Better Aircraft Design For Lower Fuel And Maintenance Costs

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The International Air Transport Association (IATA) [1] predicts about 3.6 billion passengers will fly in 2016—an increase of 800 million since 2011. This demand is driven by several factors. During the last 40 years, the cost of flying has decreased by 60 percent while passenger growth has increased more than tenfold. Additionally, the introduction of larger, long range aircraft in the 1970s, deregulation in the 1980s, and the rise of online bookings in the 1990s, have all led to more opportunities for air travel.

Taking flight with improved design

The air transport industry has been through many economic dips during the past four decades, yet it has always bounced back quickly with travel demand higher than ever. However, the increasing volatility of aviation fuel prices has a significant impact on airline operating costs and profitability. In 2003, fuel costs accounted for 14 percent of operating costs [2]; in 2012, it accounted for 33 percent.

Combine the growing number of passengers, higher fuel costs, and the increased operating costs of aging aircraft fleets, and it’s no wonder the major civil OEMs are expected to deliver nearly $100 billion worth of aircraft in 2013 as production surpasses the record levels of last year.

Today’s generation of airliners aim to be game changers for customers in terms of reduced operating costs. For example, Canadian aircraft maker Bombardier's much anticipated CSeries boasts a host of technological advancements never seen before on commercial aircraft. In addition, their engineers have saved over 2,000 lbs [3].

through the use of composite materials in the wings, nacelles, rear fuselage, and empennage. They believe this will deliver savings of 20 percent less fuel than its closest competitors.

Boosting aircraft efficiency

Both the Airbus and the Boeing are spearheading the composite materials revolution, and although the introduction of new technologies has contributed to years of delays and cost overruns to their flagship programs, the operational efficiencies delivered to airlines is unprecedented. Almost half of the Boeing 787 [4] and Airbus A380 [5] airframes are comprised of composite and plastic materials which delivered a 20 percent weight reduction when compared to a more traditional aluminum airframe. If we consider the A380, a single kilogram of weight saved equates to 3,750 liters (991 gallons) of fuel saved over the life of the aircraft.

The key to delivering weight saving through the use of composites is in understanding how different materials react to different loads. Composite materials react very well to being loaded in tension, so they are ideally suited to the cyclical high tension loading experienced in the fuselage and wings. Introducing composites in these areas also significantly decreases the impact of the fatigue-related maintenance burden on the airline. Experience shows that aircraft manufactured with composite structures, already in service for many years, can require up to 35 percent less scheduled maintenance labor hours than traditional aluminum structures due to the greatly reduced risk of fatigue and corrosion.

In compression loading situations or where metallic materials perform better than composites, there is an increasing move towards titanium as a lightweight, low maintenance alternative to aluminum. Titanium alloys can withstand heavier loads better than aluminum while having greatly reduced fatigue concerns and excellent corrosion resistance.

The Airbus A380 has also made significant use of another new material, GLARE (Glass Laminate Aluminum Reinforced Epoxy) to replace traditional aluminum wing skins. GLARE displays better impact properties, fatigue characteristics, and corrosion resistance—all at a lower specific weight. Furthermore, as with other composites, the properties of this material can be tailored during manufacturing to modify the properties to match local stresses.

Looking ahead

Moving forward, we should see revolutionary new materials which have yet to be seen on current aircraft. Consider for example, Metal Matric Composites (MMCs), which combine an aluminum or titanium matrix with oxide, carbide or nitride, reinforcement. They have the potential to deliver many improvements over traditional materials including specific strength, stiffness and corrosion resistance at a lower density.

MMCs also have the potential to radically change product designs by utilizing near-net shape forming and selective reinforcement techniques. However, to realize these benefits, considerable research into manufacturing processes and costs need to be finalized. Other potential future material advancements include nanocomposites. Metal-matrix, polymer-matrix and ceramic-matrix are being considered, but currently, commercially producing sufficient nanoparticles is not possible without further developments in the production process.

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Links:
[1] http://www.iata.org/pressroom/pr/Pages/2012-12-06-01.aspx
[2] http://www.iata.org/pressroom/facts_figures/fact_sheets/pages/fuel.aspx
[3] http://www2.bombardier.com/en/3_0/3_8/market_forecast/BCA_2012_Market_Forecast.pdf
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