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TITANIUM USA 2014

Recent Global events and Catastrophes have created a Paradigm Shift in material Choices for decision makers within the Chemical Process and Oil and Gas Markets. Piping and Equipment manufacturers and large OEM's have been tasked with designing components and systems that increase performance, improve life cycles and reduce risk. Titanium offers all of these with the correct design and application. With that said titanium products are facing increasing competition within this market space from products such as Fiberglas Reinforced Pipe (FRP), Duplex and Super Duplex Stainless Steel materials. Pricing should not be the only evaluation tool used for determining which product is the best material of choice. Safety and Performance characteristics are now at the top of list when it comes to the design criteria that is used within these Industrial Markets. This presentation will provide an overview of these current market conditions and why Titanium can provide solutions to these problems and provide superior performance over the long term.

A novel oral appliance for providing breathing assistance during sleep for the treatment of both snoring and sleep apnea has been developed by CSIRO researchers and Oventus Pty Ltd clinicians. Sleep apnoea occurs when the air passage in the throat becomes blocked during sleep and causes people to stop breathing. People can suffer hundreds of events per night and it is estimated that about 4% of men and 2% of women in the Western world have sleep apnea, but it could be as high as 14% of adults have the disorder. Left untreated, sleep apnoea can have serious and life-shortening consequences: high blood pressure, heart disease, stroke, automobile accidents caused by falling asleep at the wheel, diabetes, depression, and other ailments.

Additive manufacturing was used to enable the device relying on its ability to affordably provide a custom fit with a lightweight, comfortable device. A 3D scanner is used to map a patient's mouth anatomy, and that custom design can be 3D printed in titanium, with a recess for the user's teeth with an opening to allow air from outside to be drawn in. The air passes through an airway on each side, and is directed into a posterior region of the mouth, bypassing issues with tongue and lower jaw position. In more severe cases, the opening to the outside can be connected to a continuous positive airway pressure machine, providing more comfort and increased patient compliance compared to a mask. Researchers moved into industrialisation, writing software that would automatically read a 3D scan result and morph a file in a database to meet the patient requirements.

This paper will share the experience of developing this technology and discuss the advantages/shortcomings of the potential growth in 3D printing in the bio-medical industry.

This presentation will examine the opportunities and challenges surrounding the titanium revert chain. The aerospace inventory overhang continues to wind down at a time where melt rates are increasing, driving a continued focus on "closing the loop". Difficulties continue due to the growing geographical diversity of generation sites, and educating new sources on the importance of segregation and cleanliness. The industry is also experiencing supplier consolidations while scrap pricing is moving towards parity with sponge and alloy. Each of these phenomena will be discussed and the impact on the near-term and long-term future considered.

Undoubtedly, the commercial aerospace industry is facing unprecedented growth and record backlog. This creates both challenges and opportunities for suppliers throughout

the value chain. Titanium can be viewed as a strategic commodity; thus, this industry's health is of particular importance to both engine and airframe OEMs. This presentation will briefly address the various categories within the value chain. It will also explore significant developments over the past 5 years until present. It will discuss varied topics, such as sourcing from Russia, the impact of additive manufacturing, and the effects of vertical integration by the mills.

With the government and industry driven focus on new material systems and additive manufacturing, new processes for material consolidation techniques are constantly being developed. One such system, cold spray, bombards particles onto a substrate and induces bonding through particle deformation derived from the kinetic energy of the impact, all while remaining in the solid state. It has been successfully used in re-manufacturing and surface modifications. However, with the focus on near net shape manufacturing techniques coming to the fore, a shift towards bulk net shape materials created with cold spray has begun. Research presented here used the cold spray technique to consolidate martensitic Ti-6Al-4V powders at the highest kinetic energy levels possible in order to introduce the highest levels of deformation and work in the consolidated material. The resulting samples were tested for tensile strength, macrohardness, and microhardness. Microstructural features were analyzed with secondary electron microscopy and optical microscopy. The relationship between the level of work introduced to the system, microstructure, and mechanical properties will be discussed.

Porous-layer coated titanium medical and dental implants have been the industry standard for several decades. Sintered-on wire or beads, as well as plasma sprayed titanium coatings, have been the most common methods for creating a porous surface structure for effective osseointegration in these devices. Each of these coating methods generates a unique porous structure and efficacious methods have evolved over the years to ensure cleanliness of the final device. The use of several new additive layer manufacturing (ALM) methods to fabricate implant devices with integrated porous surface structures has presented new challenges to achieving the required level of cleanliness in this industry. These new ALM methods, such as electron beam manufacturing (EBM), as applied specifically to titanium devices, create unique and complex porous surface structures that present considerable challenges for appropriate cleaning. These complex structures involve a combination of interconnected and closed cell porosity. Exposure to cutting fluids, cleaning fluids, solvents, blast media, grinding media, passivation solutions and many other chemical agents during processing presents several possible means of

contamination. These potential contaminants tend to become entrapped in unique ways in these complex porous structures and need to be completely removed prior to packaging as finished goods. Images of the complex porous structures will be presented in both spatial and cross-sectional view via optical and scanning electron microscope (SEM) imaging.

Significant volume of titanium is consumed every year as plates, sheets or tubes by the Power Generation, Process and Desalination markets. These volumes have been fluctuating significantly over the recent past, generating lack of visibility and concern for all the players along the supply chain. What are the drivers and trend on market?

Vallourec Heat Exchanger Tubes has collected views and experiences of various suppliers and end users and has built a unique understanding of these complex markets. Albert Bruneau will discuss the key drivers of titanium consumption in the industrial market and provide an estimate of the evolution in the coming years.

The business of supplying world class quality master alloys to the titanium industry is much like world cup soccer, difficult to predict, guaranteed to change, surprise, disappoint, as well as delight. This presentation will touch on various factors which impact the master alloy business from the supply and demand dynamics of raw materials, global sponge production, scrap recycling efficiency all leading to the requirements for master alloy. The precision for planning, production and distribution of master alloys is critical.

Supporting the future requires navigating through all of the hurdles and having the right quantities of raw materials in the pipeline and the physical assets in place to manufacture and deliver customers exact requirements, precisely when needed at world class quality.

Innovative powder metallurgy processes for manufacturing the titanium components for critical applications from hydrogenated titanium powder will be presented. The manufacturing of titanium alloy components by low cost blended elemental approach that includes various room temperature consolidation techniques (die-pressing, direct powder rolling, and cold iso-static pressing) followed by sintering and high temperature post

processing (forging, rolling, extrusion, ring rolling) will be discussed. It will be demonstrated that the low cost ADMA patented powder metallurgy processes (ADMATALTM) provide the best combination of mechanical properties that meet or exceed the properties obtained on the identical titanium alloys by conventional ingot metallurgy processes. Phase and structural transformations occurring upon these innovative processing and resulting microstructures/properties relationships will be also discussed.

Electron beam melting is a perfect tool to prepare high purity metal electrodes for further use in powder production by Electrode inert gas atomization. In ALD's in house furnace electrodes of high purity metals have been prepared and further atomized to powder by the Electrode inert gas atomization technology. The paper will focus on preparation of the material by melting different kind of available input material and give some results of powder properties.

The changing nature of defense threats is driving a transformation in the systems and tools utilized to combat those threats. It is a transformation that is also raising new questions about the role of titanium as a strategic defense material. How is the new defense picture affecting use of titanium in the weapons and support systems of today and in the future? Is sequestration behind us? Should we count parts, not pounds? Mrs. Hickton will discuss these and related issues in the context of current U.S. and European defense budgets and the stresses felt in an era of austerity, juxtaposed against growing Chinese defense spending. She will also highlight how titanium has transformed from a strategic material whose value was measured in pounds, to an innovative material whose uses are far more varied and for which value is measured by its inclusion in sophisticated, advanced technology systems.

Abstract unavailable

Metalvalue is cooperating with a Swedish company Bofors Bruk AB (named as was the Alfred Nobel's company: not surprising for a company located in the same city of Karlskoga) and its daughter company METEC Technologies AB to develop a new technology able to manufacture parts from a few ten grams to a few kilograms: the MMS SCANPAC™ process.

Developing a new technology takes time: from the first idea in 1996 to the last patent registered a few weeks ago (a total of 6 complementary patents), years have been spent in R&D, prototypes, pre-¬□series, end user tests, etc. Now the process is operating and already used to supply alloyed steel, tool steel nickel alloy parts at full density with the same or better properties of forged products.

The same technology is used for titanium. The technology is environmentally friendly, no toxic binder, energy saving, material saving. The driver for its development is simply cost: it allows to make parts cheaper than the conventional route. The fact that they are metallurgically better (because they are made from powder) is just a plus. This cost saving comes from different factors: the powder itself is cheap because, despite the fact that the process can use ultra-¬□high purity atomized powder it allows to get it at low price because it will use the left over from the production of additive manufacturing powder. In addition the manufacturing cost is inexpensive and parts are pressed at high speed. Products can easily be qualified for aerospace usage (due to the manufacturing steps ending with a low cost HIP operation).

All the experience already gained from manufacturing other metal parts, can be transferred to titanium. The SCANPAC- MMS process will contribute to develop volumes in titanium parts for many industrial applications.

The paper looks at the factors involved in the production of rutile, starting with the geology, location, country risk, grade, costs of production, environmental management, through to ability to fund large capital expenditure, jurisdictional challenges, and shareholder return consideration.

Recently, an innovative approach in blended elemental powder metallurgy of titanium and titanium alloys was developed. Its key feature consists in using of titanium hydride powder instead of commonly used titanium metal powder what results in improved balance of mechanical properties due to lower residual porosity, lesser contamination and finer microstructure as compared to conventional titanium powder metallurgy. This paper

is stressed on the results elucidating fundamental advantage of titanium hydride based powder metallurgy which consists in synergetic influence of specific compaction mechanism, activated sintering due to a sequence of phase transformations accompanying dehydrogenation, and reactions of surface located impurities with atomic hydrogen with a formation of volatile products leaving the compact through an open porosity network. Efforts to scale up this approach from laboratory experiments to commercial level capable to solve the cost- performance dilemma of titanium powder metallurgy are demonstrated.

The Kroll technology developed by Defence Metallurgical Research Laboratory (DMRL) is successfully transferred to Kerala Minerals & Metals Limited, Kerala, India for the establishment of the country's first commercial facility for titanium sponge production with a starting capacity of 500 MT per year. The KMML titanium sponge production facility producing titanium sponge regularly in the batch size of 3.5-3.75 MT by the combined process technology demonstrated by DMRL. While several engineering improvements are being brought in during the regular production of titanium sponge at KMML, an elaborate product quality assurance and certification procedure is taken up by DMRL for using the titanium sponge for critical aerospace applications.

As part of the sponge quality assurance programme, large number of samples from randomly chosen production batches have been analyzed through chemical analysis, button melting and hardness testing. Industrial scale melts from selected sponge lots of size 1.75 MT have been made and taken for characterization of down stream processing through forging, hot rolling, extrusion and cold rolling etc. A number of titanium alloys such as Ti6Al4V and half alloy have been melted and processed for the manufacture of several mill products.

Note: Presentation was given by Christopher Jackson, Market Analyst, Retech Systems, LLC on behalf of Dr. Chaganti, Defence Metallurgical Research Laboratory

Since 1950s, China Titanium Industry stimulated the development of China Aerospace and Aviation, shipping chemical industry, etc and formed consummate a scientific research □production system. China Titanium Industry has been an important part of world titanium Industry. Lead by Baoti Group Ltd., Baoji city has formed the titanium industry Cluster in China to spearheads the development of China Titanium Industry towards the world. China government uses it as trigger to build China Titanium valley and aim to make China Titanium valley as the flagship and China's largest research and

production base. And China Titanium valley will invigorate new vitality to the world Titanium Industry.

A commercially pure titanium sheet precipitated TiC in surface the layer was fabricated by anodization in NH4NO3 and heat treatment in air. The fabricated sheet showed relatively high photocatalytic activity in 0.1M KI solution of just below the activity level of the P-25 particle made by Deguza Corporation. It exhibited photocatalytic activity in antifungal and antivirus tests under black light irradiation, and the high photocatalytic activity under black light irradiation is considered to be related formation of anatase type titanium dioxide and increase of surface area. It also showed photocatalytic activity under visual light irradiation, which, is considered to be attributable to the existence of carbon and nitrogen in titanium dioxide.

The Center for Advanced Non-Ferrous Structural Alloys (CANFSA) is a new Industry/University Cooperative Research Center (I/UCRC) focusing on state-of-the-art research related to non□ferrous structural alloys. Established in 2011 by faculty at the Colorado School of Mines and the University of North Texas, this member-driven center combines computational modeling and experimental approaches to advance industrially-relevant projects. The center currently has 12 industrial members who provide funding for 15 separate research projects, of which more than a third are focused on titanium alloys. This presentation will provide a brief overview of CANFSA, and summarize some of the projects of interest to ITA members.

We will describe the key issues that investors are debating on aerospace stocks now. Most of the issues are viewed with a large dose of pessimism, explaining the multiple compression and stock under performance seen in the sector YTD.

ADMA installed the first pilot scale unit for production of hydrogenated titanium powder at our Plant in Twinsburg, Ohio and started manufacturing of this powder in December 2013. The annual capacity of this plant is 250,000 lbs. A design of a full scale capacity unit with 1,5 mln pounds annual capacity had been completed. The innovative ADMA non-Kroll patented process for manufacturing of hydrogenated titanium powder and ability to produce the titanium hydride powders with consistent chemical composition, characteristics and quality that meet requirements for low cost blended elemental powder metallurgy approach will be presented.
The future plans for designing and construction of full scale manufacturing plant with 45 mln lb capacity will be discussed.

Higushi, Shinya (September 2014) 'Overview of Japan Titanium Industry' presented at TITANIUM 2014, Hilton Chicago, Chicago, IL USA 235

Mr. Koike provided an overview of the current Japan outlook in the titanium industry.

Kreitman, Kevin L. (September 2014) 'NFPA 484 Overview' presented at TITANIUM 2014, Hilton Chicago, Chicago, IL USA 253

The 2015 edition of NFPA 484 Standard for Combustible Metal, has been released and supersedes all previous editions. A number of changes are taking place within NFPA dust standards, in part based on comments from the Chemical Safety Board. These include NFPA's creation of a Technical Correlating Committee which now oversees all of NFPA's dust standards and the current development of a new standard covering Combustible Dusts (NFPA 652) which is under development. The 2015 NFPA 484 Standard for Combustible Metals, contains a significant reorganization and new material consolidating and creating new chapters which are applicable to all metals in a combustible form. A number of the items in these new chapters are applicable to new and existing facilities. A review of these changes along with an overview of OSHA's Combustible Dust information and Chemical Safety Board recommendations related to Titanium will be discussed.

Leach, Wade (September 2014) 'Titanium Demand and Trends in the Jet Engine Market' presented at TITANIUM 2014, Hilton Chicago, Chicago, IL USA 267

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 new engine programs 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.

If you handle titanium fines or create titanium fines you will likely have a fire. The regulations for the safe handling and transport are voluminous and contain multiple cross-references. This presentation will attempt to identify simple practical steps that can be taken avoid spectacular videos, injuries to employees and massive damage to equipment and facilities.

Lyssenko, Taras (September 2014) ‘A Unique Perspective of the Aircraft Produced and Used by the Greatest Generation' presented at TITANIUM 2014, Hilton Chicago, Chicago, IL USA

Mr. Taras Lyssenko, the "T" of A. and T. Recovery, has worked locating and recovering the lost Navy airplanes of Lake Michigan for the past 25 years. He has retrieved nearly four dozen aircraft that are now on display in museums across the country. Taras has a unique perspective of the aircraft produced and used by the Greatest Generation to preserve our freedom and of the project to preserve the history for present and future generations. Website: http://www.atrecovery.com/

Everyday demands for improving fuel efficiency, reducing exhaust emissions and improve vehicle performance, force designers to reduce vehicle weight. Exhaust system applications, including mufflers and exhaust pipes are one of the main targets. Since titanium was introduced as an alternative material for exhaust system, Akrapovič Company has been constantly looking for new technologies that help us speed up the production process and reduce the manufacturing costs and is therefore more attractive to original-equipment manufacturers (OEM). Parallel with our standard design process, several new approaches are introduced to additional reduce the exhaust weight. This paper presents our new challenges in the development of the lightweight exhaust system: introducing thin wall structures, designing special elements (flexible joints) made of new titanium alloys and finally joining different materials to optimal withstanding applied loads.

Earlier presentations at this week’s conference have focused on demand trends within specific end-use markets as well as supply trends within specific raw materials or elements of the supply chain. This presentation will attempt to summarize the current

market drivers, headwinds and levers in a qualitative form in order to project a holistic view of the global supply/demand balance into the future.

US 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.

Alcoa has a proud and long history of supplying multi-material solutions to the US defense market. For the past seven years, Alcoa Defense has accelerated that market growth by providing a single, market facing entity to both the US Department of Defense and original equipment manufacturers. This presentation will describe the breadth of Alcoa’s multi-material solutions along with a discussion of Alcoa Defense’s strategy to strike the appropriate balance between performance and affordability given the current budget environment and will contain specific examples of titanium solutions that were able to provide benefit to the warfighter.

CRC will be sharing the results from their most recent quarterly titanium market report. This includes a brief summary of demand trends and the sequential changes to the supply landscape. The information will also include a gauge into the overall health and momentum for key end-markets like commercial aerospace, military & defense, energy, industrial, and medical. Data series presented will likely include: current downstream order growth (also by market), channel expectations for 2014 and 2015, an update on the inventory situation, estimated producer lead times, and a general pricing index. The 3Q results can be compared to a time series of survey results dating back to 2006. We also look at titanium trends in relation to a few other specialty materials.

Lessors are some of the largest buyers of aircraft. How do they view the current state of supply and demand? What is the state of the financing markets for aircraft? Is there

enough money available to pay for the record backlog and delivery rate? Nicholas Pastushan, Chief Investment officer of CIT Transportation Finance, one of the world's largest lessors, will give a buyer's view of aircraft markets and the state of aircraft finance.

China experienced low sponge production for several decades, then there was a boom in the sponge project investment. Will this trend will continue? This presentation will give a brief picture about sponge production in China.

Authors: Peyman Samimi, David Brice, Yue Liu, Peter C Collins
Titanium alloys are generally described as having superior corrosion resistance at room temperature. However, at elevated temperatures, titanium suffers from poor oxidation resistance and consequently, loses its resistance to corrosion. This limits the service temperature of titanium in application to ~550°C. Although the high-temperature oxidation of Ti and Ti alloys has been a subject of several research efforts such studies however are often constrained to the composition of specific alloys and neither the mechanisms associated with evolution of oxide layers nor the effects of oxygen on the microstructure of the material are well-understood. To better explore the influence of composition variation on the oxidation behavior of the binary Ti-X systems, a novel combinatorial approach was adopted whereby a series of compositionally graded specimen, (Ti-xMo, Ti-xCr, Ti-xAl and Ti-xW) were prepared using an additive manufacturing approach, and subsequently exposed to still-air at 650°C. A suite of the state-of-the-art characterization techniques including scanning and transmission electron microscopy as well as atom probe tomography were used to assess, as a function of the local average composition: the structure and composition of the oxide; the oxide adherence and porosity; the thickness of the oxide layers; the depth of oxygen ingress; and microstructural evolution of the base material just below the surface but within the oxygen-enriched region.

CSIRO's 2014 Titanium Challenge Winner **TITANIUM USA 2014 Best Master Dissertation Winner**

Osteosarcoma is an aggressive type of bone cancer, which often needs radical surgical treatment methods to contain the spread of the cancer cells. In this study, a novel method of designing patient specific orthopedic implant to assist in surgical treatment of osteosarcoma is studied. The implant design comprising of conformal lattice structure suitable to be manufactured using Selective Laser Melting (SLM), is proposed. The design process is automated using a custom developed algorithm to reduce processing time.

The generated designs are mechanically tested to validate the algorithm. The results show that structures with functionally gradient density can be adapted to reduce stiffness mismatch between the bone and implant. Proposed implant design is predicted to have significant impact on patient's quality of life compared to conventional mass-produced orthopedic implants.

Integrated Computational Materials Engineering (ICME) methodologies are effective tools to reconfigure the materials development process to meet specific properties and accelerate implementation of new higher performance alloys into demanding applications. New alloys, meeting specific properties to achieve desired performance goals, can be designed much more quickly and at lower cost than empirical trial and error methods. This is achieved at the design stage by specifying and developing the precise chemical composition and processing parameters of the alloy, using extensive thermodynamic and kinetic databases, advanced properties modeling along with ICME computational tools based on physics, and quantum mechanics.

QuesTek Innovations has applied its Materials by Design® approach to develop three new castable titanium alloys with strength and ductility characteristics similar to wrought titanium (e.g., wrought Ti-6Al-4V) and with greater strength and ductility over traditional cast Ti-6-4. The development of these alloys has been sponsored by a U.S. Army-funded Small Business Innovation Research (SBIR) program administered through Picatinny Arsenal, New Jersey.

Today's Aerostructures market is primed for growth. It is shaped by supply chain alignment, increasing oil prices, and decreasing interest rates. These factors along with a forecasted fleet of greater than 50,000 in 2035 and the OEM's record backlogs and build rates give rise to a bullish forecast for the titanium demand from the Aerostructures market.

Large scale developments in commercial real-estate, power generation, and hydrocarbon processing place a heavy burden on local water resources and the environment. In many regions of the world, the use of fresh, potable, or desalinated water for industrial cooling is limited or severely restricted. Developers are forced to look at alternative sources of cooling water or other methods of heat rejection to balance competing energy, environmental, and water conservation goals. The use of available seawater or treated sewage effluent as a cooling media can be an effective water conservation strategy but also presents unique challenges in terms of equipment reliability and maintenance. This presentation will look at several examples of how the use of titanium in heat transfer equipment enables developers to plan for a wider range of cooling water conditions, and better serve the local community’s water and energy conservation needs.

Norsk Titanium is a Norwegian company, founded by Alf Bjørseth’s Scatec AS in 2007. It has developed a novel game changing technology (3D printing) to produce complex Titanium components with unsurpassed quality. This patented Direct Metal Deposition (DMD) technology is based on plasma arc and customer benefits include (i) reduced price, (ii) shorter lead times and (iii) increased design flexibility.

General Electric has developed a super alloy machining technology called Blue Arc™ that has shown the capability of rough-machining Titanium tens of times faster than conventional methods with significantly reduced tool wear concerns. GE is offering to license this technology to commercial partners who develop their own machining techniques and equipment, after they review our technology and determine if it would be valuable in their products and services.

Low electrical contact resistance and high corrosion resistance are important properties for metal separators in fuel cells. Titanium is the most promising material for metal

separators due to its excellent corrosion resistance. One of the technical problems of titanium separators is deterioration of contact conductivity. The contact resistance of titanium separators easily increases during use because of its ease of passivation. We have developed graphite coated titanium to solve this problem. The coated titanium is anticipated to be suitable for fuel cell separators.

Mr. Zimm will share ICF's perspective on the following issues:
• What is the outlook for aerospace production by end user market?
• What are the implications for new aircraft programs for advanced materials?
• What are the key trends shaping the aerospace supply chain in 2014?
• What are the potential challenges that additive manufacturing poses to titanium suppliers?