

**TITANIUM 2004**  
**October 3-5<sup>th</sup> New Orleans, Louisiana USA**  
**General Session Proceedings**  
**Table of Contents**

**World Trends Panel**

**Timothy G. Rupert, President & CEO - RTI International Metals Inc.**

*Abstract:* Titanium plays an essential role in critical military aircraft and other defense hardware around the world. Mr. Rupert will review the history of titanium's development for defense-related applications and discuss the relative contribution of military applications as it relates to annual titanium U. S. industry shipments. The presentation will highlight several significant military titanium applications, including aerospace, naval, and ground support systems, as well as discuss the growth of new applications and the resulting opportunity for the titanium industry.

**J. Landis Martin, Chairman and CEO - TIMET**

*Abstract:* In 2004, market demand for titanium has increased as the world economy improves and the aerospace industry begins to recover. Stronger demand for industrial products, particularly in Asia, parallels the improving trend seen in the aerospace sectors. There are stronger economic fundamentals both in the USA and abroad that support this turnaround in our industry. We will examine these economic indicators and the state of the industry focusing on both the commercial aerospace and industrial markets from historical and prospective viewpoints.

**John P. Monahan, President & CEO - VSMPO Tirus, U.S.**

*Abstract:* Mr. Monahan will be speaking about recent trends of titanium production in Russia, and will present a projection of how those trends may influence and shape the future of titanium manufacturing activity in Russia and the supply of Russian titanium into the global market.

**Sylvain Gehler, Managing Director - Specialty Metals Company**

*Abstract:* With increased market demand titanium sponge supply is of critical importance. Mr. Gehler will review Kazak and Ukrainian titanium sponge industry as well as titanium sponge world supply and demand situation. The speaker will also look at changes expected in the titanium sponge industry in the years to come.

**Keiji Koyama, Senior Officer of Iron & Steel Sector - Kobe Steel, Ltd.**

*Abstract:* Shipments of titanium mill products in Japan continued at high levels for two years in a row. Japan's titanium industry shipped 14,434 tons of mill products in 2001 and 14,481 tons in 2002. Shipments of titanium sponge reached a record high of 25,107 tons in 2001 and similarly high level of 22,652 tons in 2002.

World shipments of titanium mill products have traditionally been strongly influenced by the business cycles of the aerospace industry. Japan, on the other hand, has seen a steady increase in mill product shipments, although there was a small slump from 1997 to 2000. Growth was due to the continuous efforts to develop new applications for commercially pure titanium, in particular titanium sheet. Nevertheless, in 2003 mill product shipments dropped below 14,000 tons for the first time in three years, to 13,800 tons. Titanium sponge shipments fell below 20,000 tons for the first time in three years to 18,617 tons.

However, after mill product shipments hit bottom in the second quarter of 2003, demand began to recover. In 2004, shipments improved considerable as business conditions surrounding the titanium industry showed clear signs of improvement. If current mill product shipments continue at the same pace as in the January to June period, total annual shipments could rise beyond the 14,500 tons forecast early this year. Shipments of titanium sponge, after hitting bottom in the third quart of 2003, have also been rising sharply.

The Japan Titanium Society has 169 associate member companies as of July 2004. The Technical Committee of the Society sponsors workshops for those interested in developing new applications for titanium. By widening the scope, further progress will be made in titanium applications.

The Japan Titanium Society is involved in two recent activities. One is the development of the JTS Process, a new refining process to make high purity titanium sponge at a low cost. The other is the international standardization of titanium, a project proposed by the Japan Titanium Society that is currently under way. Tasks have been divided among five working groups, with Japan being in charge of nondestructive testing.

**Markus Holz, Managing Director - Titania S.p.A.**

*Abstract:* The European Aerospace market has been gradually expanding. In Civil Aerospace the AIRBUS has been playing a major role, with more airplanes than Boeing delivered in 2003 and far wider horizons ahead in the years to come, while military aerospace, though still controlled by US producers, is well represented in Europe with programs such as the Eurofighter and Rafale, the Tiger, the A400M, and the Airbus tankers.

CP Titanium absorbs a great part of the European Titanium market in view of Europe's less vigorous vocation towards the aerospace market than the U.S. For this reason, Europe has seen a growing number of processors devoted essentially to cp titanium and its specific applications.

This presentation will provide final figures on consumptions and exports as well as specific data on trends for the markets where the main areas of growth are. Among these, all equally characterized by a strong demand for versatility and utmost flexibility, the chemical and petro-chemical market has been growing on a rather fertile ground. Strictly interrelated with the economy of emerging countries, the Chloro-Soda market as well appears to have revived while the plate heat exchangers market is perhaps the one with a greater degree of stability, and the energy-related and desalination markets have suffered the least recession over the past years because of the ever increasing need to ensure power and sweet water worldwide. An outlook on the emerging market applications – military for land vehicles, automotive, architecture – will also be provided.

### **Furkhat Faizulla, Advanced Material Japan Corporation**

### **Mark S. Kamon, President - Dynamet Incorporated**

#### **Aerospace Panel:**

#### **Craig W. Musson, Director, Commodity Management - Pratt & Whitney**

*Titanium Applications in Turbine Engines, and Aerospace Market Trends & Issues*

*Abstract:* Mr. Musson will present an overview of titanium applications in Pratt & Whitney's engines, as well as trends in the aerospace industry that affect Pratt & Whitney's titanium demand. He will also outline his concerns regarding current titanium industry trends.

#### **Brian W. Smith, Materials & Process Technology Manager - The Boeing Company**

*The Boeing 7E7 Dreamliner*

*Abstract:* The 7E7 is Boeing's latest exciting commercial aircraft offering. Seating approximately 250 people, this airplane targets the middle of the market in terms of aircraft size and range. This airplane distinguishes itself from its competitors in fuel efficiency, passenger comfort, price, maintainability and long term value. A key aspect of the success of the 7E7 is the choice of advanced materials and processes. Advanced polymeric composites are used extensively throughout the airplane. In addition, the 7E7 also makes extensive use of titanium and is expected to incorporate a higher percentage of titanium than previous Boeing commercial aircraft models.

Increased titanium use is directly related to increased composite use. Titanium alloys have better galvanic and thermal expansion compatibility with carbon fiber composites. They also offer excellent corrosion resistance. In largely composite areas of the airplane, this can significantly reduce corrosion-related inspection and maintenance costs. The higher initial cost of titanium relative to aluminum will be partially offset by innovations in titanium alloy, process and machining technologies. Further, the 7E7 is expected to use titanium in large scale landing gear applications, similar to the 777.

Boeing's interest and investment in titanium continues. This is expected to grow with composite applications on subsequent new models that will build on 7E7 technologies. Our research and development activities will continue to push advancements in titanium alloy properties and innovative fabrication processes.

#### **Tony S. Esposito, Plant Manager - Plymouth Extruded Shapes**

*Near-Net Extrusion: An Ideal Manufacturing Process for High-Strength Titanium Aerospace Components*

*Abstract:* This paper describes how the near-net extrusion process provides a cost-effective solution for the production of many titanium aerospace components and assemblies.

Specifying titanium near-net extrusions for high-strength structural parts and high temperature engine components can deliver significant cost and quality benefits to aerospace manufacturers.

#### **William Pallante, General Manager - RTI International Metals Inc.**

*Meeting the Demands of the Evolving Aerospace Industry through the Efficiencies of Large, Complex Hard Metal Extrusions*

*Abstract:* As the aerospace industry and aircraft continue to evolve, the need for cost effective aircraft design and construction have become increasingly challenging. Simultaneously, rising fuel costs and global competition for customer traffic have made operational cost efficiency to be of paramount importance. Regardless of whether, one considers the answer to the future to be found in moving larger numbers of passengers in a single aircraft through a "hub and spoke system" or by focusing on "point-to-point" passenger traffic via highly fuel efficient aircraft; design, construction, operation and maintenance are key.

Titanium's inherent strength to weight ratio, physical and mechanical properties make this unique metal and its' alloys increasingly attractive for application in both of the above scenarios. However, today, as in the past, the perceived expense of titanium and its' alloys has hindered its' broad incorporation into new commercial aircraft design and construction. While in the long term, many of today's ongoing research and development activities are targeted at reducing the production cost of titanium sponge and powders, the near term challenge and related resistance remains. RTI International Metals, Incorporated and our industry take this challenge very seriously. We promote comparison and analysis based on "life cycle costs" and total impact on operational and maintenance efficiencies. While this concept is well know and appreciated, expansion of the use of titanium still suffers from the

perception and stigma of being a high acquisition price material. Thus, making it a choice of last resort in too many instances, where it should rightly be viewed as a functionally robust and cost effective material of preference.

Hence, the absolute necessity of economic conservation of material, better known as optimized buy-to-fly ratio. Through the hard metal extrusion process, material utilization can be maximized, while simultaneously keeping “tooling” costs low while permitting design evolution and flexibility. RTI Fabrication LP, located in one of our Houston, Texas facilities, produces titanium (and other hard metal extrusions) over a broad range of sizes and varying degrees of complexity. This facility along with RTI’s unique 5,500 ton direct/indirect extrusion press produces hard metal extrusions of over seventeen inches (17”) in linear cross section and having in excess of sixty square inches of total cross sectional surface area. By utilizing input billets from six (6”) to eighteen and a half inches (18.5”) in diameter and up to fifty-four inches (54”) in length, RTI’s press can push extrusion lengths that further optimize material utilization by minimizing yield loss from drops and test samples.

This unique equipment, its’ related capabilities and the highly skilled people of RTI Fabrication, LP are prepared to tackle the challenge of making cost effective complex titanium extrusions for the most demanding aerospace applications.

### **Emerging Technologies Panel:**

#### **James Williams, Ohio State University**

*Acceptance of New Processes: Challenges and Opportunities*

*Abstract:* The rate of acceptance of new processes and the products of these processes depends to a large degree on the criticality of the target application and the maturity of the competing products and processes that will be displaced. Economics also play a major role, but trading higher risk for lower cost is not commonplace.

A new process will gain acceptance faster if the following considerations are addressed:

- How costly will it be to qualify the product of the new process?
- Maturity of the process, i.e. how reproducible is the product?
- What experience already exists from other applications.
- What are the consequences of failure of components made from the “new” material?
- How stable is the producer in terms of financial viability?
- Are there alternative, competing processes under development?

This list is not intended to be exhaustive but it illustrates some consideration along the path to acceptance. Gaining experience through non-critical applications is a proven path. When this path is unavailable, it is expected that acceptance will be slower. This talk will use several examples to illustrate the process of acceptance, at least as experienced by the speaker.

#### **Mannfu Rau, AG Materials Inc.**

*Production of Titanium Hydride Powder by Using Self-propagating High-temperature Synthesis (SHS) Technique*

*Abstract:* Titanium powder metallurgy (P/M) has drawn a lot of interest as a cost-effective way of fabricating parts from this expensive material. However, the availability of low cost and high quality powders will be the key factors for this industry to have a significant growth. A novel manufacturing process for cost-affordable and consistent quality titanium hydride powder by using the self-propagating high-temperature synthesis (SHS) technique is reviewed. An example of using this hydrided powder and master alloy for producing near full density Ti-6Al-4V alloy part by blending element (BE) method is also demonstrated. Paper prepared by Mannfu Rau and Ming-yi Huang.

#### **Stan Borys, CEO - International Titanium Powder, LLC**

*The Commercialization of the Armstrong Titanium Powder Process*

*Abstract:* International Titanium Powder, LLC. is commercializing the Armstrong Titanium Powder process. Product description and plans for production facility will be reviewed. Status of application development work with industry, government and consortiums will be discussed.

### **Raw Materials Panel:**

#### **Toshihiko Saiki, Toho Titanium Co., Ltd.**

*The Future of Titanium Sponge Supply*

*Abstract:* The Titanium industry depends largely on aerospace and is very unstable where companies in the industry have experienced very large fluctuations regarding financial performances. For this reason, many sponge suppliers have withdrawn from the sponge market in the past 20 years.

Questions presented include:

If the titanium industry grows as it is expected in the future, is there any problem for sponge supply?

In the case the shortage of sponge is predicted, what is the problem for the present suppliers to increase capacity or to build a new plant of Kroll process with VDP?

And finally, how do we utilize the new process which many companies are trying to develop?

In this presentation, I'd like to give a small suggestion which will help both suppliers and customers by making the supply of sponge more flexible.

Unified specification.

Some mechanism to bridge the gap between supply and demand.

**Michael G. Metz, Vice President Commercial - VSMPO Tirus US**

*Raw Material Supply in Russia*

*Abstract:* Mr. Metz will speak on the raw material supply outlook from Russia, and its role in the global titanium market.

**Steve R. Giangjordano, Senior Vice President - RTI International Metals Inc.**

*Ferrotitanium Products and Titanium Metallic Supply and Demand*

*Abstract:* Ferrotitanium is an alloying addition used for steelmaking. This presentation will provide a general overview of raw material selection, method of production, customer requirements, and usage.

Titanium metallics used for ferrotitanium production include: scrap from aerospace components; scrap from mill products; sponge from current production and from stockpile releases; scrap from aircraft demolition.

Some of these ferrotitanium metallics are from the same supply and demand streams as metallic for titanium ingots for commercial aircraft, military, and industrial applications. Several facets of this interrelationship will be explored.

**Michael P. Royer, Manager - Reading Alloys Incorporated**

*Manufacture of Master Alloys used in Titanium for Aerospace Applications*

*Abstract:* Master Alloys are used to provide critical properties to Titanium for components used in aerospace applications. This paper will review the method of manufacture of master alloys by an aluminothermic reaction. Key stages of the process will be reviewed including the selection and control of raw materials, the cleaning, sizing, and quality inspections of the alloy, as well as the certification of the material for use in aerospace applications.

**Andrew Grosz, U.S. Geological Survey, Eastern Mineral Resources Team**

*US Titanium Mineral Resources*

*Abstract:* Titanium occurs in many oxide and silicate minerals; however, only two minerals contain enough Ti to be of (current) commercial importance: ilmenite (and its alteration products), and rutile. Other titanium minerals occasionally found in economic concentrations are brookite and anatase, which are TiO<sub>2</sub> polymorphs, perovskite, and sphene.

Titanium in placer deposits in shoreline sands is of greater economic importance than that in rock ilmenite deposits. Individual shoreline deposits can contain tens of millions of tons of titanium minerals. The advantage provided by loose, well-sorted sediment with uniquely attractive mineralogy is difficult to counter, even with a rock of much higher TiO<sub>2</sub> grade. Thus, titanium minerals are, for the most part, produced from placer deposits in beach sediments.

Titanium resources are widely distributed in the United States and its Exclusive Economic Zone and in particular in the eastern US. In the past, prospecting methods were based on geomorphic and geologic analyses. Today, airborne and ground-based radiometric and geochemical surveys, as well as high-resolution magnetic and induced polarization surveys are the backbone of more effective methods of exploration.

**Military Panel:**

**Steve Luckowski, US Army**

*Titanium – The Future of the Army, Here Today*

*Abstract:* Titanium is allowing the Army to achieve unprecedented weight savings in a number of armament systems. Previously considered too costly for Army weapons, titanium is now applied where performance requirements must be met at significantly lower weight. This presentation provides a comprehensive look at titanium applications in Army armament and vehicle systems, to include the M777 Lightweight Howitzer, M240 machine gun, 120mm mortar system, M107 Trailer, M16 magazine and others. Each application will be described as a case study and the benefits in using titanium will be described for each application.

**John Lawmon, Edison Welding Institute**

*GMAW Process Stability - Grade 5 Titanium Alloys*

*Abstract:* The conceptualization of light and structurally strong ground based systems, manufactured in grade 5 titanium alloy, have posed many complex and interrelated design/manufacturing challenges. Initially these challenges were met, in production, with the careful application of the Gas Tungsten Arc Welding (GTAW) process. As the alloy has transitioned from niche markets to large scale manufacture, parallel activities have focused on the development of more productive gas metal arc welding (GMAW) techniques.

Characteristic feature of titanium alloy GMAW welds are:

- Contact tip erosion
- The formation of inter-metallic alloys within the contact tip

- An unstable cathode root
- Irregular and “peaked” weld bead profiles
- Increasing (time dependant) levels of tenacious spatter

This presentation reviews

- Techniques and equipment used at EWI to monitor process stability
- Innovative welding torch developments
- Methods to reduce process instabilities

### **Larry G. Martin, Business Development Manager - ATI Wah Chang**

#### *Titanium Armor Applications*

**Abstract:** The US Army has utilized titanium in various armor packages since the early 1990's for main battle tank and medium weight armored vehicle applications. With the advent of the MIL-DTL armor material specification in the early 2000's, titanium has begun to be considered for a broader base of vehicle types and applications.

A general push toward ever lighter armored vehicles is well documented. The Future Combat System (FCS) initiative set the bar for weight reduction at near the 16 ton mark to allow for transportation in a C130 Transport airplane and now other vehicles and programs have adopted similar objectives, though often not to the weight reduction ranges of the FCS.

The changing war environment with the enemy attacking from the front, middle and rear, has increased the need for increased protection for tactical vehicles such as the HMMWV and transport trucks.

New materials such as ceramics and composites are also being introduced to help accomplish the less weight for similar ballistics objectives. Titanium is now a member of a small community of high performance materials never before considered for land-based combat vehicle applications.

Titanium armor materials are often the optimum choice for the widening range of applications and environments. Titanium is a ballistically viable, light weight, structural, and corrosive resistant alloy – with a scrap value.

Presentation will discuss titanium in various armoring applications and its importance and role in future combat and tactical vehicles.

### **Medical & Dentistry Panel:**

#### **Roy Smith, Smith & Nephew**

##### *Titanium and Orthopaedics "Helping People Regain Their Lives"*

**Abstract:** The focus of this presentation will be on the role and specific uses of Titanium within the global Orthopaedic industry. For almost 40 years, Titanium has been used within various types of Orthopaedic implants. It's biocompatibility and strength characteristics make it one of the mainstay alloys that surgeons prefer and which the designers of Orthopaedic implant systems depend on.

In the course of describing the specific implant products made from Titanium, the presentation will project the global usage within Hip, Knee, and Trauma applications. For each application, the rationale for why Titanium is an appropriate alloy will be discussed, as well as the processing required to produce the finished implant, and the form of Titanium used as the starting point within production.

#### **John Disegi, Synthes (USA) Tech Center**

##### *Titanium Biomaterials for Orthopaedic Trauma Applications*

**Abstract:** Commercially pure (CP) titanium and titanium alloys represent a major class of materials that are utilized for orthopaedic trauma applications. Over the years, titanium has either replaced or augmented implant quality 316L stainless steel as a major biomaterial for trauma implants. A description of conventional alpha, alpha plus beta, and advanced beta titanium material properties are provided to document the unique features of fabricated surgical implants. Mechanical property advantages for Ti-15Mo beta titanium alloy when compared to CP Ti Grade 4 are highlighted for a newly designed reconstruction plate. The ability of electrolytic anodizing treatments to provide color-coded implant systems is discussed.

The wide array of titanium mill forms used to manufacture trauma products is documented in addition to incoming inspection criteria and recertification practice. Titanium material trends are presented for specific implant types, including preferred usage for craniofacial and spinal indications. Relevant product data for various types of titanium bone plates, bone screws, and specialty implants are covered. The importance of diagnostic imaging capabilities is presented along with actual data generated during high intensity magnetic resonance (MR) studies. Technical information includes recent applications for MR Safe titanium external fixation components to overcome torque, displacement, and heating problems associated with conventional iron-base materials.

#### **Karl-Heinz Kramer, F. W. Hempel**

##### *New Titanium Alloys for Medical Applications*

**Abstract:** Metallic materials are mainly used where high strengths are necessary, for joint-replacements, in the osteosyntheses for

healing bone fractures, or as dental implants. The presentation addresses some new developments in titanium alloys, their properties, their application and their availability.

The physical and mechanical properties of the different titanium commercially pure grades and titanium alloys are presented, mainly in respect to static and dynamic load such as tensile strength, fatigue-resistance, ductility and modulus of elasticity. Because of biocompatibility reasons only alloys containing non toxic elements should be used. Therefore developmental work has been concentrated on the metallic systems Ti-Zr-(Nb) and Ti-Mo-(Zr-Nb) with the goal of higher strength in combination with higher ductility, better cold working ability with a lower notch-sensitivity and advanced elastic properties.

In case of the Ti-Zr binary alloy system it could be shown that the addition of Zr to titanium base alloys in combination with cold working led to excellent mechanical properties taking advantage in the medical field of osteosyntheses.

The main advantages of beta titanium alloy Ti-15Mo for medical applications are biocompatibility, excellent casting ability, low modulus of elasticity, higher strength than commercially pure grades, good cold formability because of fully beta phase material, weldability and low notch-sensitivity.

### **Industrial Panel:**

#### **Mitchell Z. Dziekonski, President - Titanium Engineers Incorporated**

*The Production Of Seamless Titanium Tubing By The Rotary Piercing Process*

*Abstract:* Titanium Engineers has successfully adapted the rotary piercing process to produce cost effective and high quality seamless titanium tubing. Several years ago Titanium Engineers and Timken Steel entered into an exclusive and proprietary joint venture to market and produce seamless titanium tubing from 1.75" to 11" outer diameter.

Rotary piercing is a forging process where a solid round bar is heated to the hot forming temperature and positioned between two conically shaped rolls that provide the forward thrust to flow the material over a floating mandrel. The rotary piercing process produces seamless titanium tubing at a high production rate utilizing readily available bar as input material. Tubing can be produced as quickly as one minute per piece. No dies or tooling are required in this process, which enables running quantities as small as 60 to 80 feet. The processing imparts excellent metallurgical properties into the tube wall thru the working of the metal creating a uniform grain structure. In each processing stage titanium tubes are spun around the centerline, which enhances roundness, straightness, and also minimizes residual stresses.

Titanium Engineers has rotary pierced a variety of sizes and alloys of seamless titanium tubing for oilfield and industrial applications. Future titanium tube developments include utilization of the largest cold-pilger capacity (10.5"OD) in North America; allowing the production of high strength, thin wall tubing. Other areas include the use of one of the most advanced quench and temper facilities to raise the mechanical properties of lower strength titanium alloys.

#### **Mark R. Pompe, Director of Technology - West Penn Non-Destructive Testing, Inc.**

*Abstract:* This talk is designed to give the end user of ultrasonic testing services a clear picture of what needs to be ordered and what to expect from that order. It contains useful information for:

- Personnel making design decisions based upon the specified test
- Personnel who specify specific Ultrasonic tests on PO or internal work instructions
- Personnel interpreting test results
- Personnel buying ultrasonic test services

Specifications specifically covered are AMS-STD-2154 and AMS-2631, the most common military and commercial specifications in use.

Actual detection capabilities with respect to various common Ti defects will be discussed.

Advantages and capabilities of the following UT test methods will be discussed

#### **Charles Burgoon, General Manager - RTI Fabrication LP**

*Advanced Applications of Industrial Extrusions*

*Abstract:* Extruding has long been the process of choice for complex shapes and seamless tubulars, particularly those requiring extensive material removal to achieve the final shape dimensions. Since its beginning in the early 1800's this process has seen evolutionary, rather than revolutionary improvement. The proliferation of super alloys and exotic alloys for increasingly demanding applications has propelled further advances in the extrusion process, and spawned noteworthy process variations such as indirect extruding. Extrusion parameter development in support of extrudability studies has increased the importance of precise repeatability of all associated process parameters. The advent of computers, robotics, motion controls, and sensors, in combination, have allowed for significant improvements in process repeatability. Efforts to improve throughput and yield rates coincide with the prevalence of tighter tolerances in terms of dimensional, metallurgical, chemical, as well as improved surface condition requirements. These increased demands are rooted in both economics and technological advancements. The resulting process refinements, while subtle, are crucial in terms of repeatability and product consistency. In today's business enterprise

climate of statistical process control (SPC) some extrusion facilities are faced with difficult challenges in meeting new industry demands. These demands and applications will be explored and discussed in detail.

### **Emerging Markets Panel:**

#### **Architecture Applications:**

##### **Gary Nemchock, Architectural Titanium**

*Architectural Projects Completed 2004*

*Abstract:* The presentation will feature commercial and residential projects completed in the last year and those currently under construction. The focus project will be the new Denver Art Museum currently under construction that is being clad with 56 tons of TIMETAL® CP Architectural Titanium.

Commercial installations will include:

Swarovski Crystal Worlds - Vienna, Austria

City Hall - Seattle, Washington

Sun Plaza - Jakarta, Indonesia

Oostpoort - Haarlem, Netherlands

Amicorp - Curacao

Napier University - Edinburgh, Scotland

Scarborough Student Center - Toronto, Canada

Library - Tromso, Norway

Mauna Kea Astronomy Education Center - Hilo, Hawaii

Chinese-American Service Center - Chicago, Illinois

Featured residential installations in Mexico City, Cincinnati, Pebble Beach, Palms Springs, Laguna Beach, Aspen, Boston, Vancouver, Singapore and Malaysia.

##### **Hiroshi Shimizu, Senior Manager - Nippon Steel Corporation**

*Nippon Steel's Titanium Roof of Temple & Shrine and the Surface Finishing*

*Abstract:* Nippon Steel, together with the Koetsuji Temple in Kyoto and Shinden-an of the Sukiya Research Institute, have been awarded the 2003 Good Design award for the "Titanium-Roofing-for-Temples – Protecting-Historic-Buildings" project.

Note: The "Good Design" award is Japan's only system for the evaluation and promotion of integrated designs born of the "Good Design Goods Selection System" established by the Ministry of International Trade and Industry in 1957.

For the roofs of Buddhist temples, since olden times, the "best available materials of the times" have been used, such as shingles, Japanese cypress bark and copper. In recent years, however, environmental changes taking place under the influence of acid rain and so forth have begun to give rise to many problems, one of which is the shortened life of copper roofs. Historic wooden buildings, which have withstood the lapse of several hundreds of years, could lose one hundred years of their lives in a flash if they were to succumb to leaks in the roof just once.

The Koetsuji Temple, keen to hand down the temple building to posterity, sought advice on "today's best available material," from master builders of Japanese traditional style buildings who proposed titanium as today's cutting-edge material. And Nippon Steel responded to their exacting demands by developing the technology for an "alumina-blast finish" for titanium, providing color as exquisitely somber as that of "smoked tiles" and thus compatible with the beauty of Japanese traditions. The present award is public recognition of the close three-party collaboration and the concept of "titanium roofing for the protection of temples." Titanium roofing, adopted for the Ikkyuji Temple and many other Buddhist temples, was also adopted, last year, for the tea house of the Temple of the Gold Pavilion, which is on the World Heritage List.

Nippon Steel, since entering the field of building materials in 1985, has been working studiously on the task of enhancing the freedom of titanium design to meet the expectations of architects. In the process of undertaking a succession of different projects, we have added to our surface-finish menu.

We offer three kinds of roll-dull-finish (VAF+dull-finish) varying in luster, pickled roll-dull-finish, and alumina-blast-finish. In addition, we have energetically worked on color development. We have also consistently worked on the development of technologies for controlling the variation between production lots and restraining aging discoloration, as well as suitable cleaning agents.

Through such technical development, we have begun to receive various titanium-roof orders for large-scale projects throughout the world. Some of them include: the Chinese National Theater (43,000 m<sup>2</sup>, 65 tons, completion scheduled for 2005) and the Hang-chow Theater (10,000 m<sup>2</sup>, 15 tons, completion in 2004), for the roll-dull-finish. For color development: the Kyushu National Museum (17,000 m<sup>2</sup>, 50 tons, completion in 2004), which is the world's largest color-development project, and the Marque de Riscal Winery designed by the celebrated architect, Frank O. Gehry (2,000 m<sup>2</sup>, 12 tons, completion in 2005).

### **Automotive:**

#### **Hideki Fujii, Chief Researcher - Nippon Steel Corporation**

*Nippon Steel's New Titanium Alloys for Automotive Applications*

Nippon Steel has been involved for many years in research and development of titanium alloys for non-aerospace applications including automobiles, sports and utility goods. Super-TIX®800 (Ti-1%Fe-0.35%O-0.01%N) and Super-TIX®51AF (Ti-5Al-1Fe+O, N) are the alloys developed during those activities and have two major features, low manufacturing cost and high-performance, as introduced at the last ITA conference in Monterey. In this presentation, some other alloys newly developed by NSC with specially aiming at automotive applications are introduced.

Super-TIX®523AFM is a high-strength alloy which contains the third alloying element in addition to Al and Fe. Tensile strength level is 1050MPa with more than 15% elongation in an annealed condition and much higher strength can be easily achieved with solution treatment and aging. The alloy is expected to be applied to intake valves, connecting rods, etc.

NSC has also developed an alloy for muffler applications. The alloy has twice higher 0.2%proof strength than conventional Gr.2 at 700°C with keeping excellent cold formability of CP. Other developments regarding automotive parts made of titanium will also briefly shown.

#### **Kurt Faller, President - Timet Automotive**

*Ferrari Chooses TIMETAL LCB™ Suspension Springs -The First Production Car to Ride on All Titanium Springs*

*Abstract:* The Ferrari Challenge Stradale, introduced this year in the U.S., is the first automobile sold in America to employ titanium suspension springs, and the first production car anywhere to use titanium springs throughout. The titanium springs are part of a design strategy to minimize weight and maximize performance by focusing on lightweight materials and advanced fabrication technologies. The Challenge Stradale is a street legal car with serious racetrack intentions. Rigorous testing and development were required to assure suitability for extreme conditions. The springs are produced by CIMA, Sp.A., San Salvo, Italy, from elastically wound coils of TIMETAL LCB™ supplied by TiMET Automotive®, Morgantown, PA.

#### **Takashi Yashiki, Eng. Manager R&D, Market Development - Kobe Steel, Ltd.**

*New High Performance Titanium For Exhaust Systems*

*Abstract:* Motorcycle mufflers are usually made with unalloyed titanium because of light weight and excellent corrosion resistance. However the high temperature strength of unalloyed titanium is not sufficient for parts exposed to high temperature exhaust gas. Though the high temperature strengths of Ti-6Al-4V and Ti-3Al-2.5V are higher than that of unalloyed titanium, its cold workability is disadvantageous for mass production of exhaust systems.

For these reasons a new heat resistant titanium alloy for exhaust systems, Ti-1.5%Al, was developed. This alloy was designed to have both good cold workability, that was the same as grade 2, and good heat resistance. For compatibility of cold workability and heat resistance, the impurities of this alloy were restrained to the level of grade 1, and a small amount of aluminum, which is not harmful to cold workability, was added.

The yield strength of Ti-1.5%Al at room temperature was about 300MPa which was the same as grade 2, but the yield strength at 200 – 500°C was twice or three times that of grade 2. This alloy has good cold workability and good oxidation resistance, too. In this presentation, the research results to obtain more resistance to high temperature oxidation than that of Ti-1.5Al will be introduced.