GLOBAL TRENDS IN INDUSTRIAL MARKETS

ITA CONFERENCE – LAS VEGAS
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We have used for this presentation among other sources testimonies of some of our customers and suppliers.

We want to thank all of them for their contribution.
INDUSTRIAL TITANIUM - PERIMETER

**Power**
- Nuclear / Thermal
- Renewable

**Desalination**
- MSF/MED

**Process**
- Refineries / Chem
- LNG

**Others**
- Automotive / Other
- Ship
INDUSTRIAL TITANIUM – CURRENT MARKET

- Slight increase compared to 2017.
- On line with our last forecast.
- Decrease of desalination and recovery of process
- Till 20% below the peak year.

2018
28,112 MT

+ 1,112 MT vs 2017

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INDUSTRIAL TITANIUM – FORECAST ACCURACY

2018 Forecast adjustments over 5 years mainly due to Desalination

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Strengths
Ti competitiveness against other materials
Alternative products, designs and processes

Weaknesses
Perceived as Commodity Material
Lack of reliable index
Design rules not adapted
Scrap issue

Opportunities
Ammonia Heat Exchanger
Nuclear investments China, Middle East and Russia
Automotive Market
Release of copper in nature

Threats
Weak Players on Unclear Market
Clean energy revolution
Process applications and Middle East market strongly linked to oil and gas
Taxe & duties
SWOT – STRENGTH ??
Titanium competitiveness against Cu&Ni

- Market has been shaken with protectionist measures impacting negatively global Ni, Cu and Al.
- Difficult to predict the trend over medium to long term.
- Titanium existing indicators remaining less reliable compared to other metals as Nickel or Copper.

What used to be a strength over last 6 years is more questioned since mid 2018.
SWOT – WEAKNESS
Titanium perceived as commodity material

- Less specifications from end user
- Specifications handled by local fabricators
- No care of origin or traceability
- No specified process requested
- Old stock allowed
- Less Innovation Resources

Need to rebuild a strong supply chain around non military and non aeronautics Industrial markets.
SWOT – OPPORTUNITIES
Ammonia in Refrigeration

- Fewer CFCs and HCFCs are available for environmental reasons
- Ammonia is a more effective replacement for refrigeration:
  - Safe for the environment, with an ODP GWP rating of 0.
  - Substantially less expensive than CFCs or HCFCs.
  - 3-10% more efficient refrigerant than CFCs.
  - An ammonia-based design will cost 10-20% less to build.
- Ammonia is not compatible with the use of Copper tube (SCC)

Cu and CuNi will be changed to SS and Titanium
SWOT – THREATS
Weak Players on risky markets

- Lack of partnership spirit and long term view from loss making Customers
- Markets moving from global to local with contrasted situations according to exchange rates and import taxes
INDUSTRIAL TITANIUM – REVIEW PER MARKET

1. **Power**
   - Nuclear / Thermal
   - Renewable

2. **Desalination**
   - MSF/MED

3. **Process**
   - Refineries / Chem
   - LNG

4. **Others**
   - Automotive / Other
   - Ship
1 POWER: TI USE PER APPLICATION

- Nuclear: 0.162 Ti tubes MT/MW
- Coal: 0.051 Ti tubes MT/MW
- Gas Combined Cycle: 0.036 Ti tubes MT/MW

Renewable Energy

- Wind Power: 0.000
- Hydropower: Up to 30
- Solar: 0.000
- Geothermal: Variable
- Bio Energy: 0.051

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1 POWER: MARKET TREND

Global efficiency limits demand growth

Demand increase mitigated by Energy savings

Global energy demand varies by sector

Higher demand for Electricity Generation

Source: ExxonMobil. 2018 Outlook for Energy

Source: U.S. Energy Information Administration, Form EIA-860

*Includes consumed energy as fuel and feedstocks
1 POWER: MARKET TREND

Electricity generation highlights regional diversity
Net delivered electricity – thousand TWh

Source: ExxonMobil. 2018 Outlook for Energy

Regional diversity but global trend

Natural gas and renewables dominate growth
Global growth 2016-2040 - thousand TWh (net delivered)

Shift to less carbon-intensive energy, like renewable, natural gas and nuclear

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1 POWER: FACTS ON NUCLEAR
Low activity in 2017

Investment into the nuclear sector in $Billions.

- Capacity of nuclear power generation fell by 2 gigawatts in 2017.
- Investment of $ 9 billion in 2017, down 70% from 2016.
- Only 4 nuclear reactors were commissioned in 2017 (7 gigawatts), including 3 in China.
- Out of 53 power plant in construction, 20 are in China.
1 POWER: FACTS ON NUCLEAR
China nuclear program

- 19 units under construction with 21GW
- 5 new units in commercial operation in 2018: Tianwan 3, Sanmen 1, Shidaowan 1, Taishan 1, Haiyang 1
- 28 units waiting for approval
- Chinese government will speed up approval with 6~8 projects plan to be approved in 2019
- AP1000/CAP1400 and HRP1000 will be the trend
- Capacity will be increased by 150 GW by 2030
The past five years the Small Modular Reactor become the solution for countries with limited electricity networks.

- The International Energy Agency forecasts an increase in global demand of more than 35% by 2035. At present 43 projects are under development worldwide.

- US government has launched a $ 452 million, 6-year program to accelerate the deployment of this technology and facilitate certification. The first US SMR could be commissioned as early as 2023.

- Rosatom has just launched the Akademik Lomonosov, a floating plant equipped with two 35 MW reactors each capable of covering the consumption of 200,000 people.

- South Korea developed the 100MWe SMART project certified since 2012 by its safety authority.

- 9 projects in China ranging from 60 to 200 MW are under development, including one already under construction by Tsinghua University.
Nuclear giants are reorganizing
- Restructuring of the former Areva into Framatome and Orano
- Brookfield Asset Partners of Canada agreed to buy Westinghouse Electric Company,
- CNNC merged in China with CNEC

Trend towards SMR (Small Modular Reactors)
- 9 projects under development in China
- UK government announced funding for modular reactor development
- Ukraine had signed a MOU with SMR developer Holtec International
- The government of Canada announced a road-mapping exercise
  to explore SMRs potential

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1. **POWER: FACTS ON COAL**

Coal plant development across the world drops for second consecutive year

- 2018 Peak year for Ti in India. Several projects concluded in India over 2018 for Super Critical units. (Ennore, North Chennai, Tuticorin…). Representing over 1000MT of Ti.

- Nevertheless new constructions are down by 73% since 2015, due in large part to tighter restrictions.

- Based on the two decades long trend of coal retirements, the global fleet of coal-fired power plants should begin to decline in 2022.

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1 POWER : FACTS ON GAS

Increased Gas Combined Cycle units

- Cleanest and most efficient way of producing electricity from fossil fuels. Half the CO2 of Coal
- Investment of $500-1000/kW against $2500 for Coal and $5000 for nuclear
- As fast to install as renewable against 3 years for Copal and 6 years for Nuclear
- Several projects at final stage in UK, Malaysia, Thailand, Pakistan and Turkmenistan.

Ex: Hassyan 6 phases CCGT for DEWA. Once completed, the plant will become the world's largest IWPP plant with a whopping capacity of 9000 MW and 700 MIGD
Still several projects in the air but significant delays: capital intensive + technical challenges.

India's OTEC project is coming up in Kavaratti (Lakshadweep archipelago) after 35 years of initial plans.

The total OTEC potential around India can be up to 180,000 MW.

- The first draft of the master plan for a renewables-powered EcoVillage in the US Virgin Islands has been completed on September 2018.
- OTE want to build an OTEC plant that provides power and water to about 400 residences, a hotel and a shopping center as part of a USD-700-million (EUR 571m) EcoVillage project.
- British developer Global OTEC Resources Ltd is looking to raise GBP 500,000 (USD 700,500/EUR 564,000) through a crowdfunding platform so it could realise Ocean Thermal Energy Conversion (OTEC) projects for resorts across the tropics.
2 DESSALINATION: TI USE PER APPLICATION

3 TECHNOLOGIES

Reverse Osmosis

No tubing required

Thermal MSF

Constraint: Ti for heat reject section
+ occasionally for low temp. stage
Ti versus Copper Alloy

No Ti

Ti from
3.5 to 6 kg/(m³/d)

Thermal MED

Constraint: Ti for Top tube rows to avoid erosion from sprays.
Ti versus Stainless Steel or All Brass

Ti from
0 to 1.2 kg/(m³/d)

=> MSF is more favorable to titanium

- Relative cost of titanium to Copper Alloys is better than to All Brass
- More critical in case of tube leakage cause seawater is inside the tubes
- Higher pressure and corrosive environment

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2 DESALINATION : MARKET TREND

Technology trend not in favor of titanium
- RO is definitely the main technology
  - Lower energy consumption and modular
  - Concentrating main R&D investments
- MSF technology declining

Some opportunities anyway for titanium consumption in Desalination
- Mix RO/MED or MSF units
- MED/MSF units will remain especially in the Arabian Gulf due to seawater quality
- Present MED operation temperature is below 70°C allowing the use of aluminum brass
- Design trend to downsize MED plants while increasing the operation temperature.
- The reuse of wastewater

Some Revamping with Ti replacing Copper Alloy

Investigate the impact of the reuse of WasteWater in Process.
2 DESALINATION: FACTS
Desalination market is confirmed to be erratic and unpredictable

- After two years without thermal desalination projectone project launched in 2018:
  - ADNOC Takreer (UAE) (project divided in two parts)

- Several projects to come with uncertain schedule:
  - Yanbu 3 in Saudi Arabia
  - Jubail 3 in Saudi Arabia
  - Facility E in Qatar
  - Az Zour North 2 & 3 in Kuwait
  - Al Khiran in Kuwait

- Trends on material choice
  - Titanium is establishing itself as the material of choice for desalination plants thanks to its competitiveness
  - The trend is to shift to thinner thicknesses
2 DESALINATION: RESULTS

Ti consumption in Metric Tons

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**3 PROCESS: TI USE PER APPLICATION**

More equipment using titanium in process compared to power reference

<table>
<thead>
<tr>
<th>Component</th>
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<tbody>
<tr>
<td>Steam Condenser</td>
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<tr>
<td>HC Condenser</td>
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<tr>
<td>Refring Evaporator</td>
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<td>Component Cooler</td>
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<td>Oil Cooler</td>
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<td>Reactor</td>
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<tr>
<td>Inter Changer</td>
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<tr>
<td>Evaporator</td>
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Market recovery driven by high Barrel price

Oil prices back above $70/barrel

Pressure on Chemical products as PTA
3 PROCESS : FACTS
Opportunities to develop the consumption of titanium

Substitution of copper alloys by titanium. Example of Shell refinery in Rotterdam where propylene condenser in copper alloys is being replaced by condensers with titanium finned tubes.

3 PTA Projects at final stage in China after few years without activity.

Traditionally using Ti in the USA and CuNi in Europe.

Strong opportunities for Ti on European market.
4 AUTOMOTIVE : ZOOM

BCG market forecast to 2030 (global view)

- Usage of titanium is developing in a growing market:
  - Sports Car Mufflers
  - Fuel Tanks
  - Engine Parts: connecting rod, valve, retainer, body, suspension spring

- Development of electric cars is an opportunity for titanium:
  - Titanium underbody in Tesla Model S

- Selling Hydrogen Fuel Cell as for the Toyota Mirai
  - 0.1mm graphite coated Ti coil 40kg/car with potential 800,000 cars in 2030...

- Rechargeable Hybrid Sales Catch Up 100% Electric Cars

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More orders for new ships of all types were placed in the first three months of this year than in early 2017.

The increase covers all types – tankers, dry bulk carriers, containerships, and liquefied natural gas/liquefied petroleum gas (LNG/LPG) tankers.

Significant increase on LNG/LPG

Good positioning of Korean and Japanese Shipyards

Significant consumption of Ti grade 1 expected for the coming years
The caustic soda market is expected to grow by 7% per year over the coming years. Asia-Pacific is the main market with China as main producer and consumer. Associated Ti consumption of grade 1 as Electrode.
THANK YOU

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