“Our ambition is to be, for our customers, the worldwide metallurgy reference, innovative, agile and aware of our responsibilities”

Georges Duval, President

Sustainable solutions for Aerospace high integrity components

Enhancing your performance

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www.aubertduval.com
While earlier aircraft were based on a wooden frame, both aluminum and steel have been extensively used for fuselage and wings, further complemented by composites and titanium.

In the same time, engines have also evolved, to withstand higher and higher combustion temperatures, now reaching 800°C / 1,475°F. Hence the development of Nickel-based alloys to meet these stringent requirements. In modern aircraft, Aubert & Duval offering encompasses 90% of potential metallic applications. This is achieved since we process in-house the 4 most critical materials: High-Performance Steels, Nickel, Aluminum and Titanium.

We also master the full range of melting and remelting processes: EAF, VIM, ESR, VAR and gas atomization. We use the most sophisticated open-die and closed-die forging techniques. We forge and roll bars and sheets in all kinds of alloyed steels, Nickel-alloys and Titanium-alloys.

Aubert & Duval, the global solution

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Providing resistance at key locations

A bird is not only made of feathers! It is built on a relatively resistant, albeit supple assembly of bones and articulations which altogether connect and animate the whole body. A similar role is played by our critical parts, providing maximum safety with minimum surcharge. So, when the ‘bird’ is 80 m / 262 ft long and weighs 800 t, Aubert & Duval is the metallurgy specialist to reckon with.

**Main data**
- **diameter:** 1.19 m / 74 in
- **length:** 78.4 m / 257 ft
- **height:** 8.4 m / 27 ft

**Main materials**
- **Aluminum:**
  - 7075
  - 7010
  - 7150
- **Titanium:**
  - Ti-555.3
  - Ti-17
  - Ti-6Al-4V
- **Steel:**
  - PH13-8Mo
  - AMS 5937
  - AMS 5935

**Materials used in engine pylons**
- **Aluminum:**
  - 7075
  - 7010
  - 7050
- **Titanium:**
  - Ti-555.3
  - Ti-17
  - Ti-6Al-4V
- **Steel:**
  - PH13-8Mo
  - AMS 5937
  - AMS 5935

**Closed-die forging parts:**
- From 50 kgs / 110 lbs to 20 t
- Up to 8 m / 31.4 ft
Always trying to land as softly as birds, aircraft are built to withstand exceptional situations such as wind gusts where the impact pressure can be compared to a car crashing at 160 km/h - 100 mph, this without getting damaged, and still with only 2 main landing gear. The largest part now reaches 3.5 m / 118 in, twice the size of a human being. Material choice and quality are therefore of utmost importance to meet these requirements. With the understanding that, every second, a large passenger aircraft lands somewhere in the world.

Utmost confidence for repeated landings

Main landing gear

- Arms
- Bogie beams
- Brake rods

Main fittings

- Torque links
- Sliding tubes

Nose landing gear

- Panels

Materials

- Ti: T4, T662, T110, T1102.3
- Al: 7010, 7175

High performance bars

- 7EPROVIDEVARIOUS TYPESOF semi-finished products for hydraulic and electric actuators, braking pads and related fittings, namely for landing gear locking, retraction and steering, or braking torque systems.

Closed-die forging parts:
- From 50 kgs / 110 lbs to 201
- Up to 8 m / 314 in
Meeting the most arduous requirements

No parts in the engine face as many stress challenges as rotating parts: temperatures close to 800°C / 1,475°F, corrosion from gas and humidity, resistance to shock and crack propagation, to name a few. And this for hours and hours... with minimized fuel consumption. Hence the necessity for the most advanced materials such as Nickel-based Superalloys and Titanium, and for the most demanding techniques such as open and closed-die forging.

A 100M€ investment for disks

The newly built 40 KT closed-die forging press is the center piece of our fully-automated EDPL (Engine Disk Production Line).

Lean workshop integrating all steps from the preparation of our own billets to final ultrasonic tests.

Main materials

<table>
<thead>
<tr>
<th>Superalloys</th>
<th>Common name</th>
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<tbody>
<tr>
<td>INCO 718</td>
<td>PER718</td>
</tr>
<tr>
<td>Waspaloy</td>
<td>PER72</td>
</tr>
<tr>
<td>Gatorized Waspaloy</td>
<td>PER3</td>
</tr>
<tr>
<td>INCO 901</td>
<td>PER901</td>
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<tr>
<td>AD730 New</td>
<td>-</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Aluminum Alloys</th>
</tr>
</thead>
<tbody>
<tr>
<td>2618</td>
</tr>
<tr>
<td>7050</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Titanium Alloys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ti624.6</td>
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<tr>
<td>Ti624.2</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Powder metallurgy</th>
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</thead>
<tbody>
<tr>
<td>Gas-atomized alloyed steels, superalloys, or titanium powders, further hipped into semi-finished or near net-shaped products.</td>
</tr>
</tbody>
</table>

Fan disks

Compressor shafts

LPC/IPC disks

HPC disks

Cone shafts

Turbine shafts

Fan disks

HPC disks

Compressor shafts

Spinners

HPC disks

Compressor shafts

Turbine shafts

LPC/IPC disks

HPC disks

Cone shafts

Fan disks

Turbine shafts

HPT disks

LPC/IPC disks

HPC disks

Cone shafts

Fan disks

Turbine shafts

HPT disks
Safety, flexibility and speed

Over the decades, helicopters have become an irreplaceable transportation means. Not only for traditional military, offshore or business requirements, but more and more for police, anti-terrorism, border protection, health care and other emergency issues. For the next decade, it is predicted that approximately 16,000 turbine helicopters will be needed, the vast majority consisting of new rotorcraft for fast growing countries such as China.

When incompatible becomes feasible

Helicopters must endure a very high torque effect in the main gear box, as well as many vibrations. At the same time, to avoid fatigue, the same parts must offer very high hardness characteristics. This is made possible with Aubert & Duval nitriding or carburizing proprietary grades such as FND, FDG and FDG which allow to combine flexible core and hard surface.

Engine parts

High Performance Steel Bars

Available in small or larger diameters and cut-to-size, these bars are machined, then used in the main rotor, 42- and 90-degree transmission systems, main frame, and other demanding applications.

Main materials

Main fitting

Transmission box parts

Rotor parts

Common name

AMS 5937

AMS 5938

AMS 5719

15-5PH

17-4PH

AMS 6493

FND

FDG

GKH

Closed-die forging parts:

• From 50 kgs / 110 lbs to 20 t
• Up to 8 m / 314 in
Max diameter for disks:
1,200 mm / 47 in
Setting the bars at their highest

New! Titanium bars
Through its UKAD investment in a new 4,500-ton forging press, Aubert & Duval has made the first step towards the manufacturing and sales of bars made of commercially pure and alloyed titanium.

Our customers transform our bars

Rods, rod-ends and struts
These are generally fabricated out of round bars, and potentially used all across the aircraft or helicopter.

Structural fasteners and assembly components
Round bars or wire for bolts, nuts, studs, pins, clamps, hinges, all kinds of fittings, and other safety parts.

Gears and shafts
While shafts are essential parts of aircraft engines, 42- and 90-degree transmissions are key to helicopters integrity. Other gears and shafts can be found in several other devices: APUs, wing flaps, landing gear, pumps, etc.

Bearings and ball screws
Ball bearings, roller bearings, flange bearings are used in numerous areas, such as engines and hydraulic or electric actuators.

The material you need, where you need it

Offering state-of-the-art products would be of no use if not supported by a first-class logistics service. Aubert & Duval is constantly adapting its service offer to meet changing logistical requirements.
We are therefore able to deliver medium or small-size orders on a regular basis for call-off supplies, or rapidly when it comes to emergency shortages.

Certifications and specifications
In addition to general certifications (ISO 9001, ISO 14001, ISO 18001), our Lyon Service Center is certified to the most stringent industry specific standards: ISO 9120 (aero design and manufacturing), ISO 9120 (aero distribution) and AQAP 2110 (NATO). Also, our products are AMS, ABS and ASNA specified.

For more information on bars, please refer to our dedicated brochures. You can download them on our website.

http://www.aubertduval.com
High-resistance molds for Composites and Titanium

Molds for SuperPlastic Forming and Hot Forming of Titanium

SuperPlastic Forming, with or without Diffusion Bonding, Hot Forming and Twist and Camber technologies are used for complex shapes in titanium such as fan blades, aircraft wing access panels, cockpit frames, nozzles, doors, engine casings... Aubert & Duval supplies the upper and lower dies, and heating press platens that endure high temperature and pressure.

Molds for Composites

Aubert & Duval provides mold parts for processes such as RTM, Infusion, Vacuum Bagging... with or without Autoclave curing... adapted for CFRP - Carbon Fiber Reinforced Polymers, honeycomb and prepreg. Our markets are structure and engine components, and helicopter blades.

Alloys with low thermal expansion coefficient

HPS

A&D grade | Common name
--- | ---
X205PF | 0-X30CN25-21

NISA

A&D grade | Common name
--- | ---
XN40F | 0-X30N6D40-20
XN50F | 0-NiC27Ti16W5
XN52F | 0-NiFe28Cr15
XN37F | 0-X30NiO/W6-25-4
PER101F | 0-NiCo4Cr10TiMo

Alloys with low thermal expansion coefficient

HPS

A&D grade | Common name
--- | ---
ENX106F | FeNi36
T7016 | Iron-Nickel alloy casting
TZ20 %Ni+Co | Iron-Nickel alloy casting

Titanium and Composites are becoming widely used for their mechanical properties due to their weight advantage. SuperPlastic Forming (SPF) is a well known solution for titanium hollow fan blades. Molded or injected composites can be found in nearly all aerospace sectors: civil and military fixed wings, helicopters, launchers, UAVs... When it comes to the corresponding tools, their design simplicity, life expectancy and heating/cooling speed are key parameters to optimizing manufacturing costs.

The Aubert & Duval Foundry is a dedicated high-tech and flexible workshop, integrated in a state-of-the-art steel mill. Thanks to its long experience, Aubert & Duval Foundry offers a wide range and cost efficient solutions:

- Large choice of high-performance steels (heat creep resistant, low thermal expansion) and nickel alloys.
- Single-block tools for large or extra-long dimensions: molded parts up to 12 m, with a maximum weight of 20 t.
- Complex designed and multi-part molds.
- Aerospace-level service in terms of quality, dependency and delivery.

Four-part mold for acoustic panel - no welding (Vacuum Bagging) Weight: 10 t

Mold for helicopter blades 9 m / 12 t 364 cm

Tooling for engine exhaust outlet

Tooling for fan blades

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Meeting our customers ever more demanding requirements

Aubert & Duval contributes to the global sustainability challenge. We work exclusively on fully and easily recyclable materials. By developing enhanced materials solutions, we allow our customers to build ever more fuel-saving aircraft. In addition, our production and warehousing sites are ISO 14001 certified.

Components and parts we produce at Aubert & Duval are critical and have to comply with the most stringent specifications. Therefore, our products go through advanced non-destructive tests:
- Magnetic particle inspection
- Fluorescent penetrant testing
- Red dye penetrant testing
- Eddy current testing
- Ultrasonic testing (including phased array)
- Radiographic testing

Many NDT are performed at different steps in the metallurgical process, from melting to the delivered parts. Aubert & Duval is accredited by COFREN to perform certification examination for level 1 and 2 in accordance with COSAC (EN 4179) and COPA (EN473).

We make sure we deliver the best product

Fully integrated tier 1 supplier

In fine metallurgy, each process step strongly depends on how the upstream ones have been carried out. In the past, a single person would master the whole chain from raw material selection to end-testing, thus ensuring the customer with an optimized flow. Today, thanks to its integration scheme, Aubert & Duval can provide the same kind of benefits, with the volumes, speed and quality corresponding to most modern requirements. We are today able to manage the full chain from raw materials to machining.

We already work together

- Airbus
- Aircelle
- Asco Industries
- Astrium
- AVIC
- Boeing
- Dassault
- Eurocopter
- General Electric
- Goodrich
- IHI
- ITP
- KHI
- Liebherr
- Messier-Bugatti-Dowty
- MTU
- Pratt & Whitney
- Ratier Figeac
- Rolls-Royce
- SHF
- Snecma
- Spirit
- Techspace Aero
- Turbomeca

... and many others

We make sure we deliver the best product

Improved performance

More reliable

Cleaner and safer

Sustainability

All our handled materials are systematically recycled. This is particularly necessary while only a part of the weight bought will actually fly. We contribute directly to environmental protection through the development of ever more effective materials. These combine several of the following features:
- Resistance to high-temperature, allowing the highest-yield engines.
- Lower density, to lighten the aircraft weight, hence also decrease fuel consumption.
- High intrinsic mechanical resistance, in order to use less materials.
- Surface immediately resistant to corrosion, to avoid hazardous chemical coatings.
We invest in new solutions

New materials

**HPS**

**ML340**
This duplex hardening grade is specifically adapted for turbine shafts operating at high temperatures (450°C/840°F) and requiring 2230 MPa/333 Ksi resistance. This allows savings in weight, together with engine efficiency improvement, hence lower gas consumption.

**HPS**

**MLX17 & MLX19**
These new precipitation hardening steels show a strength of 1700/1900 MPa (247/276 Ksi), and simultaneously keep an excellent resistance to stress-corrosion cracking. Eliminating the need for cadmium plating, it is a most environmentally friendly solution.

**AI**

**Aluminum-lithium alloys**
Aluminum lithium grades (such as 2199 in 2005) allow weight gain up to 4%. Their static properties are equivalent or higher to 7010/7050 and fatigue and rigidity properties improved more than 10%.

**NISA**

**AD730**
Design to improve engine efficiency and save fuel, AD730 is a fully-innovative nickel-based superalloy. It withstands higher temperatures (700°C/1,350°F) while preserving strength, creep and fatigue resistances at a competitive cost.

**New facilities**

**Coping with Titanium demand**
**UKAD**
Due to its density (4.5 vs 7.8 for steel) and high resistance to corrosion, titanium has become a more popular material for a variety of aerospace applications. We invested in a new 4,500 tons state-of-the-art fast forging press in the frame of UKAD, for an amount of 47 ME€. It allows the company to complement its integrated supply chain, and to market new products such as commercially pure and alloyed titanium bars.

**PM**

**Powder metallurgy**
With its sister-company Ernestel, Aubert & Duval is the world leader in this most promising technology. It offers a large range of grades, from alloyed steels, to Nickel and Cobalt superalloys, and even Titanium. Powders are then compacted and converted through different process routes like closed-die forging or extrusion. The whole Group operates an impressive 7 atomizing furnaces of all sizes, equipped to meet your most stringent cleanliness requirements. The latest addition – Durin™ furnace in Söderfors (Sweden) – guarantees available capacity for further development.

**HPS**

**New VIM furnace for larger ingots**
Aubert & Duval has recently extended its vacuum melting capacity by investing in a new VDP (Vacuum Induction Degassing & Pouring) furnace. This cutting-edge facility allows the casting of ingots of 20 t.

*UKAD is a S/50% Joint venture with UKTMP the leading Kazakhstan titanium one-to-ingot producer.*

Our R&D expenditure represents 4.7% of our added economic value.

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