Overview of Titanium applications in Dassault Aviation Airframes

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Overview of Titanium applications in Dassault Aviation Airframes

Agenda

- Dassault Aviation
- Part applications and processes
  - Parts machined from plates
  - Forged parts
  - Casting
  - SPF-DB
- Example of canard surface assembly
- Others: Tubing / Fasteners / Direct Manufacturing
- Titanium distribution on Rafale and Falcon
- Challenges
- Conclusion
- Aircrafts in production: Rafale, Falcon, nEUROn
- A world leader in top-of-the-range executive jets.
- Approx 11,500 employees; Based in France and United States and 8 other international locations.
- Aircrafts in more than 77 countries across 5 continents.
- More than 8,000 aircrafts delivered, representing 25 million hours of flight time.
Parts machined from plates: Rafale's leading edge slat tracks

- **Advantages**: High mechanical properties, non specific supply
- **Drawbacks**: High buy to fly ratio (5.5), geometrical limitations

Size: 310x90x45mm
Thickness range: 4mm

Leading edge slat tracks machined from Ti-6-4 plates
Investment casting Ti-6-4/Rafale rib 1

Size: 1250x300x250mm
Thickness: 2 to 25mm
Investment casting Ti-6-4: Titanium central box for Horizontal Stabilizer
Horizontal stabilizer
Falcon 50, 900, 2000, re-engineering: composite + titanium box

- Casting used for functional integration reducing fasteners and parts
- Titanium used for high specific strength

<table>
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<th>Before</th>
<th>After</th>
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<tr>
<td>Number of parts</td>
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<td>36</td>
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<tr>
<td>Fastening elements</td>
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Horizontal stabilizer: titanium casting central box

Catia model

Vacuum investment casting Ti-6-4

Stereolithography

Shell mould

Final part

Casting
Investment casting Ti-6-4

- **Advantages**: Delivers complex parts, functional integration, thin walls, low buy to fly ratio
- **Drawbacks**: Casting factor, long development time, frozen geometry, specific design for each supplier

Size: 990x520x330mm
Thickness range: 2-5 mm
Buy to fly : 2 to 3

Size: 1250x300x250mm
Thickness range: 2-25mm
Buy to fly : 2
Forged parts Ti-6-4: Rafale Wing fittings

Size: 270x300x180mm
Forged parts: Rafale under wing fittings

- Advantages: high mechanical properties, intermediate buy to fly ratio (4)
- Drawbacks: Long development time, frozen geometry, geometrical limitations
SPFDB: Super Plastic Forming Diffusion Bonding

Canard surface

Leading edge slats
SPFDB : Rafale Leading edge slat and canard surfaces

- **Advantages**: Very low buy to fly ratio, fully integrated parts
- **Drawbacks**: Complex process, frozen geometry, high quality thin sheets requirements, chemical milling

**Leading edge Ti-6-4**

**Canard surface Ti-6-4**
Example of canard surface assembly

Number of parts: 5
Pin is electron beam welded on fitting
SPF-BD → No fastener

Size: 2000x1000x200mm
Others: Tubings / Fasteners / Direct Manufacturing

**Tubings**: Ti-3-2.5 and CPTi
- 600m of hydraulics tubing for F7X
- 150m for a Rafale

**Fasteners**: Ti-6-4
- 110000 titanium fasteners for F7X
- 60000 titanium fasteners for Rafale

**Direct Manufacturing Ti-6-4**
- Ventilation system
- Prototyping

CPTi air conditioning pipe

Titanium fasteners
Titanium distribution on Rafale and Falcon airframes

Why Titanium used:
-1- benefits of high specific strength (highly loaded parts in small volume)
-2- for thermal expansion compatibility with composite
-3- for galvanic compatibility during direct assembly

Rafale airframes

Falcon airframes
Challenges

Environmental
- Eliminate fluonitric acid for chemical milling and etching
- Recycling of scrap material
- Friendly surface treatments

Supply chain
Dassault Aviation: small player in titanium market
- Develop a strategic supply plan
- Critical parts: complex qualification process
- Very few suppliers

Technical
Downsizing qualification test plan
- Microstructure/properties correlation
- Identify impact of process steps on properties
- Identify scatter in properties
Conclusion

Dassault’s signature

Ti-6-4 only
- Well known, homogeneous in term of mechanical properties
- Easy supply
- Minimization of qualification cost

Processes optimization
- Cost driver: buy to fly ratio
- Wide range of technology

Environmental
- Focus of current research
- Chemical milling replacement by mechanical machining

Next step

Improve performances and competitiveness
- Implement new processes (ex. Machining improvement)
- Optimized design
- Secure supply chain
Back-up
**What is SPF-DB?**

SPF-DB = Super Plastic Forming & Diffusion Bonding

SPF = Superplasticity

⇒ deep hole possibility

DB = Welding by atomic diffusion in solid phase

⇒ Thin structures

⇒Perfect bonding without fasteners
Direct Metal Deposition

- LASER
- CAD/CAD
- Coaxial Nozzle
- ∆Z (Nozzle)
- part
- substrate
- Motion Table XY

Optomec LENS® 850R
Triumph DMD 505
Inss Tek Inc. MetalWorks 350

Selective Laser Melting

- CAD/CAM
- LASER
- Laser wiper
- part
- Manufacturing Chamber
- Feeding system
- Feeding chamber

Phenix PM 250, TRUMPF LF250, EOS M270, MCP Realizer II
Static properties on Ti-6-4 sheets
Variability with thickness between 0.5 to 5mm
Fatigue crack growth rate on Ti-6-4 plates
Variability between suppliers
Typical Microstructure on Ti-6-4 sheets

0.5mm gage

4mm gage
Typical Microstructure on Ti-6-4 casting