Survey of Army Titanium Trends and Technologies

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Outline

• Why the Army needs titanium
• Cost Barriers to Use
• Technologies to Promote Affordability
• Current and Future Applications of Titanium
• Future Efforts in Affordability
The Army is Transforming

Titanium is a key material to meet the Army’s goal of a rapidly deployable, highly survivable force.
Why the Army needs Titanium

• The Army requires weapons systems and vehicles that have high:
  – Transportability
  – Maneuverability
  – Survivability

• Titanium is playing a critical role in this revolutionary change by:
  – Excellent ballistic performance for range of threats
  – Highest strength-to-weight ratio structural applications
  – Allowing designers to achieve the lowest weight possible in a design
Barriers to Titanium Use

• Army requires lower price than the current technology supports
  – Aerospace titanium material
  – Traditional materials used in Army systems are much less expensive

• Current material lead-times can approach or exceed 60 weeks
Barriers to Titanium Use

What makes titanium so expensive?

• Price is not cost
  – Markets set price
  – Technologies set cost
• Extraction process is batch and non-electrolytic
• Ingot processing is not continuous
• Rolling is conducted in a distributed supply chain
• Army is a minor customer when compared larger aerospace market
Cost Barriers to Titanium Use

Material Cost Driven by:

• Ti Extraction Process and Subsequent Processing Steps

• Lack of economic efficiency in processing – low yield, batch processes
Cost Barriers to Titanium Use
Idealized Approach for Army

Value Chain Independent of Aerospace Production
How the Army is Addressing Cost

Manufacturing technology programs developing and demonstrating production-ready processes in material manufacture and component fabrication

– Material Cost
  • New extraction processes
  • Single-melt processes to lower cost material while meeting performance requirements

– Fabrication Cost
  • High productivity welding processes to include robotic welding
  • Novel use of forming
How the Army is Addressing Cost

Kroll Alternative Processes:

• DARPA funded efforts: Armstrong and MER
• Output of processes is a powder product
• Army does not use powder as a finished product (no current powder metallurgy products for titanium)
• Army needs a processing route for powder:
  – Melt processing route
  – Non-melt processing route
How the Army is Addressing Cost

Kroll Alternative Processes:

• Armstrong Process
  – Continuous reduction of TiCl4 by molten sodium
  – Currently capable of 200 lbs per month
  – Ramping up to 2000 lbs per month
  – Army has produced alloy plate through melt processing route: initial structural and ballistic results are promising
  – Army has produced non-melt forging and ingot pre-forms (blended elemental) using cold-isostatic pressing and vacuum sintering approach

• MER Process
  – Carbothermic reduction of TiO2
  – Plan to evaluate melt and non-melt opportunities when larger quantities of material are available
Future Efforts will focus on:

• Continuing to support technology development activities to achieve 2000 lbs/day (Armstrong)

• Conduct compaction and melt studies to enter powder into current production value chain as “sponge” or “scrap” alternative

• Roll production-sized single-melt powder ingots into plate product

• Enter powder into casting value stream

• Conduct ballistic and structural evaluation of plate and cast products

• Continue studies on direct compaction (longer horizon)
Single-Melt Processes

• Able to use a higher percentage (up to 90%) of scrap, including turnings, to lower ingot cost
• Uses a melting torch in conjunction with a secondary torch
  – Additional benefit of directly casting the ingot into a rectangular slab
  – Makes rolling into plate forms much cheaper
  – Dramatically reduces the number of processing steps compared to the current double or triple vacuum arc melting processes and production of cylindrical ingots
• Conducting studies to include Kroll Alternative powder products into the value stream
Pulsed Gas Metal Arc Welding

- GMAW-P Waveform Developments
  - Used “double-pulse” template
    - Short duration “exciting” pulse
    - Second peak “detaching” pulse for metal transfer
  - Single-pulse GMAW-P with 100% helium shielding gas: good penetration capability

- New industry code for the welding of titanium under the American Welding Society
  - The D1.9 Structural Welding Code for Titanium
  - Publication date scheduled for January 2007
Hybrid/GMA Welding of Titanium Structures

• **Advantages**
  - Higher weld speed than conventional GMAW
  - Reduces lack of fusion defects that can occur with titanium GMAW

• **Applications**
  - Butt, fillet and lap welds
  - Long, linear welds where high welding speeds are needed

*Photos courtesy*
Are New Titanium technologies Production-Ready?

• Many advanced technology demonstrators have been made to show that:
  – The titanium material meets performance requirements
  – Processes were robust and repeatable
  – Knowledge was stored for transfer to manufacturers
  – Machinery and processes are scalable
• Technology and processes are being provided to project managers for components and systems that can be validated through testing
Advanced Titanium Prototypes

Future Combat System – FCS-W
All Titanium Vehicle

Titanium Trailer

Future Combat System – ON-MT
All Titanium Turret

Titanium Mortar Baseplate and Bi-pod
Advanced Titanium Prototypes

Titanium M240 Machine Gun

Titanium Ballistic Doors

Titanium Magazine and Springs
Welding versus Casting
Stabilizer Arm

- ManTech value engineering effort to develop a robotic GMAW-P solution
- Design modifications made to incorporate forming (reduce number of welds) and facilitate welding
- 50% reduction in number of welds over original GTAW design
- 25% potential cost savings over current production casting
Bolt on Weight Reduction Opportunities

- Mortar carrier variant of Stryker (MCV)
- Overall vehicle weight greater than conventional Stryker variant due to addition of armament system
- Large steel bay doors and hatches are heavy
- Opportunity to lower weight by substituting titanium as a “bolt-on solution”
- Weight reduction can help support additional of other capabilities without further vehicle weight increase
**Bolt on Weight Reduction Opportunities**

### Picatinny/PM Stryker Weight Study Initiative

**MCV-B Bay Doors and Engine Cover:**
- Lightweight alternative to current steel solution
- **Right door prototype:**
  - Steel = 271 lbs (current solution)
  - Titanium = 166 lbs
  - Weight savings = 105 lbs
- **Left door prototype:**
  - Steel = 276 lbs (current solution)
  - Titanium = 165 lbs
  - Weight savings = 111 lbs
- **Engine cover:**
  - Steel = 148 lbs (current solution)
  - Titanium = 92 lbs
  - Weight savings = 56 lbs
  - Applicable to all Stryker variants

* Collaborative work with Hi-tech Welding and Forming
Stryker FSV/ RV Vehicle Commander
Lightweight Protection

- **Urgent need** established by PM Stryker
- **ARDEC Design** based on SBCT 3/2 input
  - Problem: Steel won’t work
    - Too Heavy for Cupola Drive Motor
  - Solution: Low-cost Titanium through Army MANTECH
    - Cost: $5,500 per unit
- **ARDEC In-House LRIP** enabled rapid fielding
- **8 Brigades** to be fully equipped (550 Kits Total)

**ARDEC LRIP to OIF: (PM Fielding)**
- SBCT 2: 67 Kits MAY-05 (40 currently in OIF)
- SBCT 3: 67 Kits JUN-05

**Small & Disadvantaged Partners:**
- SBCTs 1,4,5: 201 Kits AUG-05
- Spares: 74 Kits SEP-05

**APR-05 IED Incident**
SBCT 1st Brigade – 25th Infantry Division
**Soldier Unharmed**
Future Efforts in Affordability

• In August of 2004, a DOD team prepared a report to Congress regarding low-cost titanium needs and technology development activities
• Report suggested that Title III Defense Production Act Authority would be a mechanism for the DOD to scale-up a new low-cost titanium industry
• US Army commissioned a study of Army need to develop an adequate case for an emerging DOD market – “Phase 0 Study”
• Phase 0 study has been made to OSD and recommendations have developed a case for the use of Title III authority should be sought for industrial base expansion
Future Efforts in Affordability

The Army has waited for industry to change…..no more time to wait, the time is now to change.

(Looking for volunteers)
In Summary

• Titanium is a metal that can help the Army achieve its objectives
• The prohibitively high cost of titanium is being reduced through improvements in materials processing and fabrication
  – Kroll Alternative Process Development
  – Single-Melt Processing
  – New automated welding techniques that increase welding productivity at a fraction of the cost
• Titanium is subject to strong market forces for pricing; stronger supplier base for non-aerospace titanium is required

Supporting our soldiers remains the highest priority