Streamlining automated processes for composite airframe manufacturing

With the commercial aerospace industry spreading out across the globe, OEMs are facing growing pressure to be first to market with state-of-the-art aircraft. When you add the volatility of fuel prices and the need to reduce operating and total lifecycle costs, you can understand why aircraft manufacturers are rapidly adopting the use of advanced composite materials for primary structural components. These components include fuselage skins and substructure, wing skins, ribs, spars, stringers and shear clips, along with complete empennage assemblies and pressure bulkheads.

FiberSIM is a software suite that addresses the entire composite engineering process, from conception, laminate definition and ply creation through to simulation, performance optimization, flat pattern generation, documentation and manufacturing. SyncroFIT is a group of software products for authoring and managing the assembly interfaces and the hundreds of thousands of fasteners that are typical in an airframe. With the QPE, engineers are able to generate quality plans and inspection data based on design and manufacturing characteristics created by FiberSIM and SyncroFIT and saved in the CAD model.

Considering the manufacturing process

The use of composites introduces a high level of uncertainty and variability contrary to the well understood structural and...
Simulation

manufacturing behaviour of other materials, such as aluminium. Composite design requires a careful balance between the geometric requirements, the material form and the manufacturing process.

For example, a monolithic skin panel, a T-shaped stringer and a sandwich panel fairing must be treated differently. Likewise, different material forms, such as woven fabric, unidirectional tape or a non-crimp fabric, all represent unique design and manufacturing implications. Finally, the manufacturing process, such as hand layup, automated tape laying, automated fibre placement, resin transfer moulding (RTM) or forming, needs to be taken into consideration. The specific combination of these variables influences the design approach and, ultimately, the cost and quality of the finished product. Balancing all of these elements constitutes a significant challenge. A solution that incorporates simulation capabilities tailored to the specific material and manufacturing process will provide early visibility into the challenges that will occur during the build process.

Improving the engineering environment

In an effort to increase throughput, cut production costs and improve quality and repeatability, automated deposition processes are quickly becoming the manufacturing method of choice for composite aerostructure components. Unlike the NC machining of metals or the injection moulding of plastics, manufacturers of automated processing equipment for composites are installing relatively few systems per year as opposed to the thousands being installed for the automated manufacture of other materials. However, some analysts estimate that within the next decade, more than 75% of composite parts will be manufactured with an automated fibre placement, tape laying or robotic deposition process instead of hand layup, which will drive demand for new systems.

Regardless of the method, it is clear that we are still in the very early stages of a major transformation in the way that composites are manufactured. Cycle times will decrease significantly, part quality will improve, and design-for-manufacturing techniques will evolve to the point where surprises will be rare during machine run time.

To keep pace with this evolution, the capabilities of composite design software must likewise evolve. Just as hand layup requires the ability to manage the complex splicing and staggering requirements imposed with fixed-width conventional materials, producibility simulations that mimic hand smoothing techniques and the generation of suitably shaped flat patterns, automated processes will require their own set of innovative design-for-manufacturing capabilities.

For example, a machine limitation such as a minimum course length induces a design constraint which can affect ply boundaries, potentially interfere with mating part footprints, and influence part weight. Identification of such constraints must therefore be highlighted and addressed during the design process rather than being left for manufacturers to resolve. Ignoring these critical manufacturing requirements in design will inevitably result in costly design iterations, over-design, and situations where as-built does not conform to as-designed, a significant certification risk.

By working closely with the manufacturers of automated deposition systems and CAM software for composites, a set of requirements has emerged that enhances the engineering environment so that the design of composite components for automated manufacturing can be fully defined and optimized.

Minimum course length, staggered ply origins, minimum strip width and minimum cut angles are some of these manufacturing requirements that are part of FiberSIM software. And with the composite manufacturing industry leaning toward machine-independent part definition, additional functions are likely to become part of the design environment. However, a separate category of machine-specific, run-time parameters will still remain part of the offline and machine programming CAM software environment.

Managing airframe assembly complexities

With the increased usage of composites and the ability to tailor thicknesses to support loading conditions, the specification of fasteners is becoming unmanageable. A number of issues, such as material compatibility, hole preparation methods, structural requirements, and cost and lead time implications of specialized fasteners, are raising
Simulation concerns. It is generally acknowledged that nearly 15% of detail design activity is associated with managing assembly interfaces, fasteners and holes. In fact, industry figures show that more than 50% of these problems are associated with assembly definitions.

When you couple these definition issues with the automated drilling and fastener methods used to improve quality and cut cycle times, you have significant challenges. You need to precisely control feed rates and drill speeds through stacks to avoid potential damage to the composite material from drill break-through or chip extraction. NC programmers require detailed stack thickness and material information to properly throttle drilling operations. Typically, significant time is required to obtain this information on each fastener location. As programs progress through the development process and subsequently involve sustaining engineering efforts, it will be critical to have a solution that reduces cycle times to implement changes and eliminate errors.

With a clear understanding of these challenges, VISTAGY realizes the importance of having a solution to manage the complexities associated with modern airframes containing numerous joints and fasteners. This is where SyncroFIT comes in.

With the unique capability to capture assembly joint definitions and manage the interactions between both modelled and non-modelled components, SyncroFIT is enabling firms to reduce engineering development times, effectively manage the change process, and reduce the number of engineering change orders that are typical in an aircraft program. It automates tedious tasks, such as computing grip lengths, loading and positioning hardware or temporarily installing a clearance solid to detect potential collisions upon assembly. Managing the airframe as a series of joint definitions allows the engineer and downstream consumers to navigate the assembly in a logical way. It provides the capability to fully define the part stack-up and feed NC programming systems with the information required to drive automated drilling and fastening systems.

Keeping up with change

Design changes in the engineering process are inevitable and can cause significant disruption. Consider the cascading impact of a skin thickness change in a fuselage panel that is implemented as part of a weight-saving initiative. In an engineering design, such a change may affect laminate stack-up, ply drop-off locations and shapes, the skin inner tool surface, the substructure mating surfaces, fastener specifications and, ultimately, weight and balance. In manufacturing engineering, the change may affect the ply layup tables, the bill of materials, the supplier build-to packages and the maintenance and service documentation.

In manufacturing, the change may affect the fibre placement programs, the composite flat patterns, the automated drilling and fastening program, the laser projection files and the process plans. In tooling manufacturing, the skin IML tooling and the substructure tooling may change. Finally, the First Article Inspection plan and other QA documents might change as well. The issue is not the implications of a single change, but that it takes only a couple of inconsistencies or missteps in the change process to derail a whole development program. Getting the change process correct requires a combination of expertise in design, analysis, manufacturing and process planning, all within the context of a composite material environment.

Optimizing critical processes

Manufacturing aeronautics is becoming pervasive in aerospace composites. As a result, aerospace firms need to take a more comprehensive approach to the design and manufacture of composite parts and assemblies. Efficient composite engineering tools extend beyond CAD, PDM and CAE to encompass an airframe engineering-specific view of the process and product details.

Ultimately, the foremost challenge facing designers and manufacturing engineers is the need to recognize and rapidly accommodate the inevitable changes that occur throughout the development process without errors and costly delays. As the role of composites continues to evolve, software developers, including VISTAGY and its partners, are committed to delivering solutions that will empower aerospace firms to continuously optimize the design-to-manufacture process.

More information: www.vistagy.com