Advancement of thermoplastics in commercial aerospace

by Vic Hillyard

The Airbus A319 was the first commercial aircraft to dare to have a non-metallic leading edge on its wings — it used a PPS/ woven carbon fiber composite. However, since its first flight, the advancement in the use of thermoplastics within the airframe, engine and auxiliary systems of commercial aircraft, in Europe and the United States, has been slow, but steady.

In the 1970s, commercial airline objectives were weight reduction, increased safety factors, lower manufacturing costs and reduced maintenance schedules. To fulfill these goals, aerospace engineers looked to thermoplastic material manufacturers and component suppliers to develop the necessary resins, filler systems and manufacturing technology.

The industry responded with materials like polyetherimide (PEI) and polyarylsulphone (PAS), replacing flame retardant polycarbonate (PC), nylons and thermoset composite for interior use; polyetheretherketone, (PEEK), replacing metallic components in non-critical structural, fuel and electrical components; and acetal (POM) replacing metallic and sliding parts in galleys and service trolleys. These are but a few of the innovative products that should have transformed the aerospace industry in the United States.

TECAPEI GF 30 output pulley

In Europe, Airbus began training their commercial aviation engineers, (whose discipline included system, design and materials), to utilize these materials in order to achieve the objectives set. Not so in the United States, where traditional metallic philosophy often triumphed over new material technology.

Why? There are several factors:

We, the thermoplastics industry, did not, (and still don't!) have sufficient historical data to compare with the incumbent materials of manufacture. Aluminum, steel, titanium et al, have a proven track record, (40 years+) in this specification dominated industry. Thermoplastics have no such track record — yet.

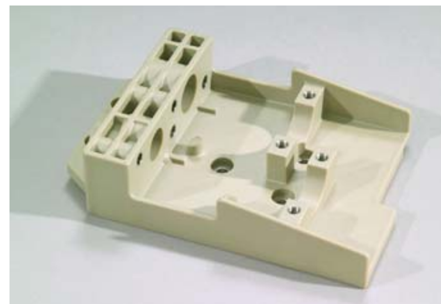
Thermoplastics do not have the strength of most metals — huge weight savings, yes; better corrosion resistance, of course; design flexibility, absolutely. But to an engineer who is comfortable with having a product with huge mechanical properties, none of this matters. That engineer will always take the tradition metallic solution, because, as in many walks of life, nobody wants to be the first, and fail.

The number of college graduates coming into the industry in North America with an aviation degree, and specific non-metallic expertise, is still a relatively low number compared to the more traditional material engineer.

Key decision makers in the aerospace industry will always opt for the "safe" solution, citing liability as their driver. The rewards of reduced weight, reduced maintenance costs, design flexibility, and more cost-effective manufacture, are shunned.

So, although commercial aerospace still continues to revolve around metallic properties and design, the small thermoplastic community within this sector, has begun to evolve.

New blends of materials, coupled with innovative filler systems, have begun to fulfill the technical and commercial requirements of the "New Age" airplanes, namely the B787 and A350/380.



TECAPEEK GF 30 sensor plate

To enable the use of these materials, a monumental change in the way materials are specified for aerospace has occurred. Boeing and Airbus have made their supply chain contractors responsible for complete systems, instead of individual components. By doing this, the responsibility (liability), for the materials in the system, is that of the contractor actually making the system.

Consequently the contractors, such as Honeywell, Goodrich, Moog, etc., are writing their own specifications for materials. This releases them from the shackles of having to meet ancient, metallic-based requirements written into many specifications, these documents having been written before many of today's engineering resins were commercially available, and hence were representing a major hurdle to the introduction of thermoplastics.

So how has the thermoplastic industry responded to this shift in material acceptance, and where has the impact been seen within the actual airframe?

Auxiliary components in the interior of all modern day aircraft now have to conform to new FAR specification 25.853. This was once a standard for machined aluminum and acetal stock; now these parts are made from a newly developed polyphenylene oxide, (modified PPO), or polytetrafluroethylene, (PTFE). Lighter, safer and more cost effective to manufacture, these parts make excellent candidates for replacing similar components in older airframes.

The specification for interior paneling has also been significantly tightened to reduce fire and toxic gas issues. Thin sheet, manufactured from pre-colored aircraft grade PEI and PAS, then vacuum or pressure formed to the final geometry, has given the airframe designer newfound opportunities to innovate, as seen in the "flat bed" concept on the B777.

Environmental control systems, once a staple for corrugated aluminum tube, plus thermoset tape wrapped wire, have been replaced with blow molded and extruded polycarbonate, (PC) and polyethylene, (PE), and a flexible PEEK insulator, which allows the assembly to conform to the new specifications. Waste liquid storage and control systems have switched to polyamideimide (PAI), from traditional aluminum and cast metal, giving excellent weight reduction, and better chemical resistance.

Conductive electrical applications have always been a difficult fit for thermoplastic, a material that is fundamentally an insulator. The resistivity required for varying levels of electrostatic dissipation (ESD) was achieved with carbon fibers and particulates, but always with a property or contamination penalty. Now, using carbon nano technology, and new blending techniques, the designer can actually quantify the required resistivity, and a thermoplastic formulation can be compounded to accurately reproduce that value. No more are all metallic systems required to achieve a safe and accurate level of ESD.

Similarly, where metal was thought to be the only method of shielding electrical systems from radar detection, or lightning strike, thermoplastic matrixes such as PEEK, polyphenylene sulphide (PPS), and polyamide (PA) coupled with glass and metal fibers, have sufficient conductivity and strength to provide light, yet protective materials for these application requirements.

The exterior of the airframe represents a completely different set of technical parameters. Rain and salt erosion, chemical resistance to incredibly aggressive fuels and oils, fatigue due to excessive mechanical demands, all made the environment for "standard" thermoplastics a seemingly impossible arena to play in.

And then along came the thermoplastic composite.

These continuous woven fiber materials, are impregnated with specific thermoplastic resins, PEEK and PPS being the most prevalent, to give a myriad of properties. Lightweight, chemical compatibility, cost effectiveness and structural strength have allowed these materials to be utilized on the exterior of both major air framers current and (hopefully) future designs.

With the thermoplastics industry now consolidating its vast portfolio of resins, finessing properties, forming amalgams, blending hybrids; with a seemingly endless menu of filler formulations; with manufacturing technology still evolving; and more importantly, more young innovative engineers and designers joining our ranks, I would say that the future and possibilities are limitless as confidence and success grows in the aerospace market sector. ■

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