

Mr. Bob Marsh has moved into Wah Chang's Niobium Sales Group. Mr. Marsh has over 25 years of experience with metals production and sales. He has extensive knowledge of the company's niobium and titanium product lines. In his new role, Mr. Marsh will manage sales development of niobium products for chemical and mineral processing as well as other applications. Contact Mr. Marsh at 541-967-6919, by fax at 541-967-6994 or by e-mail at bob.marsh@wahchang.com

Robert Marsh

Ms. Carolyn Gardener recently joined Wah Chang as Sales Manager for the company's aerospace titanium products. These include Ti-3.25V tube hollows and other products, such as Ti 1270. Ms. Gardener will also work on developing new aerospace market niches for Wah Chang.

Carolyn Gardener

Ms. Gardener brings extensive metals experience to her new position. She joined titanium-giant Oremet as Sales Service Coordinator in 1981 and was later Manager of Inside Sales. Subsequently, she held titanium sales management positions with Oremet-Wah Chang, then with (WC's) sister company Allvac. Contact Ms. Gardener at 541-812-7026, by fax at 541-967-6994, or by e-mail at carolyn.gardener@wahchang.com.

ABSTRACTS

CORROSION CONFERENCE

Wah Chang's third biennial corrosion-oriented conference, Corrosion Solutions, will be held in Sunriver, Oregon, September 9–13, 2001. The event currently features 40 presentations, including three keynote addresses, several panel discussions, and many papers covering multiple topics (for a full list, go to www.corrosionsolutions.com). Following are four abstracts that provide a small sample of what the conference technical sections will encompass. To enjoy the full menu of presentations, papers, interaction, and special events live, contact Conference Secretary, Sheryl Renzoni at 541-926-4211 ext: 6280 or by e-mail at sheryl.renzoni@wahchang.com. Sign up as soon as possible; space is limited and available on a first-come, first-served basis. ■

Niobium Solves a Rupture Disc Corrosion Problem

By **Danny Gibbs, Sterling Chemicals**
B.J. Sanders, Consultant

Rupture discs have been used for many years to protect pressure vessels from being over-pressured. In addition to being used alone, the ASME Code also allows them to be used beneath pressure safety valves to prevent corrosion of the valves in a severely corrosive environment where high nickel alloys and zirconium are used as the primary material of construction for the pressure vessels and piping. The anisotropy of zirconium does not allow its use for the fabrication of rupture discs. By their design, rupture discs are very thin. Often, the use of high nickel alloys in a severely corrosive environment is not satisfactory due to the slight metal loss of the disc due to corrosion, which results in premature failure. Niobium has similar corrosion resistance to that of zirconium, and there are no physical and mechanical property limitations to prevent it from being successfully used in the design and fabrication of rupture discs. This paper presents a case history where niobium was used as rupture disc material to replace a high nickel alloy disc that was failing prematurely due to corrosion. ■

Continuing Innovation in Zirconium Explosion Clad Manufacturing

By **Antoine Nobili, Nobelclad Europe**

The explosion clad manufacturing Groupe of Nobleclad Europe and DMC CLAD Metal Products continues in the development of higher quality, lower cost zirconium clad products. This paper includes information on progress in bonding with standard grade zirconium. Pros and cons of interlayer is also reviewed as well as production data on simultaneously bonded Zr/Ti/Steel plates. Options for reducing zirconium thickness, and consequently cost, are also discussed. ■

Effects of Tin in Zirconium

By **Dr. Te-Lin Yau, Corrosion Consultant**

Unalloyed zirconium has inconsistent corrosion and oxidation resistance in high-temperature water and steam. This abnormal behavior is attributed to the presence of minor impurities like nitrogen and carbon. Alloying with tin helps zirconium to behave more predictably in hot water and steam. It also improves zirconium's mechanical properties, such as strength and creep resistance.

Tin is the most important alloying element for zirconium. The zirconium-2.5% tin alloy, (Zircaloy-1) was initially recommended for the USS Nautilus reactor. However, Zircaloy-1 had an increasing rate of corrosion and oxidation over time. The beneficial effects of tin cannot be fully realized unless small amounts of iron, chromium and nickel are present.

Consequently, Zircaloy-2, a zirconium alloy with 1.20–1.70% tin, 0.07–0.20% iron, 0.05–0.15% chromium and 0.03–0.08% nickel, was developed and specified for the Nautilus reactor. To achieve optimal performance, the tin content needs to be controlled at the low end and the iron/chromium/nickel content at the high end of the specification. As an alloying element for zirconium, tin may be beneficial in the short term but is not reliable in the long term. In order to be more consistently beneficial, there is a need to balance all alloying elements in Zircaloy-2.

Tin may be a major impurity in UNS R 60702 or Zr 702, a commercially pure zirconium alloy for corrosive applications. The presence of tin in Zr 702 results from the addition of Zircaloy scraps in the production process. This practice may yield a few benefits, which include consistent

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strength, improved corrosion/oxidation resistance in water and steam, reduction in cost and material conservation.

Nevertheless, tin is not as corrosion resistant as zirconium in most corrosives. Small amounts of tin may be beneficial or acceptable for Zr 702. Too high a tin content will definitely degrade zirconium's corrosion resistance. How high is too high? According to the ASTM specification B-752 for castings, the percentage of tin in Zr 702C shall not exceed 0.10. This requirement is not in ASTM specifications for other Zr 702 products. Thus, it is necessary to determine the limitation of tin content in Zr 702.

Published data and results from Wah Chang's recent tests have been collected to identify the effects of tin in zirconium. It has been found that the presence of up to 6,760 ppm tin is much more critical to zirconium in sulfuric and phosphoric acids than in acetic, hydrochloric and nitric acids. Also, with more than 2,000 ppm tin, zirconium may corrode in sulfuric acid at a low rate during the initial period, but at a somewhat higher rate during a later period. A mechanism for this behavior will be proposed in this paper. ■

Corrosive Wear Behavior of Zr in Hot Sulfide Containing Electrolytes

By **Derrill R. Holmes, Wah Chang**

The synergism effect between corrosion and the corrosive wear for Zr 702 has been researched and determined. The two different types of Zr 702 that were researched were Zr 702 with a pickled surface treatment and Zr 702 with an air oxidized surface treatment. Stainless Steel 304L was used as a standard to compare the different types of Zr 702. The electrolyte that was used was Production Raw Green Liquor from the Pulp and Paper Industry. Testing conditions of 85EC and the chemical composition of electrolyte closely simulated actual production conditions.

Electrochemical results showed that zirconium, in both surface treatments, had a lower corrosion rate than the SS304L standard. Plus the electrochemical behavior of Zr 702 exhibited a less active surface than that of SS304L. Both surface treatments also exhibited the less active surface. The samples with the oxidized surface treatment were more wear resistant. Synergism calculations showed that the Zr702 with oxidized surface had the lowest interaction between pure wear and corrosive wear. Stainless Steel 304L had the highest interaction. ■

Corrosion Solutions

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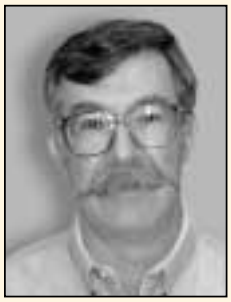

Brian Fitzgerald

Solutions" follows Wah Chang's successful "Reactive Metals Conference" held in September 1999. That event featured companies spanning 12 countries and included participants from end-users, fabricators, materials producers, equipment manufacturers, engineering contractors, academia, and others.

In his keynote speech, Mr. Fitzgerald will discuss his unique experience with corrosion challenges as well as materials issues. He is well qualified to present on these subjects. Mr. Fitzgerald has over 25 years' experience in the hydrocarbon processing industry; the last 21 years with ExxonMobil Chemical. He is currently the worldwide lead materials specialist for ExxonMobil Chemical, with responsibilities to support existing operations, ongoing projects and improvement activities.

In addition to Mr. Fitzgerald's presentation, this year's conference offers a robust menu of topics, ranging from performance of zirconium, titanium, tantalum, niobium, and specialty steels in corrosive environments to various aspects concerning the design, fabrication, and maintenance of processing equipment and much more.

A sampling of the 40 tentative presentations and panel sessions includes *"Inspection and Repair of Zirconium Process Equipment During Turnaround"* by Jason Wood, Millennium Chemical; *"Experiences with the Fabrication and Service Behavior of Components Made of Ti and Zr in the Chemical Process Industry"* by G. Wagner and H.J. Bassler, BASF; *"The Effects of Process Impurities on the Corrosion Resistance of Zr & Ti: Case Histories"* by Mike James, DuPont; *"Design, Fabrication and Test of Reactive Metal Clad Steel Equipment for Chemical Applications"*, MES; *"Exploiting Corrosion Resistance by Materials Selection – A Materials Engineer's Perspective"* by Neil Henry, ABB Eutech; *"Application of the CE Marking and Specifically the European Directive 97/23/EC (Pressure Equipment Directive–PED)"* by Raol Vieira, Bureau Veritas; *"Niobium Solves a Rupture Disk Corrosion Problem"* Danny Gibbs, Sterling Chemical and BJ Sanders, Consultant.

For more information, check out the Abstracts on page 4 and 5 of this issue, or visit www.corrosionsolutions.com for a full list of papers.

To register for the Corrosion Solutions Conference or reserve a display/stand, contact Ms. Sheryl Renzoni at sheryl.renzoni@wahchang.com, fax 541-924-6892, or phone 541-926-4211, ext: 6280. Check out www.corrosionsolutions.com during the coming months for updates on this one-of-a-kind event! ■

OUTLOOK EVENTS

Corrosion Solutions Seminars

Fall 2001, Cancun, Philadelphia, Mumbai, Singapore

Wah Chang continues its series of Corrosion Solutions Seminars this fall with intensive two-day training sessions in Cancun, Mexico (October 2–3), Philadelphia, Pennsylvania (October 16–17), Mumbai, India (November 1–2), and Singapore (November 7–8). These sessions are different from the Corrosion Solutions Conference (September 9-13) in that they are classroom-style lectures delivered by two to three presenters. Classes are very focused, concentrating on zirconium and titanium, with additional information supplied on other metals. Topics included primary uses; material specifications; metallurgy and properties; welding, joining, and heat treating; forming and machining; project management; equipment maintenance; safety; failure analysis and much more. For information on registration fees and other information or to sign up, contact Sheryl Renzoni at 541-926-4211 ext: 6280 by fax at 541-924-6892 or at sheryl.renzoni@wahchang.com. ■

Wah Chang's Corrosion Solutions Seminars offer in-depth information on everything from project management to welding reactive metals.

ANPSG Meeting to Focus on Safety

October 9th –11th Banff, Canada

Wah Chang is pleased to announce that it will co-host the 2001 Ammonium Nitrate Producers Study Group meeting in Banff, Canada, October 9–11. This year's event is being held at the elegant Hotel Fairmont Chateau Lake Louise.

Ricardo Rodriguez of Nitrochem Corporation will chair the technical sessions, with support from Gordon Collis of Simplot, David Hind of Orica, and Leif K. Rasmussen of Kemira Agro.

Tentative topics include Safe HNO_3 production and storage; Nitric Acid Plant Explosion in Immingham, UK; N_20 abatement (BASF technology); CEM NOx analyzer; New AN Neutraliser Control Scheme; Experiences with Bulk Flow Coolers; Impact of Impurities and pH on AN Stability; Survey of Recent Pump Explosions; AN/UAN Safety Round Table; AN Prill Tower Emission after Scrubbing; and much more. Details on the event, including a preliminary schedule, are available at www.anpsg.org.

For information on attending the meeting, contact Ricardo Rodriguez by phone at 613-348-3681 ext: 280 or by e-mail at RodriguezR@Nitrochemcorp.com. For information on exhibiting, contact Wah Chang at 541-926-4211 ext: 6280 or by e-mail at sheryl.renzoni@wahchang.com. Space is limited and will be allotted on a first-come, first-served basis. ■

ITA Expecting its Biggest Show

Sept. 30th –Oct. 2nd Las Vegas, Nevada

Allegheny Technologies Incorporated's High Performance Metals Group will take part in the upcoming 17th Annual Titanium Conference and Exhibition, September 30–October 2 in Las Vegas, Nevada. Members of ATI's Allegheny Ludlum, Allvac, and Wah Chang companies will be on hand at Booth #26 to answer attendees' technical questions.

The International Titanium Association is planning the biggest conference and most expansive exhibition it has ever held. According to the organization, "The annual ITA conference provides excellent opportunities to meet with fellow suppliers, competitors, and customers related to the titanium field. This year's conference will not only provide remarkable insight on latest industry trends, but also provide specific titanium application breakout sessions. These sessions focus on the Marine/Offshore Applications, Medical Applications, Chemical Processing, as well as Aerospace Applications."

For more information, contact the ITA by phone at 303-404-2221, by fax at 303-404-9111, or visit the association's web site at www.titanium.net. We look forward to seeing you in Las Vegas this fall. ■

Zirconium and Titanium Alloy Development

This issue's Question & Answer column was submitted by Ken Bird, PE, a corrosion engineering consultant based Denver, Colorado. He has 44 years' experience working with reactive metals and has also worked on the equipment fabricator side of the business. Mr. Bird says engineers seeking better solutions for the corrosion challenges that they face often ask him what new alloys are on the horizon. In the following Q&A, he focuses on development of zirconium and titanium alloys.

QUESTION:

What titanium and zirconium alloys are available for the Chemical Processing Industries? Are new alloys on the drawing board?

ANSWER:

Titanium, zirconium's sister element, is alloyed with other elements to improve its corrosion resistance or expand the corrosion resistant range to cover some reducing conditions. The oxide film formed on titanium is more conditional than that formed on zirconium. In reality, very few elemental alloying agents will improve the corrosion resistance of titanium under reducing conditions. Titanium, as a pure metal, is corrosion resistant under oxidizing conditions. The elements that improve the resistance of titanium under reducing conditions are the noble metals: palladium, ruthenium, etc. Common alloys of titanium (e.g., Ti-6Al4V, Ti-3Al2.5V, Grade 12, etc.) are formulated to meet specific operating conditions with an emphasis on strength and ductility while minimizing the impact on corrosion resistance. Alloying noble elements will modify the corrosion resistant barrier (surface oxide film) formed on these metals.

The case is similar with regard to zirconium. Since this reactive metal has excellent corrosion resistance over a wide range of media, including strong reducing (HCl) and strong oxidizing (HNO_3) materials, it is impractical to modify its film via alloying. One basic alloy of zirconium, however, is manufactured for additional strength and ductility. Alloy R60705 (or Zr 705) contains approximately 2.5% niobium and is used primarily for fasteners and column internals. Zr705 exhibits corrosion resistance similar to Zr702 (which is basically unalloyed zirconium) in many solutions, but not always. In some environments, Zr702 offers superior protection against corrosion.

In summary, the emphasis on zirconium alloy development is to improve the quality of the zirconium oxide (ZrO_2) corrosion barrier/surface oxide film; not to degrade the corrosion resistance via alloying.

Mr. Bird can be reached by phone at 303-457-9667 or by e-mail at Hkbird@aol.com. ■

Seeing is Believing

Over the 21 years that Outlook has been published, many case histories and other articles have touted the corrosion resistance of zirconium. During these two-plus decades, Wah Chang was "taking its own medicine", using Zr-702 in various applications in its own plant. In one instance, the corrosion-resistant alloy was used in a scrubber operation. The metal sample shown here (accompanying photo), survived 20 years in a severe environment—chlorine gas with caustic solutions, oscillating daily in pH from 2 to 11. A testament to zirconium's durability, the serial number on the sample is still visible.

Mr. Randy Scheel will discuss this and other Wah Chang case histories during a presentation at the company's Corrosion Solutions Conference this fall in Sunriver, Oregon. For more details, call Sheryl Renzoni at 541-926-4211 ext: 6280 or check out our web site at www.corrosion-solutions.com for the latest information.

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permanent finish works great for cleats and won't corrode," he says.

Like 60 NiTiNOL alloy, new and potential uses for 55 NiTiNOL abound. Julien and Baker are excited about several, including high pressure seals (Julien says that the material works especially well at low temperatures); liners for oil piping systems (he points out that the alloy is very flexible due, in large part, to the low elastic modulus); lock washers (Baker trumps their great strength); and vibration dampening devices [Julien states that the martensite (high transition temperature) NiTiNOL has been shown to have a specific damping capacity of 40%]. And on the idea machine continues, no end in sight.

"I think this is the material of the future," says Julien without a trace of skepticism. "NiTiNOL is the finest material an engineer could have to work with." After awhile, it starts to sound like something found at a certain crash site in Roswell, New Mexico, circa 1947—an alloy from another world… almost too good to be true.

Which takes us full circle back to the beginning of this story. When asked jokingly whether stock is available in his company, Julien hands on head, elbows out, looks at the inquisitor and chuckles. "You don't know how many people ask me that question," he says with a wry smile. "Everyone realizes that there is so just much potential for this material." Yes indeed… the sun is shining on Gerald Julien's world of nickel-titanium, and the forecast looks promising.

For information on Wah Chang's specialty alloys, contact Customer Service at 541-967-6977. For information on Nitinol Technologies' products and potential licensing agreements, contact Gerald Julien by phone at 253-926-5590 or by e-mail at nitinol@ix.netcom.com. ■

Farewell to a Friend

Mr. Hidemasa Imai

During our 30-plus years of doing business with Chemical Processing Industry customers, we at Wah Chang have had the opportunity to form lasting relationships with many special people. Mr. Hidemasa Imai, of MES (Mitsui Engineering and Shipbuilding), was one of those unique individuals who makes doing business a pleasure.

On June 27, MES, Wah Chang and the industry in general lost Mr. Imai to a bicycle accident in Tamano, Japan. Mr. Imai was respected around the world for his extensive knowledge of and experience with zirconium and titanium. His experience with reactive metals stretches back to the late 1970s, when he was a key member of the MES team that constructed Japan's first Monsanto Process MAC-B plant for Daicel. Over the years, Mr. Imai was involved in many titanium and zirconium fabrication jobs, crisscrossing the world from Japan to Korea… to India, Russia and beyond. In Japan, Mr. Imai's expertise earned him the nickname "Mr. Zirconium", a moniker he was proud of.

Hidemasa Imai was a supporter of Wah Chang, a friend, and a frequent and well-received speaker at the company's Corrosion Conferences. We will miss "Mr. Zirconium" at our Sunriver event this fall. And afterward, like so many others, we will miss working with this warm personality and intelligent professional. ■

OUTLOOK

LYNN DAVIS . . . . . President

PARRY WALBORN . . . . . Vice President, Commercial

GARY KNEISEL . . . . . Director of Sales

KIRK RICHARDSON . . . . . Editor

Outlook is published quarterly by Wah Chang (Albany, Oregon office). The newsletter contains information on reactive and refractory metals, including hafnium, niobium, titanium, vanadium, and zirconium, as well as chemicals. The properties listed herein are average values based on laboratory and field test data from a number of sources. They are indicative only of the results obtained in such tests and should not be considered as guaranteed maximums or minimums.

INFORMATION & ORDER CONTACTS

Wah Chang
(headquarters)
P.O Box 460
Albany, Oregon 97321
Tel: (541) 926-4211
Fax: (541) 967-6990
www.wahchang.com
www.corrosionsolutions.com

Sales/Tech Support
Tel: (541) 967-6977
Fax: (541) 967-6994
E-mail: custserv@wahchang.com

CPI Service Center–U.S.
Tel: (541) 812-7038
Fax: (541) 967-6979
E-mail: starlene.ladd@wahchang.com

For information on agents/distributors of CPI products
call: **(541) 967-6906**

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For information on Allegheny Ludlum products
call: **(412) 394-2800**