Market Opportunities for Titanium and Ti Alloys In Pressure Hydrometallurgical Applications

Murray S. Pearson and Kevin S. Fraser
HATCH, Oakville, Ontario, CANADA.

ABSTRACT

The development of new hydrometallurgical processes operating at elevated temperatures and pressures over the past two decades has made possible the extraction of precious metals and high value base metals from formerly uneconomic sources. Examples include the extraction of gold, silver and Platinum Group Metals (PGM’s) by pressure oxidation (POX) of refractory sulphide minerals, high pressure acid leaching (HPAL) of nickel and cobalt from lateritic ores, and partial oxidative leaching (POL) of nickel, cobalt, copper and zinc from sulphide mineral concentrates.

Such unit operations occur in pressurized reactors (“or autoclaves”) under process conditions which produce highly aggressive environments, and as such, offer unique opportunities for the application of reactive metals such as titanium, zirconium and tantalum in materials selection decisions.

This paper presents the market opportunities for the application of titanium and titanium alloys in hydrometallurgical extraction facilities, the major participants in the mining and metallurgical business sector, and the associated EPCM firms that undertake the design work. It also outlines some of the process implications, operating advantages and economic factors that are considered by engineers and owners in evaluating the preferred materials of construction and their potential application in modern autoclave facilities.

July 18, 2008
AUToclave TECHNOLOGY

Market Opportunities for Titanium and Ti Alloys In Pressure Hydrometallurgical Applications
About Hatch

- Employee owned
- Projects in more than 80 countries
- More than 8500 professionals worldwide
- More than US$20 billion of projects now under management
- EPCM, Integrated Teams, Project and Construction Management Services
- Consulting – process, technology and business
- In-house engineering services for operations
- Serving mining & metals, energy and infrastructure sectors
Global Operations

Canada
- Calgary, Alberta
- Montreal, Quebec
- Sorel-Tracy, Quebec
- Sudbury, Ontario
- Toronto, Ontario
- Hamilton, Ontario
- Vancouver, British Columbia

Europe
- London, England
- Moscow, Russia

USA
- Boston, Massachusetts
- Buffalo, New York
- New York, New York
- Millburn, New Jersey
- Monroeville, Pennsylvania
- Pittsburgh, Pennsylvania
- Pleasanton, California
- San Francisco, California
- Seattle, Washington

South America
- Antofagasta, Chile
- Santiago, Chile
- Lima, Peru
- Sao Paulo, Brazil
- Vitoria, Brazil

South Africa
- Johannesburg

India

Australia
- Perth
- Sydney
- Townsville
- Whyalla
- Wollongong

China
- Shanghai
- Beijing

Philippines
- Manila

(Yellow indicates regional hub)
Autoclave Technology

- Autoclave technology consists of all equipment and systems associated with chemical processes operating under *elevated pressures and temperatures*.
Autoclave Processes

Pressure Oxidation
- Gold/Silver
- Uranium
- Zinc
- Copper
- Lead
- Rare earth metals

Pressure Leaching
- Nickel
- Cobalt
- Zinc
- Aluminum
- Rare earth oxides
- Vanadium
Pressure Oxidation Conditions

- Sulphide minerals are oxidized to elemental sulphur and/or sulphuric acid (5 – 10 g/L free acid).
- Whole ores or mineral concentrate slurries (FeS, FeS$_2$, AsFeS, (Ni, Co)S$_2$, etc.)
- Elevated temperature (up to 235°C, 455°F)
- Elevated pressure (up to 3450 kPa(abs), 500 psia)
- High purity oxygen gas (> 99.5% v/v)
- Complete oxidation (> 96%)
Pressure Leach Conditions

- Chemical dissolution of minerals and ore gangue using lixiviant (i.e. 98% w/w H₂SO₄, 15% w/w HCl)
- Whole ores oxide concentrate slurries (i.e. NiO, CoO, FeO₂, Al₂O₃, etc.)
- Elevated temperature (up to 270°C, 518°F)
- Elevated pressure (up to 6900 kPa(abs), 1000 psia)
- Complete extraction (> 96 – 98% of target metals)
- Free acid (i.e. 20 – 30 g/L H₂SO₄, 7 – 8% w/w HCl)
Nickel Laterite Projects
New Laterite Projects 2005 - 2020

Source: U.S. Geological Survey Mineral Resources Program

Working Together SAFELY

HATCH™
Project Development

- HATCH utilizes a gated, risk-managed process beginning with the Business Case of the Client, through project set-up, implementation and turnover to operations.
- The entire process can take over 5 years from its inception to project completion.

PROJECT LIFECYCLE PROCESS - A Phased Approach to Project Development

1. DEFINE PROJECT OPTIONS
   - Possible technologies and plant configurations reviewed

2. SELECT MOST VIALBLE OPTION
   - Determine optimum project solution and evaluate viability

3. DEVELOP PROJECT DEFINITION
   - Prepare a rigorous and comprehensive plan for project implementation

4. PROJECT IMPLEMENTED
   - Work the plan. Change is minimized in FEL4

[Diagram showing Phased Approach to Project Development]

Working Together SAFELY

HATCH
Front-End Loading (FEL) Phases

INITIAL CLIENT BUSINESS CASE

FEL 1
DEVELOP APPROPRIATE OPTIONS
Conceptual Study

FEL 2
OPTION SELECTION AND VIABILITY
Pre Feasibility Study

FEL 3
PROJECT DEFINITION AND PLANNING PHASE
Feasibility Study

FEL 4
PROJECT IMPLEMENTATION PHASE
Execution

START UP & COMMISSIONING

INTENSIVE FOCUS HERE FOR COMPLETE SUCCESS HERE
Pueblo Viejo Project
Conceptual Study

- Technology Assessments and Options
- Site Selection Analysis
- Sustainability assessments
- Environmental Assessment
- Conceptual layouts and general arrangements
- First cost estimate and project schedule
- Initial Gate Review
- Qualitative Risk Assessment

Working Together SAFELY

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# Refractory Gold Ore Economics

**Open Pit Refractory Resource**

Gold : Sulphur Ratio = \( \text{Au (g/t)} / (S^- + S^0 \%) \)

## Gold Values Only - No Silver or Base Metal Credits

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With Present Refractory Process Technology the Resource is Not Economic

Low Economic Potential, Except at Existing Refractory Site

Moderate to High Economic Potential, Depending on (1) Gold Price (2) Power Cost and (3) Location

Very High Economic Potential

Source: G.L. Simmons Newmont Mining Corp., 2004
# Refractory Gold Ore Economics

**Underground Refractory Resource**

**Gold : Sulphur Ratio** = \( \text{Au (g/t)} / \text{S}^+ + \text{S}^0 \) (%)

**Gold Values Only - No Silver or Base Metal Credits**

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**Gold Grade [g/t]**

- With Present Refractory Process Technology the Resource is Not Economic
- Low Economic Potential, Except at Low Cost Underground Mine
- Moderate to High Economic Potential, Depending on (1) Gold Price (2) Power Cost and (3) Location
- Very High Economic Potential

Source: G.L. Simmons Newmont Mining Corp., 2004
Pre-feasibility Study

- Project objectives set
- Preliminary engineering
- Hazards review
- Firm process flow diagrams developed
- Plant footprint and configuration determined
- Budgetary procurement and overview plan for global sourcing
- Implementation planning, preliminary cost and schedule are developed
- Risk elements further defined
- Second Gate Review
Conceptual Site Layouts
Feasibility Study

FEL 3

- Environmental, Health and Safety Plan for project implementation
- Frozen general arrangements/firm P&IDs
- Complete mechanical & electrical equipment lists
- Definitive cost estimates and schedule
- Critical equipment orders and work packages
- Defined global sourcing strategy
- Project execution plan and procedures
- Risk mitigation plan & change management plan
- Final Gate Review

Working Together SAFELY

HATCH™
Equipment Design
Structural Design
Use of Titanium Materials

- Titanium Materials are primarily used for their corrosion resistance in and around the autoclave vessels.
- In Pueblo Viejo process facility, titanium fabricated equipment, piping, and mill products are \(~20\%\) of the direct cost of the pressure oxidation units.
Use of Titanium Materials

Feed Piping – Ti Gr. 2

Agitators – Ti Gr. 12

High Pressure Vent Piping – Ti Gr. 12

Internals – Ti Gr. 2

Discharge Piping – Ti Gr. 2

Working Together SAFELY
Use of Titanium Materials

Distribution by Weight

- Large Bore Ducting 21%
- Small Bore Piping 35%
- Severe Service Isolation Valves 21%
- Autoclave EXW Clad Flange Covers 5%
- Autoclave Agitators 7%
- Dip Pipes and Inserts 9%
- Autoclave Internals 9%
Use of Titanium Materials

Distribution by Cost

- Severe Service Isolation Valves: 39.6%
- Small Bore Piping: 23.7%
- Large Bore Ducting: 14.2%
- Dip Pipes and Inserts: 5.3%
- Autoclave Internals: 7.1%
- Autoclave Agitators: 1.9%
- Autoclave EXW Clad Flange Covers: 8.0%
Execution

- Safety is the first priority
- Work the Plan/resist change
- Execute detailed engineering
- Trend/forecast underlying critical elements
- Periodically review risk mitigation
- Implement global sourcing strategy and plan
- Implement constructability
- Implement Design-for-Start-up Plan
- Employ rigorous QA/QC Program
- Communication key to success