Forecreu Cannulated Technology
Presentation will focus on:

- Company: Evolution into orthopaedics
- Background on Guidewire Technology
- Making cannulated screws, IM nails and Instruments
- Drilling, Tubing, Cannulated.
- Processing cannulated Titanium alloy.
- Features of Cannulated bars
- Challenges ahead, drivers for growth & Conclusion

FORECREU ITA 2010
The history

• 1952 Creation of Forécreu for the manufacturing of oil-hole fed bar for coolant rotating drills (Cutting tools).

• 1986 Development of stainless Biometal using existing processes and technical development.

• 1994 Cannulated Biometal in titanium alloy.

2006 Extension of Malicorne plant. The historical shareholders Eramet & Vallourec give up their minority share and LBO is conducted with Private Equity.

• 2008 Delicated Extrusion press (1310T).
The products

TOOLING

High speed steel and special steel straight and twisted hollow round bars for the manufacture of coolant fed cutting tools.

(Drills, taps, reamers)

HOLLOWTECH

Hollow bars with one or several holes for industrial applications (components, high pressure, nuclear, aeronautics, plastic moulding).

BIOMETAL

Cannulated bars of stainless steel and titanium alloys for the manufacturing of Orthopaedics implants and surgical tooling.

VBM Orthopaedic polymers

Injection molding of orthopaedic Polymers for use as implants

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The market

Biometal 55%

Tooling 45%

Ti.

Stainless Instru.

Stainless Implant

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Forecreu Cannulated Technology

- DHS DCS Screw
- Spinal screw
- Femoral, tibia Nails
- Cannulated Screws
- Small fragments
Surgical Technique

- Fracture fixation
Kirschner Wire technology

• Introduced by Dr Kirschner in 1985, widely used in Orthopaedics and other types of medical and veterinary surgery.

• K-wire: Dia. from 0.6 to 4.0mm (1.0, 1.2, 1.5, 2.0, 2.5, 3.2mm, etc.)

• Small for screws & large for nails
Cannulated Implants & Instruments

Two technologies for Cannulated Implants and Instruments:

– Deep hole drilling technology

– Thick wall Tubing, later called Cannulated bars
## Key decision factors - Cannulated bars

<table>
<thead>
<tr>
<th>Pros (+)</th>
<th>Cons (−)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Feasibilities</td>
<td>• Availability/limited actors</td>
</tr>
<tr>
<td>• Break through Technology</td>
<td>• Surface finish</td>
</tr>
<tr>
<td>• Consistency</td>
<td>• ID sizing</td>
</tr>
<tr>
<td>• Bar feeder approach</td>
<td>• MOQ/Prototyping specials</td>
</tr>
</tbody>
</table>
| • Cost of operating  
  – Time  
  – Scrap | • Standards OD/IDs |
| • Time to market |  
|  |  

*FORECREU ITA 2010*
Process Tube

Billet → Extrusion → Tube drawing

and/or

and/or

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The plants

PLANT MALICORNE
-Extrusion - Finishing

PLANT COMMENTRY
-Drawing

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Extrusion

1. Material inventory
2. Insertion of mandrel in the hole
3. Hot extrusion
4. Material control & testing to ASTM & ISO
5. Cutting of billets
6. Boring of the hole
7. Semi-finished extrusions

F max ≈ 1310 T
Extrusion process layout

Fmax = 1310 T

Extruded Hollow Bar
Ø ≈ 120 mm (4.7 in)

Die

Extruded Hollow Bar
Ø ≈ 20 mm (¾ in)

Container

Lubricant

Ram
Semi-finished Extrusion
Testing - Cleaning - Packing
PROCESS

FORECREU

Process Video

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Cannulated Bars

• Grade(Implant):
  – Ti 6-4 and β titanium family
  – Austenitic & Nickel free stainless
  – Memory shape alloy

• Grade(Instrument): Martensitic , Age and precipitation hardening type, etc.

• MOQ: 1-2 billets equivalent
Cannulated Titanium

Ti Family:
- Ti 6-4 eli, Ti 6-4, Ti 6-7Nb alpha + beta alloys
- Ti 15Mo, Ti 13Nb-13Zr, Ti 12Mo-6Zr-2Fe metastable beta alloys
Cannulated Bars - ID Concentricity

Typical

Ti 6-4 eli
Cannulated Bars
- Hole Properties

- Ti6Al4V eli (ASTM F136):

<table>
<thead>
<tr>
<th>General features</th>
<th>UTS MPa / (ksi)</th>
<th>YS MPa / (ksi)</th>
<th>E %</th>
<th>RA %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mini</td>
<td>typical</td>
<td>mini</td>
<td>typical</td>
</tr>
<tr>
<td>ASTM F198</td>
<td>860</td>
<td>960</td>
<td>709</td>
<td>838</td>
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<tr>
<td>ISO 5832-3</td>
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<tr>
<td>Ti6Al4VEU</td>
<td>860</td>
<td>960</td>
<td>709</td>
<td>838</td>
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<tr>
<td>ASTM F1472</td>
<td>930</td>
<td>-</td>
<td>880</td>
<td>-</td>
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</tr>
<tr>
<td>Ti6Al4V</td>
<td>930</td>
<td>(135)</td>
<td>880</td>
<td>(125)</td>
</tr>
<tr>
<td>ASTM F1295</td>
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<td>830</td>
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<tr>
<td>ISO 5832-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ti6Al7Nb</td>
<td>900</td>
<td>(131)</td>
<td>800</td>
<td>(118)</td>
</tr>
</tbody>
</table>

* gage length = (5D) to meet ASTM requirement.

Micrographic ISO and ASTM specifications:
- Free of visible micro inclusion (x 200).
- α+β equiaxed structure, according to ETTC2 A1-A9 reference pictures.
- Free of α case (hole surface and CD).
- Free of α network and α platelets.

Sampling Procedure:
Each and every batch is sampled according to ANSI / ASQC Z1.4 1993.

Forecreu typical
Cannulated Bars - Metallurgy

- Fatigue testing

Experiment layout:

- 8Hz Alternative force between 2200 N and 200 N (495 lbf - 45 lbf)
- Applied load F/2 F/2
- Four point bending deformation test

Results:

<table>
<thead>
<tr>
<th>Sample N°</th>
<th>Cycles to failure Drilled Production</th>
<th>Cycles to failure Forecreu Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62.848</td>
<td>60.650</td>
</tr>
<tr>
<td>2</td>
<td>65.446</td>
<td>69.110</td>
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<tr>
<td>3</td>
<td>87.786</td>
<td>60.022</td>
</tr>
<tr>
<td>4</td>
<td>54.949</td>
<td></td>
</tr>
<tr>
<td>Mean Value</td>
<td>67.782</td>
<td>63.260</td>
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</tbody>
</table>

Tensile Test:

Mechanical tests are performed according to ASTM E8-E8M specification.
- Tensile strength, yield strength, elongation, are tested for each and every batch in our laboratory with a 200 KN equipment.
- Typical test curve is following.
Challenges ahead & conclusion

• Improve ID Tol. + TIR
• Improve surface finish
• Manage process risk analysis
• Provide comfort with back-up inventory worldwide & Improve Lead Time
• Enforce Standards IDs/ODs
• Develop grades offering
Thanks for your attention