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TITANIUM USA 2013



**October 6-9 • Caesar's Palace
Las Vegas, Nevada**

[Abkowitz, Stanley \(October 2013\)'CREATING VALUE FOR MEDICAL PRODUCTS THROUGH TITANIUM POWDER METAL TECHNOLOGY' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 1](#)

Titanium and its alloys are the material of choice for medical devices due to their inherent properties such as strength, lightweight, durability, biocompatibility and osseointegration. Powder metal manufacturing technology provides a new opportunity to custom engineer novel titanium compositions and structures with new and useful combinations of properties, not producible by traditional melt processing. This approach provides the opportunity for new materials-based solutions to the medical device designer to overcome the limitations of current material options in the design and manufacture of higher performing medical device products

[Abkowitz, Susan M. \(October 2013\)'TITANIUM COMPONENTS FOR AIRCRAFT, MEDICAL AND INDUSTRIAL APPLICATIONS BY POWDER METAL MANUFACTURE' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 6](#)

Authors: S.M. Abkowitz, S. Abkowitz, D. H. Main, H. Fisher

Dynamet Technology, Inc., Burlington, MA 01803

Powder metal (PM) titanium technology offers a viable processing alternative to conventional manufacture of titanium parts from titanium mill products. There has been significant recent increased global interest in advanced technologies such as additive manufacturing and new methods of producing titanium powder that have many hurdles to overcome. Dynamet's mature processing approach for manufacture of high quality near-net shape titanium products is increasingly being qualified for use in demanding applications including aerospace.

The compatibility of titanium with graphite fibers in advanced composite aircraft structures has resulted in the increased use of titanium in aircraft. Titanium is strategically replacing aluminum in aircraft structures because aluminum corrodes in contact with graphite in the presence of moisture. The near net shape capability of powder metal (PM) titanium alloy preform shapes and reduced machining required offers users a significant cost advantage. This need along with the maturity of the powder metal sinter and sinter + hot isostatic press (HIP) processes has prompted Boeing to qualify Dynamet's PM Ti-6Al-4V alloy for commercial aircraft applications. This presentation will provide an overview of the qualification process for PM Ti-6Al-4V, and the properties that can be achieved with As-sintered and with Sintered + HIPed PM Ti-6Al-4V produced by an elemental blend approach. The shape making capability of the PM titanium process will also be illustrated. Additionally a new ASTM specification for PM titanium alloys, including but not limited to Ti-6Al-4V alloy, has just recently issued. It is anticipated that this will facilitate the adoption of PM titanium produced, by this manufacturing method and other powder consolidation methods, for application for military, medical and industrial components and general use applications.

In addition to the manufacture of conventional titanium alloy compositions, powder metal manufacturing is an enabling technology for developing and producing novel titanium alloy compositions and metal matrix composites. Examples of these non-conventional compositions, resulting material properties and current and future product applications for industrial and medical applications will be presented.

[Baeszler, Ken \(October 2013\)'RE-EVALUATING THE EDM PROCESS FOR TITANIUM MACHINING' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 16](#)

Until recently, many manufacturers of titanium components have considered Electrical Discharge Machining (EDM), either completely off limits, or to be used as a primary process coupled with a secondary operation. Many times, the secondary operation is solely in place to remove the parent material damage caused by the thermal process of EDM. Recent improvements in electronics have led to the development of new clean EDM generators that substantially reduce the heat affected zone and micro-cracking caused by the thermal removal of material. In addition to research completed at AgieCharmilles, independent studies are cited from the University of Birmingham that provides evidence supporting the re-evaluation of the EDM process, including:

- Improved EDM technology processes

- A review of EDM surface integrity results showing reduced heat affected zone and near zero recast layer and residual stresses.
- Fatigue resistance tests comparing the EDM process with the milling process.
- Alternative wire electrode materials (coated, pure steel) showing improvements in cutting speed and elimination of Zn and Cu contamination.
- Ability to control the thickness of the oxide layer through manipulation of the generator spark characteristics.

Today's clean EDM technology opens up new avenues of manufacturing for many titanium applications. Intricate parts can now be designed with the EDM process in mind, thus reducing tooling and material cost, improve deliveries and eliminate secondary operations.

[Barnes, John \(October 2013\)'WHAT'S UP DOWN UNDER? – ADVANCES IN TITANIUM PRODUCTION AND PROCESSING IN AUSTRALIA' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 31](#)

Authors: Barnes, J.E.1, Doblin, C1, Duxson, P2, Lathabai, S1, Nguyen, V1, Henry, W1, Gulizia, S1, Jahedi, M1, Helvey A3, & Coleman, G3

1. Commonwealth Scientific Industrial Research Organization, CSIRO, Clayton, Vic
2. Coogee Titanium
3. The Boeing Company

The Commonwealth Science Industry Research Organization (CSIRO) is Australia's national science agency, has an integrated supply chain oriented development program specifically focused on titanium. Originally built off platforms for novel titanium metal production, the program has grown to include processing and manufacturing techniques including additive manufacturing and machining technologies. CSIRO leveraged off of Australia's mineral wealth of titanium bearing ore years ago and is this investment is beginning to pay off. Soon Australia will join the exclusive club of titanium metal producers and has become an integral part of metallic additive manufacturing. To that end, CSIRO has been deploying scientists in concert with industry partners, to develop a means to enhance these technologies. This presentation will focus on advances and unique capability that CSIRO has developed around metal production and its current state as well as unique capabilities in additive manufacturing powder and machining.

[Barrett, James \(October 2013\)'APPLICATIONS FOR LIGHT WEIGHT MATERIALS IN MODERN MILITARY VEHICLES' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 40](#)

The changing nature of the battlefield has generated a demand for lighter and stronger military equipment. The rapid timing of modern conflicts, for example, requires exceptionally fast deployment of military vehicles and artillery systems, bringing into consideration the load

capabilities of available cargo fleets, fuel consumption, runway length in theater (given load weights), and rapid redeployment of equipment for maintenance and retrofit.

The asymmetric nature of the battlefield further requires quick and agile movement with minimum resource requirements. The terrain in these conflict areas is often unpredictable, and lighter equipment is ideal to reposition or withdraw in unimproved areas. Also, refueling stations and other resupply points are dependent on the security situation and are often managed by extra-military sources, making their availability unpredictable.

[Bolderson, Robert \(October 2013\)'TITANIUM VESSEL DEVELOPMENT SOLUTIONS TO MANUFACTURING CAPABILITIES AND MARKET APPLICATIONS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 49](#)

This presentation will cover the following:

- Recent Advances in Ti Joining Technologies
- Titanium alloys most suited for ship production
- Obstructions to Commercial Development
- Offshore Patrol Vessel (OPV) - Market Potential
- Light Modern Metals Manufacturing Institute (LM3I) as a Market Driver
 - o DoD Grant - \$70 million + industry matching funds
 - o Ti vessel a potential consideration
- Industry Support Initiatives

[Byrne, John P. \(October 2013\)'INTERNATIONAL TITANIUM ASSOCIATION' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 68](#)

John Byrne serves as Vice President of Aircraft Materials and Structures for Boeing Commercial Airplanes' Supplier Management. Byrne is responsible for the purchase of raw materials, standards, fabricated parts, assemblies and major structures for all commercial airplane programs.

John also serves the key role of linking Supplier Management with the Fabrication Division. Additional responsibilities include managing Ural Boeing Manufacturing, a Boeing joint venture, located in Russia, focused on titanium machining.

John joined Boeing in 1987 as a quality engineer at the company's Fabrication Division in Auburn, Wash., following five years of work with the United States Department of the Navy. He held a variety of quality, manufacturing and leadership assignments across the Fabrication

Division. In 2001, John was named the director of the Machine Parts Manufacturing Business unit, which produced complex machined parts and assemblies for Boeing single- and twin-aisle commercial airplanes. John's next assignment was the Director of Business Operations and Supply Chain Management for the Fabrication Division.

John transitioned from operations to Supplier Management in the spring of 2003. His first assignment was leader of raw materials and purchased outside production; two years later standards were added to his responsibilities. He was named to his current position in June of 2011.

[Cain, Kevin J. \(October 2013\)'INDUSTRIAL MARKETS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 77](#)

The Power Generation, Oil & Gas, Desalination and Chemical Process markets continue to be the lifeblood of the industrial titanium industry. The opportunities which exist in these industries as well as other markets, such as mining and fertilizer production will be presented. The influences on all of these markets are varied from regional economic growth to the production of shale gas. The influences and resulting opportunities that exist today will be the basis for the Global Industrial Market analysis.

[Canario, Michael J. \(October 2013\)'ADVANCED COMPOSITES – COMPETITOR OF TITANIUM?' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 93](#)

Following the precedent set with military aircraft, advanced composites have emerged as the materials of choice for primary structure of the latest generation of large commercial aircraft. Will this trend continue? What impact will there be on the demand for titanium if the usage of advanced composite materials grows? This presentation will study the history of advanced composites adoption in aircraft design. Included will be a quick review of the strengths and weaknesses of advanced composites and the resultant benefits and costs. Some current examples of the trades between aluminum, advanced composites and titanium will be explored.

[Cao, Helen \(October 2013\)'TRENDS OF TITANIUM INDUSTRY AND MARKET IN CHINA' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 102](#)

Abstract Unavailable

[Cohen, Robert \(October 2013\)'EMERGING MANUFACTURING PROCESS TECHNOLOGIES FOR TITANIUM AEROSPACE PARTS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 116](#)

In this presentation, Mr. Cohen discusses the technologies by which TECT machines components for aerospace applications and the advanced technologies under development. The most significant change in engines from the perspective of process technology is the transition to

composite fan blades in engines. The trend of using composites in the engines of double-aisle airplanes has now moved to using more composites in the engines of single-aisle airplanes.

For TECT, this means the engine fan blades are changing from solid titanium to resin-based or metal matrix composite fan blades with titanium leading edges. Therefore, TECT is now focused on the technology for manufacturing titanium leading edges.

When composite technology was first introduced, titanium suppliers were concerned that less titanium would be required on engines. However, this has not been the case. With more complexity driven by the change to composite technology, the amount required versus complete blades turned out to be more than originally expected. In addition, as more metallic parts on the platform are replaced by composites, titanium is needed to serve as a bonding agent.

The input weights are different, but engines still use a fair amount of titanium, he says. And with all the new composite applications on the airframe, the amount of titanium used is pretty astronomical.

[Daigle, Robert J. \(October 2013\)'MOUNTING PRICE PRESSURE ON THE MEDICAL DEVICE INDUSTRY' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 141](#)

Medical device manufacturers are reporting mounting pressure to lower prices as its stakeholders in the Health Care industry attempt to lower their costs. According to a survey conducted by a hospital group purchasing organization, hospitals are losing money on high-cost medical devices. The Health Care industry has indicated a growing interest in purchasing lower-cost alternative products. Stakeholders are communicating their plans to seek less expensive alternatives to brand-name medical devices that could provide similar clinical outcomes, potentially squeezing profits from manufacturers and the supply chain.

[Dalton, Hunter R. \(October 2013\)'TITANIUM DEMAND AND TRENDS IN THE JET ENGINE MARKET' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 147](#)

Titanium is used in jet engines for its excellent mechanical properties, ease of fabrication, and light weight. The next generation of engines will continue to use titanium extensively even as engine temperatures are increasing in the effort to drive efficiencies higher. This presentation discusses the current market drivers and forecast for jet engine deliveries, the demand for titanium used in the production of jet engine components, and the effect of changes in jet engine design on future titanium demand.

[Dave, Deepan M. \(October 2013\)'INDIAN MARKETS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 154](#)

Indian Rare Earths Limited (IREL) is a Central Public Sector Undertaking under the administrative control of the Department of Atomic Energy, Government of India. The Company is engaged in the mining of beach sands through its three Plants namely Chavara, Manavalakurichi and Orissa Sands Complex (OSCOM) located in the coastal areas of

Kerala, Tamil Nadu and Orissa respectively for the separation and marketing of about 510 thousand tonnes of Ilmenite per annum and associated heavy minerals like rutile, zircon, monazite, sillimanite and garnet. IREL also has a Rare Earths Plant at Kerala (Alwaye) for processing monazite for the production of rare earths chloride, trisodium phosphate and thorium oxalate as well as a Thorium Plant at OSCOM for the production of mantle grade thorium nitrate.

Since incorporation of the Company at Mumbai in 1950, IREL has grown steadily during the past 62 years and has reached at a sales turnover of about Rs.6224 million with export component of Rs.2008 million. The Company has been generating profits continuously during the last 12 years and paying dividend. IREL also has been a significant earner of valuable foreign exchange for the nation and has been exporting its products to advanced countries like USA, UK, France, Germany, Norway, Japan etc. Over the decades, IREL has built up a corporate image in the world market as a reliable supplier of beach sand minerals and rare earth compounds.

[Dewhurst, Philip \(October 2013\)'GLOBAL SUPPLY OF TITANIUM SPONGE' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 161](#)

Between 2003 and 2012 there were two periods of rapid growth in output of titanium sponge interrupted by a sharp fall in 2009, with the result that in 2012 sponge production reached 236kt, more than three times that in 2003. This was principally a result of massive expansion in industrial quality capacity in China, combined with rising output in Japan and Russia particularly since 2009.

The sharp increase in titanium sponge production between 2010 and 2012 was due to rising demand for both aerospace and industrial applications combined with a fear of a shortage of suitable titanium feedstock, particularly in 2012. As a consequence, sponge consumers built up considerable inventories, and a fall in production is expected in 2013.

In 2013, there are 23 companies worldwide with capacity to produce 333ktpy of titanium sponge: fourteen in China, three in the USA, two in Japan and Russia, and one each in Kazakhstan and Ukraine. Rotor grade capacity, mainly in Japan, Russia, Kazakhstan and the USA, is estimated to be about 130ktpy.

The paper draws together historic titanium sponge output data by country and company showing recent trends in global output, and capacity developments in producing companies. It outlines the factors that have driven the titanium sponge market since the world economic slowdown in late 2008, and looks to future trends. Corporate control of the titanium sponge market is summarized, and the impact of company projects on future supply is analysed in relation to forecast aircraft output to 2018.

[Dreier, Oliver \(October 2013\)'SOURCING OF TITANIUM FOR AIRBUS & THE EADS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 177](#)

With the new aircraft programs ramping up, the titanium needs for the aerospace industry are constantly increasing. This presentation will address opportunities Airbus & the EADS offer as well as challenges Titanium suppliers have to face when delivering into this market.

Sourcing of Titanium has developed over the last years to a strategic activity in the metallic procurement commodity. With the evolution of technology in mind, Airbus and the EADS are constantly looking for improvements to the existing products and applications with the clear objective to continuously deliver value to their customers.

[Duz, Vladimir \(October 2013\)'ADMA PROCESS FOR HYDROGENATED TITANIUM POWDER PRODUCTION' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 189](#)

Authors: Vladimir Duz, Vladimir S. Moxson, Andrei G. Klevtsov, Viktor Sukhoplyuyev

ADMA Products Inc., 1890 Georgetown Road, Hudson, Ohio 44236, USA

The innovative ADMA non-Kroll process for manufacturing the hydrogenated titanium sponge and powder will be presented. ADMA has designed and installed a pilot scale manufacturing unit with annual capacity of 250,000 lbs of titanium hydride (TiH₂) powders. It has been demonstrated that use of hydrogen reduces the powder manufacturing cycle to less than 24 hours. The ability to produce the titanium hydride powders with consistent chemical composition, characteristics and quality will be discussed.

It will be shown that the titanium hydride powders can be used in production of CP Titanium or Titanium Alloy components via the low cost Blended Elemental Powder Metallurgy (BEPM) approach. The atomic hydrogen reduces the impurities content in Titanium P/M products to AMS specification requirements and, subsequently, hydrogen is completely removed during sintering operation.

The ADMA patented processes (ADMATALM) provide the best combination of mechanical properties, and the microstructures of titanium alloys are free of the defects, typically attributed to high interstitial content observed in titanium alloys produced from conventional magnesium reduced or sodium reduced titanium sponge fines. Extensive tests have been consistently demonstrating the properties that meet and surpass those obtained via conventional ingot metallurgy processes.

[Erdel, Berthold P. \(October 2013\)'THE M3 SMART SYSTEM ' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 197](#)

The attributes of Light, Small, Simple, Fast, Strong and Smart permeate practically all of Manufacturing- for Process and Product alike. Aerospace and Defense seek to build for optimum weight and speed characteristics and reduced fuel consumption. Aircraft designs are for economic, efficient, safe and environmental-friendly flying. At the core of it all are Advanced Performance Materials, of which Titanium is a big part.

A lot of attention has been given to its exploration and conversion from mineral to metal as well as its productive and cost-effective machining.

The ever increasing demand for titanium, its supply shortages and high market prices and apparent shrinkages within its cycle of usage have manufacturing companies look for managing this material with a defined, reliable, beneficial and smart process.

The new, innovative Metalinx Material Management System is the game changer the industry has been looking for. Known as the M3S, it embraces all facets of pre-processing, processing and post-processing of scrapped parts, chips and swarf. The M3S secures precise collection, accurate monitoring, timely disposition and smart asset management within the recycling process.

This self-contained, autonomous system ensures complete visibility, maximizes recycled value, guarantees best market price at any time and accommodates the mandates of Green and Blue-Manufacturing.

[Forsythe, Bradley J. \(October 2013\)'THE EVOLVING SUPPLY CHAIN IN AEROSPACE RAW MATERIALS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 200](#)

This presentation will review the internal and external factors that over the last two decades have influenced the aerospace raw material supply chain. It will also discuss some of the various methods and techniques that have attempted to align supply chains and balance supply and demand over this period. Characteristics of our industry will be considered that have impacted how the supply chain has evolved. Current product life cycles and how new types of materials as well as new process technologies are continuing to evolve the supply chain in aerospace raw materials today.

[Froes, F.H \(October 2013\)'COST EFFECTIVE DEVELOPMENTS FOR FABRICATION OF TITANIUM COMPONENTS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 207](#)

The major reason that there is not more wide-spread use of titanium and its alloys is the high cost. In this paper developments in one cost effective approach to fabrication of titanium components powder metallurgy is discussed under various aspects of this technology .The aspects to be discussed are the blended elemental approach , prealloyed techniques ,additive layer manufacturing , metal injection molding , spray deposition , far from equilibrium processing (rapid solidification mechanical alloying and vapor deposition) and porous materials . Use of titanium powder for sputtering targets, coating, as a grain refiner in aluminum alloys and fireworks are not addressed.

[Graham,Don \(October 2013\)'MACHINING TECHNIQUES FOR DIFFICULT TITANIUM ALLOYS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 221](#)

Titanium alloys exist in several allotropic forms: alpha, beta and gamma. The former is relatively easy to machine. Alloys with a combination of alpha and beta phases (Ti 6Al-4V being the most common) are more difficult. Fully beta alloys have become prominent over the last 10 years and are considered quite difficult to machine. Gamma alloys (based on the Ti-Al

intermetallic system) are attractive because of their impressive mechanical properties and because they are non-flammable. These later alloys are very difficult to machine.

The machinability characteristics of the various alloys will be discussed. Included will be a discussion of modern techniques such as the use of high pressure coolant for turning, peel milling, dynamic milling and trochoidal milling. The impact these cutting techniques have on production cost, productivity and surface condition will be covered.

Green, Jeffery A. (October 2013)'STRATEGIC MATERIALS IN THE SEQUESTER ERA ' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA

Jeff Green of J.A. Green & Company will discuss provisions of The National Defense Authorization Act for FY 2014 that are designed to position the Department of Defense as a more assertive force in preserving sources of strategic and critical materials, including titanium. The proposed legislation makes a number of authorizations and reporting requirements with regard to key materials, including \$41 million to stockpile critical materials, a report to investigate the legality of previous national security waivers to the specialty metals clause, and a review of critical materials used in the F-35 joint strike fighter.

[Hickton, Dawne S. \(October 2013\)'COMMERCIAL AEROSTRUCTURE SUPPLY CHAIN' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 233](#)

With order backlog at record levels for commercial aircraft, what are the implications for titanium suppliers, users and overall demand? Is the titanium industry prepared to support projected record production levels? Can the supply chain deliver on anticipated build rates? How might advances in technology, geopolitical crisis, economic and financial events or other factors impact titanium demand? As part of her overall assessment, Ms. Hickton will take her listeners inside the supply chain for an experiential look at how it works and the challenges it faces to capitalize on the unprecedented potential opportunity for titanium in the commercial aerospace marketplace.

[Higuchi, Shinya \(October 2013\)'OVERVIEW OF JAPAN TITANIUM INDUSTRY' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 256](#)

Mr. Higuchi will provide an overview of the current Japan outlook in titanium industry.

[Himstead, Greg \(October 2013\)'A SNAPSHOT OF TODAY'S GLOBAL AEROSPACE DISTRIBUTION CHALLENGES' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 270](#)

The global network of aerospace clusters and the service providers that support the multi-tiered supply chains are facing an increasing array of complex challenges as volumes increase; work packages move; airplane, engine, and systems backlogs mount; supply chains length, and new value stream efficiency initiatives proliferate.

From a leading aerospace distributor's point of view, we will present a snapshot of today's aerospace industry supply chain management initiatives, materials management innovations, lingering commodity risks, regional inventory dynamics, and progression of the distributor's value proposition.

We will also offer some observations comparing today's evolved supply chain with the past and shed some light on the potential development of the vital role that distribution will fulfill in the future.

Ivasishin, O. M. (October 2013)'BLENDED ELEMENTAL Ti-Zr BASED ALLOYS PRODUCED FROM HYDROGENATED POWDERS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA

Authors: O.M. Ivasishin¹, V.S. Moxson², M.M. Humenyak¹, D.G. Savvakina¹, M. V. Matviychuk²

¹ Institute for Metal Physics, Kiev, Ukraine

² ADMA Products, Inc, Hudson, OH, USA

This work was concentrated on manufacturing and evaluation of Ti-Zr and Ti-Zr-Nb alloys produced by blended elemental powder metallurgy (BEPM) using titanium hydride and zirconium hydride powders. Phase transformations upon heating and their influence on densification and homogenization of hydrogenated powder compacts were studied. Role of hydrogen as temporary alloying element in synthesis of the alloys was elucidated. Gases emitted from compacts upon vacuum heating were analyzed in order to determine the potential of hydrogen in purification of powder surfaces and in minimizing the final impurity content. Microstructure and tensile properties of the produced alloys will be discussed.

[Janda, Haden \(October 2013\)'TITANIUM AS A METAL OF CHOICE FOR MEDICAL IMPLANTS: PRESENT AND FUTURE' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 281](#)

Titanium is a highly versatile material with a wide range of applications in almost every field of modern medicine. Due to its biocompatibility, corrosion resistance, and strength-to-weight ratio, titanium has become a material of choice for the orthopaedic device industry. Mr. Janda's presentation will highlight current applications of titanium, which includes devices designed for superior fatigue strength, bone conservation, and osseointegration. He will also discuss future applications and highly complex designs made possible through powder metallurgy and additive manufacturing technologies.

Khanna, Gautam (October 2013)'WHAT DRIVES RELATIVE VALUATION OF STOCKS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA

Abstract Unavailable

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[Kooman,Piet \(October 2013\) 'HIGH STOCK REMOVAL WITH ABRASIVE BELTS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 289](#)

Over the last years, Timesavers supplied and developed machine equipment to grind Titanium sheets and plates. After severe R&D Timesavers introduces a new machine that changes the way metal parts are machined. The machine has been developed in cooperation with the Technical University of Delft, located in the Netherlands.

In engineering this new machine concept, particular attention was paid to its design and ergonomic features. The result is a high-tech machine with intuitive control, easy access to the abrasives, and simple and fast work piece loading/ unloading.

This completely new design of machine has the advantage that it can process larger parts, quicker and more accurately (+/- 0,01 mm), and to a finer finish ($Ra < 0,2 \mu m$), than conventional grinding machines. At its heart is a reciprocating table that runs on precision bearings, as opposed to standard wide belt grinding machines which usually have a conveyor belt or a roller feed table

The Timesavers' reciprocating grinding machines make use of the advances in coated abrasive belt technology. By using an endless belt the Timesavers machine is incredibly easy to retool. Because it is the roller, which remains on the machine, which is dynamically balanced, changing the consumable needs no special training nor does the consumable itself require balancing; with the dynamic forces controlled within the machine not on the consumable, far higher abrasive surface speeds can be employed: more grits per second translates into higher stock removal rates and finer finishes. Changing from a course belt for high stock removal to fine finishing is a matter of moments without having to use any tools.

The machine is fitted with a vacuum table that can hold a range of parts, small or large, thin or thick; it's possible to routinely grind parts as thin as 0.18 mm with a clever adaptor plate. Another feature of the vacuum table is its ability to hold complex flat parts even if they have multiple holes, and still achieve a maximum holding vacuum. The vacuum table is integral to the machine

The powerful software in the human machine interface allows the operator to list parameters within a program. When running in manual mode, the operator has the choice of saving current settings as program steps; a simple to use 'teach-in' function. To optimise machine use further, an operator can dictate grinding belt speeds, table traverse speeds, stock removal per pass or per cycle, the amount of cycles and the grinding belt direction.

An easy access coolant filter with a large recycle pump keeps the machine clean inside; the grinding cabin with a specially designed water curtain ensures all the grinding dust is flushed out preventing interference with the grinding process or disturbance of delicate finishes.

Timesavers has a well-equipped grinding laboratory, in which we can run samples for customers and use it for our own research.

[Kreitman, Kevin L. \(October 2013\)'TITANIUM AND COMBUSTIBLE METAL SAFETY' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 299](#)

Metals in a combustible form including titanium, can present fire and explosion hazards. Improper handling of these materials in fire incidents, place personnel and responders at great risk, these risks however can be minimized through proper pre-planning, engineering, housekeeping, and training.

Preventive actions are important to minimizing potential fire and explosion hazards. Knowledge of the risks associated with the metal and the form it is in along with proper housekeeping will greatly reduce risks and likelihood of an incident.

Should an incident occur however, how the incident is handled is critical to a safe outcome. The proper handling of fires involving titanium and metals in a combustible form does not occur by happenstance. One of the most important items is to ensure that pre-planning with emergency responders on the risks and hazards associated with titanium and other metals in a combustible form has taken place prior to the incident, to ensure proper actions are taken in the handling of the emergency which is critical to a safe outcome.

Developing a close working relationship with the facility and working closely with facility personnel is a must to minimize risks for the facility and emergency responders. Incidents involving a fire at a titanium or other facility involving metals in combustible form may very well present additional risks based on the form of the material involved, such as powders, dusts, molten metal, as well as the potential involvement of chemicals that may be associated with the processing of the metal.

It is essential that facility personnel and emergency responders develop a close working relationship and policies and procedures to ensure the safe handling of incident should they occur. This presentation will provide a general overview of NFPA's Combustible Metal Standard, the importance of housekeeping, and the proper handling of fires involving titanium and metals combustible form.

Lasoff ,Laurence J. (October 2013)'ALPHA BETA PROCESSED 6Al-4V EXTRUSIONS: PROPERTIES AND NEW, NEAR NET, SOLUTIONS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA

Larry Lasoff of the law firm Kelley Drye & Warren will address the government's fiscal situation, with a specific focus on the Budget Control Act and sequestration. Mr. Lasoff's

talk will provide an inside the beltway outlook on the impact of sequestration on government procurement policy and the upstream defense industry supply chain, including the titanium industry.

[Legate ,George \(October 2013\)'ALPHA BETA PROCESSED 6Al-4V EXTRUSIONS: PROPERTIES AND NEW, NEAR NET, SOLUTIONS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 350](#)

The production of Ti 6Al-4V beta processed extrusions have grown in leaps and bounds over the past 10 years as extrusions have They replaced other wrought forms of titanium and aluminum in commercial aircraft and the industry looks for near net materials that are compatible with the construction.

Due to process constraints faced by many extruders almost all titanium shapes are processed in beta range. The resultant beta microstructure while quite acceptable for many structural components has intrinsically poorer fatigue properties as compared to what 6Al-4V will deliver when it has been alpha beta processed. Also 6Al-4V that has been beta processed will also not respond to the STA heat treatment that is used to strengthen the alloy.

Nu-Tech does not face such processing constraints and can extrude 6-4 in the alpha beta range. The author will discuss Nu-Tech Precision Metal's experience alpha beta extruding 6 Al-4V. He will also compare the hot working of 6-4 extrusions to other hot working methods and then present the exceptional longitudinal, transverse, and radial mechanical properties, and the texture found in extruded shapes, bars and hollows.

The development of alpha beta extrusions allows for such advantages as: 6-4 hollows that can be heavily cold worked, large near net alpha beta extrusions that can replace forged block and heavy plate, stronger (STA) 6Al-4V extruded hollows with better fatigue properties, and extruded bar and shapes that can be a cost effective substitute for rolled bars and closed die forgings when there are low volume requirements. The author will also review the current level of acceptance within national standards and industry sectors.

[Lilly,Abby \(October 2013\)'A TIER ONE VIEW ON THE FUTURE OF MATERIALS IN AEROSPACE MANUFACTURING' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 368](#)

Abstract Unavailable

[Löber,Guido \(October 2013\)'FUTURE SECURITY OF SUPPLY FOR](#)

[MASTERALLOYS FROM A EUROPEAN POINT OF VIEW' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 375](#)

This paper will focus on Masteralloys for the production of Titanium Alloys. Following a short introduction of Masteralloys regarding their production, their application and the current supplier base; the paper will discuss factors expected to influence future changes in supply and demand of Masteralloys. Additionally, the presentation will touch on some of the challenges this expected future brings to Masteralloy producers as well as to Titanium smelters – all from a European point of view.

[Mandal,Sudipto \(October 2013\)'GENERATION OF 3D SYNTHETIC MICROSTRUCTURES FOR TWO-PHASE TITANIUM ALLOYS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 386](#)

Co-author: A.D. Rollett

Keywords: Titanium, texture, orientation relationship, misorientation, phase transformation

Titanium alloys are widely used in industries like aerospace, chemical, energy etc. due to their high strength-to-weight ratio and excellent mechanical and corrosion properties. Their mix of hexagonal and bcc phases at room temperature mean that the prediction of their anisotropic mechanical properties is challenging. However, at elevated temperatures these materials are single-phase bcc. During the transformation from BCC to HCP, the parent and product phases are frequently observed to obey Burgers orientation relationship. According to the Burgers OR, the close packed $\{011\}$ plane of the bcc lattice is parallel to the close- packed (0001) plane of the hcp lattice and the $\langle 111 \rangle$ direction in the bcc lattice is parallel to the $\langle 11-20 \rangle$ direction in the hcp lattice.

In the present study, information about grain size, shape, misorientations and orientations for a beta-stabilized Ti alloy are extracted from experimental EBSD data and are used to create 3D microstructures using DREAM3D software. In order to study the texture changes and variants selection during the transformation, hcp grains are inserted into a single crystal of bcc and all the twelve variants are generated by imposing the Burgers OR. Misorientation statistics obtained from the simulation are then compared with experimental data.

This work is being supported by the Boeing Company. Interactions with Prof D. Banerjee and Prof S. Suwas (IISC) are gratefully acknowledged.

[Marks,Harold \(October 2013\)'PEELING EVOLUTION IN SPECIAL ALLOYS – HOW THE PEELING PROCESS EVOLVE IN MODERN LINES MEETING CUSTOMERS](#)

[REQUIREMENTS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 399](#)

PURPOSE: Our paper introduces the advantages of production of peeled bars from hot rolled coils. The new technology of coil to bar peeling allows to optimize the processing in the rolling mill increasing the output producing small diameters bars in coil not in straight length. The proposed technology will also reduce the peeling processing cost due to several advantages like the minimization of the removed material and the handling procedures.

METHODOLOGY: The peeling process from coil needs special solutions mainly on wire preparation. Straight the coil in a proper way is a must in order to obtain a good quality on the final product in terms of tolerance and triangularity, to do this two straightening system are installed in line: the wire is pre-straightened by a H/V multi-roll straightener and after the wire pass through a horizontal and vertical cold rolling head able to remove all the memory form from the material compressing it and at the same time improve size tolerance reducing at minimum metal removal.

RESULTS: This process gives important advantages on the peeled bar production:

- Optimization of the hot rolling process with benefits on the rolling mill.
- Reduction of the metal removal on the bar increasing the material yield.
- Increase tool life.
- Complete in-line process without any intermediate storage area.
- Modular process that could be connected with non-destructive tests, chamfering, bundling...
- High output of prime quality material
- Fully automated line and smart lay-out solutions allow a single operator to manage the complete process.

[Matviychuk,Mykhailo \(October 2013\)'HIGHLY ALLOYED TITANIUM ALLOYS PRODUCED BY LOW COST BLENDED ELEMENTAL POWDER METALLURGY APPROACH' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 407](#)

Authors: Mykhailo Matviychuk¹, Orest M. Ivasishin², Dmytro Savvakina², Vladimir A. Duz¹, Vladimir S. Moxson¹

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Highly alloyed Titanium alloys as Ti-1Al-8V-5Fe (Ti-185), Ti-5Al-5Mo-5V-3Cr (Ti-5553), Ti-10V-2Fe-3Cr (Ti-10-2-3), Titanium Aluminides and others processed from ingots require special melting approaches, repeated homogenizing heat treatment and hot working operations to minimize segregations. With low cost Blended Elemental Powder Metallurgy (BEPM) manufacturing approach, the products are inherently homogeneous and do not require any special processing to minimize segregations. This presentation will discuss a unique and low cost ADMATAL™ process for manufacturing the highly alloyed Titanium materials from Hydrogenated Titanium powders. It would be demonstrated that Low-cost Powder Metallurgy (PM) process can be successfully used for manufacturing the various high-alloy titanium alloys Ti-1Al-8V-5Fe (Ti-185), Ti-5Al-5Mo-5V-3Cr (Ti-5553), Ti-10V-2Fe-3Cr (Ti-10-2-3). It would be shown that the microstructures and phase composition of these alloys can be widely modified using the different sintering cycles and heat treatments. This allows improving the combination of their mechanical properties that are meeting or exceeding the properties of the identical alloys produced by traditional ingot metallurgy processes.

[McCoy,David \(October 2013\)'TZMI FEEDSTOCK PRESSURE ON THE TITANIUM SPONGE MARKET' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 416](#)

Titanium minerals have seen an unprecedented surge in cost for sponge producers of the last two years. First it was rutile, which jumped 340% in price of a weighted average traded basis (higher in the spot market) between 2010 and 2012. More recently, the price for other high-titanium content feedstocks used to make sponge have become more expensive as legacy contracts progressively expired. The changes in manufacturing costs to produce sponge have change so much in recent years that sponge companies started to explore alternative feedstock sources and mixes, while at the same time trying to ensure no net impact on sponge quality.

Titanium sponge producers are expected to account for around 6% of 2013 mined feedstock units. No longer is rutile, nature's highest quality TiO₂ mineral, an insignificant cost when making a tonne of sponge. So does this mean that producers of sponge will need to look at lower quality titanium feedstocks? Does the importance of scrap rise in the value chain?

The solution may be a mixture of new and old suppliers, with some rebalancing between the sources of minerals and alternative titanium units.

There has also been rationalisation in the suppliers for high-titanium content feedstocks in recent years. Two of the world's largest TiO₂ pigment producers have back-integrated into the titanium feedstock market. These producers are expected to progressively

demand more of their own high-grade minerals be internally consumed in the chloride process to manufacture TiO₂ pigment, leaving less for the external sponge market.

All of this is driving up the cost of sponge manufacture. One Japanese producer has publicly postulated that relocation of operations to other lower-cost countries may be considered. The use of scrap in melted products has increased as the cost-gap between sponge and scrap widened.

In China there has been a rapid expansion of titanium slag production capacity, primarily using small, batch process technology which currently operates at very low efficiency. Similar technology is being rolled out in Vietnam and India, as governments require value-add processes to be employed rather than basic raw mineral exploitation. There are approved projects in Vietnam to expand further into the sponge sector, while in India a small scale commercial plant was commissioned in 2012.

In this paper, TZMI will present a holistic review and independent forecast of the global titanium mineral market, focusing on its impact on titanium sponge producers. TZMI will also place the titanium mineral demand for sponge manufacture in context with the growing global supply base for titanium sponge and its demand for use in melted products.

About TZMI: TZ Minerals International Pty Ltd (TZMI) is an independent specialist consulting and publishing company, established in 1994, with offices in Australia, USA, China and South Africa. The TZMI team has decades of cumulative production and consulting experience across the titanium value chain, from resource estimation to divestment, and the depth of skills enables advice to be provided ranging from high-level strategic M&A decision support to operationally-focused plant optimisation. TZMI's Publications and Data Services support its consulting activities.

McGee, Mike (October 2013) 'GETTING THE MOST OUT OF YOUR CAPITAL INVESTMENT WITH OPERATIONAL READINESS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA

Thousands of activities must be accomplished to produce the deliverables required for a successful plant start-up. How can owners gain greater control and certainty to meet the business goals of their new production program?

The speaker introduces an operational readiness plan to manage the integration of all the pieces including capacity planning, commissioning, start-up activities, ramp up, risk mitigation, and return on investment for full production capacity. Once the new capacity is accomplished, the speaker outlines asset productivity methods to sustain this in the long term.

Combining these two strategies reduces the risk of underachieving assets at start up and over the long haul. Participants will understand how to:

- Maximize the rate of return from the capital investment
- Optimize the trade-offs between initial capital investment and operations reliability and life cycle costs
- Limit financial risks
- Establish a superior workforce
- Implement best practices for plant operations, maintenance and logistics.

[Mertens ,Tobias \(October 2013\)'INVESTIGATION OF SELF-ORGANIZED TiO₂ LAYER AS PRE-TREATMENT FOR STRUCTURAL BONDING OF TITANIUM' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 425](#)

In the aerospace industry new design concepts offering weight savings are high in demand. In the recent generation of aircraft (e. g. Airbus 350 XWB, Boeing 787), composite materials have shown new perspectives in terms of structural efficiency and performance. Due to the increasing amount of composite materials used in the aircraft structure, new corrosion concepts have to be developed. In order to avoid galvanic corrosion, more titanium has to be used in aerospace (14 wt.-% in Airbus 350 XWB). To increase the efficiency and performance of the aircraft the connection between composite materials and titanium should be realized by adhesive bonding. However, it is well-known in aerospace industry that titanium materials exhibit critical issues in regard to long-term stable adhesion. Reflecting this, the surface treatment is the most important step to ensure durable bonds.

Within this work, a TiO₂-nanotube layer is formed by anodisation. This anodisation process is used as a pre-treatment for structural bonding of the titanium alloy Ti6Al4V. For reference, an alkaline etching process (Turco 5578) and a second anodising procedure in an alkaline anodising electrolyte (NaTESi process) are employed to evaluate the TiO₂-nanotube structure.

Using the TiO₂-nanotube process, the surface area could be enlarged by a factor of 20, compared to the initial surface after alkaline etching. The mechanical tests (floating roller peel test, wedge test) show that the area enlargement due to the anodising processes enhances the bonding durability in hot/wet conditions. The results obtained, confirm the correlation between the morphology and the bond strength. The improved adhesion properties after the anodising pre-treatments can be related to the contributions from the mechanical interlocking of the adhesive in porous oxide layers and the chemical and physical interactions between the hydroxylated surface and the epoxy film adhesive.

Using the TiO₂-nanotube anodising at 5 V and 15 V, respectively, a high resistance against crack growth can be achieved. In comparison to the other treatments (NaTESi

process, alkaline etching) the TiO₂-nanotube anodising leads to the lowest crack growth under hydrothermal conditions. The investigations show that in principle the TiO₂-nanotubes can be used to achieve a long-term stable adhesion on Ti6Al4V even at combined mechanical and hydrothermal loads.

[Metz, Michael G. \(October 2013\)'OVERVIEW OF RUSSIAN MARKET FOR TITANIUM MILL PRODUCTS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 442](#)

Demand for titanium in the Russian Federation is growing significantly, with overall demand expected to double between 2010 and 2017. Aircraft industry demand is the primary driver for growth, along with solid demand from power generation, shipbuilding, and general industrial uses for titanium.

[Michaels, Kevin \(October 2013\)'2013 AEROSPACE TRENDS IMPLICATIONS FOR TITANIUM' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 448](#)

Dr. Kevin Michaels has more than 25 years of aviation experience, including hundreds of consulting engagements for leading aviation and aerospace companies worldwide. Dr. Michaels is a globally recognized expert in the aerospace manufacturing and maintenance, repair, and overhaul (MRO) sectors and has significant expertise in business-to-business marketing, customer satisfaction, and strategic planning. His experience spans all major market segments, including air transport, business and general aviation, and military. He was a founder of AeroStrategy, director of Strategic Development with Rockwell Collins Government Systems, and principal with The Canaan Group. He began his career as a project engineer with Williams International, a gas turbine original equipment manufacturer.

[Mitchell, Gene \(October 2013\)'TITANIUM IN SHIPBUILDING' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 464](#)

Titanium and its alloys offer many benefits for naval ship applications due to their well known properties including high corrosion and erosion resistance, high strength to weight ratio and in the case of one particular TIMET alloy, very high fracture toughness and stress corrosion resistance of base materials and welds. However excessively high initial cost, including welding fabrication cost, continues to present a strong impediment to wider scale usage of titanium for achieving improved system performance and life cycle cost savings. Mr Mitchell will present a brief overview of the following aspects of titanium usage in naval ship applications:

- Examples of current applications of CP and alloy titanium

- A development program for replacing a nickel based alloy with titanium alloys
- Cost, service and fabrication related factors impeding the wider use of titanium.
- An example, involving titanium, illustrating the need for better overarching coordination of research and development work so as to significantly improve computational methods for engineering characterization of material performance.

[Okamoto,Akio \(October 2013\)'KOBE STEEL SUPPLIES HIGH HEAT TRANSFER TI SHEET FOR USE IN OTEC DEMONSTRATION PROJECT' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 475](#)

Kobe Steel, Ltd. has supplied a high heat transfer titanium sheet called HEET™ for use in the heat exchangers of an ocean thermal energy conversion (OTEC) power system in a demonstration project in

Kumejima, Okinawa Prefecture. It is the first time that HEET™ has been applied in an OTEC power system.

OTEC power generation utilizes the temperature difference between deep seawater and surface water. Warm surface seawater is pumped through a heat exchanger where a low-boiling-point fluid, such as ammonia, is vaporized. The resulting steam drives a turbine to generate electricity. Cold deep seawater goes through a second heat exchanger to condense the vapor back to liquid. The high heat transfer titanium sheet enhances the heat transfer performance by more than 20 percent. This HEET™ application is hoped to make large advances in lowering the power generation cost to verify the practical use of OTEC power generation, which is attracting attention as a renewable source.

[Paramore,James \(October 2013\)'PRODUCTION OF TITANIUM ALLOYS WITH EXCEPTIONAL MECHANICAL PROPERTIES BY HYDROGEN SINTERING AND PHASE TRANSFORMATION \(HSPT\)' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 485](#)

Authors: James Paramore, Pei Sun, Z. Zak Fang, Mark Koopman, University of Utah

Keywords: hydride, hydrogen, low-cost, metallurgy, PM, powder, sintering, titanium

Hydrogen sintering and phase transformation (HSPT) is a new, low-cost, powder metallurgical process to produce titanium alloys with mechanicals properties that exceed ASTM standards for wrought titanium alloys. Powder metallurgy (PM) has long been sought after as a means to reduce the cost of titanium products, as the majority of cost

associated with titanium stems from the complicated and energy intensive wrought processing methods that are currently employed in industry. However, PM has fallen short as a viable means to produce titanium for critical applications due to poor densification and the undesirable microstructures that result from traditional PM processes. HSPT has several unique characteristics that set it apart from other PM processes. During HSPT, compacts of TiH_x powder are sintered under dynamically controlled partial pressures of H₂ and subsequently dehydrogenated. The presence of comparatively weak Ti-H bonds during sintering increases diffusion rates and, therefore, significantly increases densification kinetics. This means full densification is achieved at lower temperatures and shorter times than those required for traditional titanium sintering. Additionally, the Ti-H system undergoes a eutectoid transformation during cooling. The decomposition of primary β grains during the eutectoid reaction results in significant microstructural refinement. This phenomenon gives HSPT unprecedented control over the microstructure and mechanical properties of the alloy. Therefore, by controlling the partial pressure of H₂ throughout the thermal cycle, fully dense titanium alloys with engineered microstructures may be produced in the as-sintered state without the need for post-processing. Because of this, HSPT shows great promise as a low-cost alternative to wrought processing for the production of titanium alloys with application-tailored mechanical properties.

Pastushan, Nicholas (October 2013)'AIRCRAFT SUPPLY & DEMAND + FINANCING MARKET' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA

An overview of aircraft finance markets and an assessment of commercial aircraft supply and demand.

Patera, Stephen M. (October 2013)'USE OF TITANIUM IN OIL REFINERIES' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA

This presentation will concentrate on the utilization of titanium products in refineries and why it is suited for this application. Titanium's use in refineries goes back decades, and has increased ever since. With the introduction of lower grade crudes and the corrosive nature of the subject environment, titanium is an ideal choice and lends itself to these applications.

We will examine the advantages of titanium in coking units, distillation columns and condensers.

[Plester, Dennis \(October 2013\)'TITANIUM FEEDSTOCK OUTLOOK – AN INTEGRATED PRODUCER AND CONSUMER'S VIEW' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 496](#)

The merging of Exxaro's mineral sands assets in South Africa, the Tiwest Joint Venture minerals sands/titanium dioxide operations in Western Australia and Tronox's titanium dioxide pigment production facilities in the United States and Europe has seen Tronox become a significant, fully integrated titanium dioxide company with direct control over its entire supply chain from pit to pigment.

As a large producer and consumer, Tronox is active on both sides of the supply and demand environment for titanium feedstock. In this paper, Tronox will present commentary on the outlook for titanium feedstock supply based on its involvement in mineral sands production, and on feedstock demand both as a titanium dioxide pigment producer and a continuing participant in the marketing of feedstock into pigment and non-pigment applications externally. The latter includes welding consumables and titanium sponge markets.

[Qin, Guihong \(October 2013\)'RESEARCH OF HOT TANDEM ROLLING PROCESS OF TC6 TITANIUM ALLOY BARS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 505](#)

The test on effect of three kinds of tandem rolling process on microstructure and property of TC6 titanium alloy bars was conducted in this paper. The result shows that the microstructure and property of the bars produced by process one are able to meet the requirement of the specification, but the microstructure is not uniform, the content of primary α phase in the center of the bars is much more than that of the edge. The bars which was produced by process two room temperature and elevated temperature tensile-strength can not meet the requirement of the specification. After analysing the reasons of the failure of the above two kinds of processes. However, Both of the microstructure and the mechanical property of the bars produced by process three are able to meet the requirement of the specification produced by process three.

Rao, M. Narayana (October 2013)'EFFECT OF ALLOY CHEMISTRY, PROCESSING AND MICROSTRUCTURE ON STA PROPERTIES OF TITANIUM ALLOY Ti-6Al-4V' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA N/A

Ti-6Al-4V is the most widespread titanium alloy and comprises 60 percent of the total titanium production. Titanium alloys microstructure is the most widely varied and results in the widest range of properties. Ti-6Al-4V is used in numerous applications in annealed condition with tensile strength of about 900MPa. STA condition gives rise to most pronounced strength, hence further advantage of specific strength in aerospace applications. The full hardenability of the alloy is limited to about 25mm thickness and achieving STA properties in a component becomes most difficult task. The paper brings out the various experimental and production trials carried out to achieve the full hardenability in the alloy component. It is observed that not only the quench delay, finer

control of iron, oxygen and martensitic lath size contribute to the enhanced mechanical properties of the alloy.

[Rau, Hansjörg \(October 2013\)'ELECTRON BEAM COLD HEARTH REMELTING OF TITANIUM AND TITANIUM ALLOYS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 519](#)

Authors: Hansjörg Rau, Jürgen Kiese, Jury Kazakov, Klaus-Peter Wagner

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Hearth melting of titanium and its alloys become more and more important. The original reason was to eliminate any inclusions from titanium alloys particularly used in critical rotating parts. Nowadays, environmental and economic aspects are becoming increasingly important. As the main reason may be mentioned here, protecting the world's resources by using the high volume of the existing titanium scrap.

Electron Beam Cold Hearth Remelting of titanium is a well-established melting technique at Outokumpu VDM. The EB furnace is located at the production site in Essen and its maximum capacity is 5,000 metric tons/year. Typical products are rectangular slabs and round ingots. The products reach lengths up to 5.5 meters weighing up to 16 metric tons. The produced alloys to this date are cp grades 1 and 2 as well as Ti-6Al-4V and its ELI grade. The round ingots especially made of Ti-6Al-4V can be taken for an additional melting in the vacuum arc remelting (VAR) furnace (EB+VAR). At the production site of Outokumpu VDM there are three VARs available.

Since 2008 the total amount of melted Ti-6Al-4V at Outokumpu VDM is more than 700 metric tons and the demand grows rapidly.

The melting of the Ti-6Al-4V alloy in an EB furnace is a challenge. The most important issue is to control the Aluminum content because of its pronounced evaporation during the melting process. It has been shown that it is absolutely necessary to obtain a stable process with a constant melting rate. Only in this case it is possible to realize homogenous products during a melting campaign with several ingots. Examples will be given that a homogeneous distribution of alloying elements is present both on the ingot length, as well as on the cross-section. Likewise it is shown that this is in a good relation with the conventional sampling by drilling. Moreover it is also demonstrated that this is in a good agreement within the semi-finished product.

The results of an experiment with seeded particles of hard metal show impressively that hearth melting is an appropriate measure to eliminate inclusions. It was observed that both a separation and dissolution of the particles took place.

[Rose,David L. \(October 2013\)'CLOSING THE LOOP' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 529](#)

As any market or industry matures, the dynamic of competitions' quest to add differentiable value to their customers becomes harder and harder. Whether it be consolidations on the 'supply' side or the 'buy' side, fluctuations in commodity prices, or other obstacles; the challenges grow every day.

Within the Aero, Energy, and other super alloy revert markets, 'closing the loop,' the process of recovering one's own revert stream at all points of the supply chain, is becoming the new norm. As melters become more and more dependent on revert as a high percentage of their charge volume; finding quality revert of known origin, at competitive prices, has dominated the thinking of the supply chain teams within these organizations. Establishing a revert supply partner with dependable and known sources has become key to their success.

'Closing the loop' is not rocket science, it is just common sense. By recovering more of their own revert stream, they not only create a supply stream, they also better control the quality of the revert they buy and use. A more comprehensive review of this concept will be shared during the PCC Revert Group presentation.

[Schumerth,Dennis \(October 2013\)'HYDROGEN EMBRITTLEMENT IN TITANIUM STEAM SURFACE CONDENSER TUBING TRUTHS, MYTHS & MISNOMERS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 536](#)

[Schutz ,Ronald W. \(October 2013\)'TITANIUM'S COMPETITION WITH CHROME-BEARING ALLOYS' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 547](#)

This presentation offers a cursory overview on traditional and current application arenas where titanium is utilized but competes directly with various chrome-bearing ferrous- and nickel-based alloys. These arenas span aerospace applications such as various gas-turbine engine and air-frame components, and extend to numerous non-aero arenas including chemical/petrochemical processing, pulp/paper bleaching, power generation, oil/gas production, hydrometallurgical ore processing, medical devices/implants, desalination, and naval ship and offshore marine components. The primary attributes and limitations of titanium/titanium alloys and the relevant chrome-bearing alloy competitors are reviewed, along with consideration of performance benefits versus relative cost where possible; providing some basis for identifying unique, sustainable, and promising applications for continued, and growing titanium use.

Seiner, Henry (October 2013)'MILITARY & DEFENSE' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA

The shift from conventional warfare to counter insurgency measures combined with budget pressures is impacting the design of and demand for weapons, aircraft, and ground vehicles. This presentation will address the opportunities and challenges facing the global titanium industry for both military aerospace and ground vehicle applications and will cover how these forces are likely to influence the future of titanium in this sector.

[Seiner, Henry \(October 2013\)'MILITARY AND DEFENSE OPPORTUNITIES AND CHALLENGES' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 557](#)

This presentation will briefly summarize the points made by the other session panelists and attempt to tie together the common threads of the feedstock market, the sponge market, the master alloys market and the scrap market. Included will be commentary regarding possible future developments in each of these markets. There are significant interdependencies between feedstock, sponge, master alloys and scrap. This presentation will focus on these interdependencies in an attempt to provide insight to the audience as to what developments should be monitored in order to best estimate the future of these highly volatile elements of the titanium mill products supply chain.

Building upon this theme, the presentation will also discuss information available related to these materials in the public domain to help monitor market developments. Information regarding our industry is both more and less accessible than it has ever been. With consolidations occurring in recent years, the amount of market information being released into the public domain by titanium producers and consumers is in many cases more limited than it has been in the recent past. However, government statistics and international trade information is more easily accessible than it has ever been. This necessitates that marketers and analysts turn to different sources for their insights than they may have leaned on in the past. This presentation will explore how one may go about approaching this change to market statistics to best stay ahead of the curve.

[Sparkowich, Steven \(October 2013\)'SIGNALS FOR THE FUTURE OF TITANIUM: USE OF PATENT LANDSCAPING TO FORECAST TECHNOLOGY TRENDS ' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 565](#)

As described by the World Intellectual Property Organization (WIPO), patent landscaping reports describe the patent situation for a specific technology in a given country/region or even globally. Subject matter experts conduct state-of-the-art research in the technology focus area and supplement the bibliographic data with characterizations

to highlight specific attributes of the patent claim language. To gain a deeper understanding of the patenting efforts, results are analyzed to identify patenting activity patterns, innovation trends and collaborations.

Patent landscapes can be customized to answer specific questions of importance such as licensing due diligence, business development activities or competitive intelligence monitoring. A visual representation of the trends and relationships facilitates critical discussions between senior management, technicians, scientists and legal counsel.

This presentation will survey the uses of titanium for applications in corrosion, medical/dental, aerospace, electronics and other areas. Data will be presented on patents and published applications by industry sector from the year 2000 to present. This patent landscaping example should serve as an example of how patent landscaping can be strategically used to identify potential growth areas for titanium and its alloys.

[Stansbury, Trevor \(October 2013\)'RE-IMAGINING THE EXTENDED TITANIUM VALUE CHAIN' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 580](#)

Over the last 20 years (partially as a consequence of outsourcing) most Original Equipment Manufacturers (OEMs) have lost visibility into the titanium raw materials that go into their parts and therefore exercised little or no control over where those raw materials are purchased, what is paid for them and how they are supplied. Consequently, titanium demand information flows slowly and sequentially, if at all, to those stake holders that have the greatest need for it - the raw material distributors and mills. Ironically, most OEMs have invested vast resources on leaning-out the value-added component of finished part cost, while ignoring the waste and inefficiency on the raw material side of the total product cost equation. Mr. Stansbury, an expert on extended enterprise collaboration and will share how some of the world's largest OEM's and their sub-tier suppliers are collaborating to address those challenges by leveraging aggregate, consolidated titanium demand to obtain the very best pricing and service levels.

[Toledo, Carlos \(October 2013\)'QUALITY PRODUCTS FOR THE MEDICAL INDUSTRY' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 590](#)

This presentation will address the challenges associated with developing a comprehensive supply chain to meet these requirements. Discussion will include key attributes for suppliers, logistics and the uniqueness of quality system along with deliverables associated with medical products.

[Walker, Scott, Trimmer, Andrew \(October 2013\)'THE BLUE ARC MACHINING](#)

[PROCESS ' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 595](#)

What is Blue Arc™? What are its benefits in a production environment? What are its applications in titanium? Who is developing it? When will it be available to manufacturers? All of these questions and more will be answered -- specifically how the technology relates to titanium aerospace structures, jet engine components, and power generation parts.

Chemical Engineer Mr. Andrew Trimmer, PhD at GE Research will discuss this exciting machining process and Mr. Scott Walker, President of Mitsui Seiki USA will relay valuable information about the machine tool requirement to apply the Blue Arc™ methodology successfully and efficiently.

Blue Arc™ is a High Speed Electro Erosion (HSEE) process that was developed to rough cut high strength aerospace alloys. Fundamentally, BlueArc™ is a controlled thermal removal process driven by an electrical potential between a tool electrode and a workpiece. Thermal events are more intense and widespread than conventional EDM processes and are controlled by the applied potential and current, the electrolyte, and the distance between the tool electrode and workpiece. Each thermal event erodes some of the workpiece resulting in bulk material removal. Under most conditions the contact forces between the electrode and the workpiece surfaces are negligible enabling the use of slender electrodes or light duty machines. End milling, peripheral machining, and shaped electrode profile machining have been studied. In this seminar, machining results will be shared for nickel based superalloy and titanium alloy rough machining. In each case material removal rates 2-3 times the conventional analog for similar size tooling was achieved. BlueArc™ is a versatile rough machining process that can achieve high material removal rates and significant tooling and machine investment cost savings.

[Warner, Michael \(October 2013\)'VIEW OF THE AIRLINE INDUSTRY' Paper Presented on Titanium USA 2013 Conference Proceedings. Titanium USA 2013, Caesars Palace, Las Vegas, Nevada, USA 605](#)

As Director: Market Analysis, Michael Warner leads the team developing Boeings view of the airline industry and trends in the market. In addition, Warner is responsible for Boeings annual publication, the Current Market Outlook (boeing.com/cmo), which describes the long-term demand for air travel and the resulting demand for new aircraft.

Warner joined Boeings marketing department in 1998 and most recently served as Senior Manager. Market Analysis: he was promoted to Director in 2011. Before this, he served in the Product Marketing role, presenting the value of Boeing products and services to airline customers, leasing companies and media. Prior to his roles in marketing, he spent five years in the engineering department supporting the design and certification of new Boeing airplanes including the 777.