



Technology

4 Aerospace Materials That Are Taking Off

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What You Need to Know:

To realize potential cost savings of 20 to 50 percent, manufacturing engineers are under pressure to use less fuel by reducing an aircraft's weight and ease some assembly burden.

Aluminum used to dominate aerospace materials, but now it's less than 20 percent. Composites, such as CFRPs, have taken flight.

Traditional aluminum is still part of aerospace machining; however, more aircraft structures are being composited of newer, modified heat-resistant alloys and lighter-weight composites.

Sometimes, it's not heat resistance or lighter-weight strength that aerospace manufacturers are after: It's fighting the electrical forces of nature. Enter nanoparticle and graphene.

The manufacturing industry is bolstered by engineering innovations in aerospace. Are you prepared to take advantage of the aircraft component and parts-making opportunities?

Make no mistake. Aerospace is a major force in manufacturing—and a vital boon to the metalworking industry.

First, take a look at the numbers: The top 100 aerospace and defense companies raked in \$709 billion in revenue and \$69 billion in profits in 2016, according to *PwC*. Global industry projections for aerospace materials are also robust. The materials market is projected to reach \$26 billion by 2022, at a compounded annual growth rate of 6.9 percent from 2017 to 2022, *according to* MarketsandMarkets Research.

What's fueling the growth? Demand for commercial air travel and an expected rise in defense spending, finds PwC, as well as an expanding global manufacturing base. But, most importantly, it's a nice chunk of the U.S. manufacturing economy, which means plenty of parts-making, aircraft components and custom subcontracting work from the major global aviation and defense players right here in the U.S.

"We expect this combination of a growing consumer base and low operating costs to benefit the aerospace components manufacturers and the OEMs well into the future," describes Michael Guckes, chief economist for Gardner Intelligence, in *Modern Machine Shop*.

While demand is steady, an effort to lower operating costs is also underway. To realize potential cost savings of 20 to 50 percent, manufacturing engineers are under pressure to use less fuel by reducing an aircraft's weight and ease some assembly burden. Some composites, for example, allow complex components to be assembled using automated layup machinery and rotational molding processes, according to *ThoughtCo*.

Modern Aerospace: A History in Aluminum

For nearly a century standing, the aerospace industry had relied primarily on aluminum to fabricate its parts—the same ingredient engineers tapped into when the first full metal aircraft was created in 1915. Aluminum was considered state-of-the-art and also conveniently inexpensive, notes *Composites Manufacturing Magazine*. And while the metal has served its purpose for the better part of 100 years, aerospace materials have changed.

"A typical jet built today is as little as 20 percent pure aluminum," notes Michael Standridge, an aerospace specialist at Sandvik Coromant, in an article for *Aerospace Manufacturing and Design*. "Most of the non-critical structural material—paneling and aesthetic interiors—now consist of even lighter-weight carbon fiber reinforced polymers (CFRPs) and honeycomb materials. Meanwhile, for engine parts and critical components, there is a simultaneous push for lower weight and higher temperature resistance for better fuel efficiency, bringing new or previously impractical-to-machine metals into the aerospace material mix."

Of course, this isn't necessarily news to aerospace engineers and manufacturers. Since the 1980s, businesses have been tinkering with alternative materials to create lighter, more aerodynamic planes able to withstand more extreme environmental conditions, including new composites and alloys, explains Standridge. So, what does it mean for machine shops and toolmakers?

"This will mean that machine tool providers will also need to be prepared to meet the growing and highly demanding needs of their customers at all levels of the aerospace manufacturing supply chain—having new equipment ready for sale and to be able to quickly support existing equipment maintenance and repair needs," says Guckes of Gardner Intelligence.

Here, we outline four of the most prominent (and promising) materials being used in aerospace machining and fabrication.

Aerospace as Adaptation: LeanWerks

Job shops and parts manufacturers often have to adopt what they make and whom they make it for in order to survive. Case in point: LeanWerks, a small precision parts manufacturer in Ogden, Utah, that designs and builds parts for a variety of industries including energy (oil and gas), medical, automotive and aerospace. LeanWerks' foray into aerospace is one of the more recent areas of focus for the company.

We *recently interviewed* the founder and president of LeanWerks, Reid Leland, to discuss how his company has adapted its work toward aerospace—and how it hires, trains and retains machinists who can work across all the nuances of these industries. We also discussed in detail how LeanWerks handles the skills gap.

The company had taken off making parts for the energy sector. Before 2014, the company had been investing heavily in machines with one major new piece of equipment every year. Then, the company's main industry focus had major systemic shifts, which meant the parts it was geared to build were no longer in high demand.

"At the end of 2014, there was almost no work in the oil and gas industry," *says* Leland. "In an effort to innovate our business model, we started venturing into aerospace and precision manufacturing companies, growing slowly but surely into 2017."

Challenging as it was, LeanWerks has adapted and is thriving. But it was not without its share of stress and evolution.

"[I]t was a fairly large jump from the oil and gas industries to aerospace and other industries. And it wasn't just a matter of understanding the new types of pieces we'd be working with ... From a technical standpoint, [it was also about] understanding the new materials and general requirements and certifications that we needed. It was a big challenge."

Leland's advice for others needing to expand? Make sure not to overextend.

"Though we could certainly afford a new, techy piece of equipment, this industry is based on ebbs and flows," *says* Leland. "When it's ebbing and you have a pile of debt, you can get into a pinch. My advice: Be careful and don't overextend."

1. Heat-Resistant and Lightweight Alloys

Traditional aluminum is still part of aerospace machining; however, the way in which that material is being crafted is changing. More and more aircraft structures are being composited of newer, modified alloys—including those materials previously thought to be too exotic, difficult to maneuver or expensive, reports *DesignNews*.

Heat-resistant alloys are often used to develop the engines (one of the most complex parts of the aircraft that needs to withstand scorching temperatures of 3,800 degrees Fahrenheit, or 2,100 degrees Celsius) and includes: **titanium alloys**, **nickel alloys** and **nonmetal composite materials** like **ceramics**, reports Standridge. Ceramics, however, can be *tough to shape*, despite their ability to withstand high temperatures. Titanium alloys, nickel alloys and nonmetal composite materials are similarly difficult to mend and mold without losing structural integrity.

Two specific alloys that have been around since the '70s, **titanium aluminide (TiAl)** and **aluminum lithium (Al-Li)**, are gaining popularity in the aerospace industry for their ability to withstand both high temperatures and improve the thrust-to-weight ratio in aircraft engines, as the two materials weigh half what traditional nickel alloys weigh.

"Case in point, both low-pressure turbine blades and high-pressure compressor blades, traditionally made of dense Ni-based super alloys, are now being machined from TiAl-based alloys," notes Standridge.

2. Composite Materials

Heat resistance is a top priority for engineers, but so is the overall weight of a material. Enter composites. According to *Polymer Technologies*, composite materials are lightweight, which enables manufacturers to build aircraft that are more fuel-efficient and ultimately safer for passengers. Composite material (or material comprised of metals or plastics with precise amounts of additives) use in aerospace has doubled every five years since 1987, finds *ThoughtCo*.

There are three main types of composite materials: carbon fiber, glass and aramid-reinforced epoxy. Carbon-fiber composite blends are the most poised for growth and innovation, according to *Composites Manufacturing Magazine*. The wings of Airbus' new A350 series, for example, are made up of more than 50 percent carbon fiber.

"Every pound on a plane—from passengers and luggage to airplane parts—equates to about \$10,000 in fuel costs every year. If you can reduce the weight of the airplane, you will reduce your fuel needs and lower operating costs," *explains* Carl Holt, an aerospace and composites marketing manager for Huntsman Advanced Materials. Airbus' XWB wings for its A350-1000 are the largest carbon fiber composite material-based piece in aerospace right now, a testament to the material's growth.

In addition, composites (and not just carbon fiber blends) can withstand high resistance and fatigue. And yet composites are not without their challenges. Airbus is seeing a mighty backlog as it aims to launch its composites-heavy A350-1000 plane.

"As everybody's understanding of this material continues to develop, we're trying to find the best way of using this material to achieve goals," *explains* David Hills, vice president of research and technology at Airbus Americas, to *Composites*. "That's not just in terms of how strong these components are, but also how [composites] fit into the total process of manufacturing, in terms of cost and maintaining these things out in the field."

Repairing composites, for example, is not the same as traditional aircraft. Often, repairs are done by hand. Cost of materials and production time are also major issues for aircraft manufacturers, but it is not thwarting research and development, *explains Composites*.

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Carl Holt

Aerospace and Composites Marketing Manager for Huntsman Advanced Materials

3. Nanoparticles

Sometimes, it's not heat resistance alone that aerospace manufacturers are after: It's fighting the electrical forces of nature.

Metal-matrix nanocomposites, also known as reinforced metal matrix composites, are “one of the most important nanocomposites for their high tensile strength and electrical conductivity,” finds AzoNano. There are several other types of nanoparticles being used, including polymer- and ceramics-based versions.

Unsurprisingly, aircraft are pretty susceptible to lightning strikes, which makes metallic underwiring (even with carbon fiber elements) a somewhat dangerous ingredient. To combat that danger, businesses use nanoparticles in the CFRP wing to help shield against electromagnetic interferences, finds *Composites Manufacturing Magazine*.

“Nanocomposites are the materials of [the] twenty-first century having an annual growth rate of 25 percent due to their multifunctional capabilities,” finds the *research paper*. “Applied Nanoscience.” “Chemical property like resistance or passiveness to corrosion is of prime importance [in aerospace]. Apart from low weight requirements, aerospace structures pose requirement of mechanical properties for design like strength, toughness, fatigue life, impact resistance and scratch resistance.”

4. Graphene

Graphene is a material more and more manufacturers are incorporating into their design. Why? Because of the variety of electrical applications. For one, graphene is used in epoxy resins that boost the electrical conductivity of carbon composites in fuselages.

“The aircraft industry relies heavily on composite materials, and lightning strikes pose a big risk, as composites tend to be inert and electricity wishes to find an earth,” explains Ray Gibbs, CEO at *Haydale*, in an *interview* for AzoNano. Companies, like Haydale, want to reduce or remove the copper mesh by having a conductive Faraday cage around the entire aircraft.

“We are a way off this becoming commercially available today, but it's potentially a highly lucrative operation,” says Gibbs.

On top of combating electrical activity, graphene is also known to help make airplane wings more efficient by reducing weight and fuel consumption, according to the article from *Composites*. Graphene is also ideal for electronics and wiring.

“Conventional commercial aircraft can use anything up to 60 miles of copper wiring to transmit power and communication; a substantial load for any aircraft to bear,” notes Liam Stoker, in a *blog on Aerospace Technology*.

As for widespread commercialization of the material, the aerospace industry still has some time, according to Gibbs: “It can take up to 10 years to qualify new materials in the aerospace industry,

particularly if it's in the framework of the aircraft--and rightly so."

Which aerospace materials does your shop use to make parts? Let us know in the comments below.

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