Automating Thermoplastic Composite Processes for Increased Productivity and Quality

Accudyne Systems, Inc
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VP Sales & Marketing
Company Overview

- Located in Newark, DE
- Established in 1996
- 32 Employees
- 70,000 Sq Ft Facility
- CAD Design, Engineering, Machining, Electrical, Assembly, Buy-off
Technology Segments

Factory Automation

Separations Technology

Unique Challenges

Composite Materials Processing
Technology Segments

- Factory Automation
- Separations Technology
- Unique Challenges
- Composite Materials Processing
Equipment Class

Part-purpose
Right-sized
Custom Automation Machines
Areas of Expertise

- Materials Preparation
- Pick and Place Lamination
- Composite Forming
- Fiber Placement
Partial Customer List

- Boeing
- Bell Helicopter
- Airbus
- GE Aviation
- Spirit AeroSystems
- Rolls-Royce
- GKN Aerospace
- Orbital ATK
- Triumph Group, Inc.
- Northrop Grumman
- NASA
- General Dynamics
- Lockheed Martin
Production Parts

- 787 Dreamliner
  - Stringer Charges
  - Stringer Bladder (Tool) Wraps
  - Radius Fillers (Noodles)
  - Engine Containment Cases
  - Brackets & Clips
  - Single and Double Omega Stringers

- V-22 Osprey
  - Blade Grips
  - Stringers

- A350 XWB
  - Single and Double Omega Stringers
Topics for Review

- T/P Filament Winding
- Laminate Formation
  - In-situ Consolidation
  - Tacking
- Intermediate Construction
  - Cross-Ply
  - Off-Axis
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Filament Wound T/P Parts
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T/P Filament Winder

- Winds 2 ends of ½” (12.7mm) wide tow
- Fully automated tension and temperature control
- Hot shoe & hot gas torches heat material
- Up to 30 ft/min
- Fully consolidated (<1% void) parts
T/P Filament Winder
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In-Situ Thermoplastic AFP & ATL

- Processes tape or 12 tow ends
- Start on part capable
- Closed-Loop substrate preheat
- Heated laydown nip
- Cut-on-fly capable
- Composite products include skin/stringer, honeycomb, and TiGr laminates
- Conformable heads developed
- Out of autoclave processing
In-Situ Thermoplastic ATL Machine & Head
In-Situ T/P Head

Pressure Zone
Over 100 Panels Produced
Process Speed vs Laminate Quality

- Laminate quality modeling indicated a process velocity limit of 0.03 to 0.15 mpm (0.1 to 0.5 fpm)

- Fabricated laminates bore this out - Quality improved as placement speeds slowed from 1.83 mpm to 0.30 mpm to 0.15 mpm
Tape Quality Affects Laminate Quality

**Material “A”**
- Elevated voids
- Thickness variation
- Variable fiber/resin distribution
- One resin-rich side

**Material “B”**
- Minimal voids
- Uniform Thickness
- Uniform fiber/resin distribution
- Similar resin content both sides
In-Situ vs Autoclave Properties

![Graph showing In-Situ vs Autoclave Properties](image)

- **Axial Compression**
  - In-Situ Mat'l "A": 481 Mpa
  - In-Situ Mat'l "B": 513 Mpa
  - Autoclaved Mat'l "A": 541 Mpa
  - Percentage: 95%

- **Open Hole Compression**
  - In-Situ Mat'l "A": 294 Mpa
  - In-Situ Mat'l "B": 294 Mpa
  - Autoclaved Mat'l "A": 330 Mpa
  - Percentage: 89%

- **In-Plane Shear**
  - In-Situ Mat'l "A": 133 Mpa
  - In-Situ Mat'l "B": 154 Mpa
  - Autoclaved Mat'l "A": 174 Mpa
  - Percentage: 89%
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Tacking T/P AFP or ATL Head

- Processes 3” tape or 12 tow ends
- Start on part capable
- Closed-Loop substrate preheat
- Heated laydown nip
- Cut-on-fly capable
- Speeds up to 40 ft/min
Thermoplastic Stacker / Tacker

- Capable of tacking continuous or discontinuous plies
- Ultrasonic cutting of edge trim
- Roll widths up to 4” (102mm) with wider widths possible
- Wide range of fiber orientations possible.
- 18'/min (5.5m/min) material laydown rate
T/P Helmet Preform Machine

- Pre-cut plies placed in separate stacks
- Small gantry with vacuum end-effector picks up ply and places onto tool
- Heat and pressure are then applied to secure the ply to the previous ply
- Ply placed and formed every 20 seconds
T/P Helmet Preform Machine
Ply Stacker / Staker

- Pre-cut sheets of different orientations are placed in separate bins
- Robot moves T/P sheets via vacuum end effector
- Stacked plies are heat staked together using 4 hot, thin rods
- Ply placed every 6 seconds
Ply Stacker / Staker
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Raw Material Considerations

- Many aircraft and automotive applications require no overlap and less than 0.020” gap for cross-ply applications.
- When welding/seaming two pieces together and/or producing continuous rolls of off-axis material, no gap is often required.
- Tolerances of raw materials play a significant role in productivity and scrap for automated systems. These include:
  - Edge Straightness (straight vs varying)
  - Surface Topography (flat vs wavy)
  - Fiber/Resin Distribution (uniform vs irregular)
  - Void Content (low vs high)
T/P Cross-Ply Machine

- Low cost automotive application
- 108” (2743 mm) wide continuous 0/90 panels
- Polyethylene/Glass
- Replaces woven material with 2-ply tape
- “Heat staked” for later consolidation
Cross-Ply Laminator / Tacker

- 0/+θ & 0/-θ laminates
- 0.030” (.75 mm) gap
- Heat Tacked
- Guillotine cutters
- 25 lbs/hr (11.4 kg/hr)
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Variable Angle T/S Laminator

- Variable angle continuous web
- Any angle from 30° to -30°
- Up to 30” (762 mm) wide web
- Inline slitting
- Place up to 24” (610 mm) wide uni-tape
- 0 lap, 0.040” gap
- 53 lb/hr (24kg/hr) (12” tape)
Pick-and-Place T/S Off-Axis Laminator

- Multi Degree Tape Machine
- Produces 45° to 90° degree tape from unidirectional tape
- Eliminates need for Gerber cutting of plies
- Eliminates ply kitting
- Reduces scrap
T/P Off-Axis Ply Welder

- Joins pre-cut sheets of T/P composites such as PEEK & PEKK
- Robot picks up individual sheet and places near previously placed sheet
- Lasers close ply gap to b/t .000” and .005”
- Welding devices join plies with no gap
- Laser inspects weld seam
- Material wound onto roll
IR Oven & Transfer Station for T/P Panels

- 24” x 24” platen area
- 150 ton press
- Tool heating & cooling
- IR heating of blank
- Automatic blank insertion & part ejection
- 4 inch/sec closing rate
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“Automation of T/P composite processes offers the means to increase productivity, quality and consistency for many areas within the manufacturing steps necessary to produce T/P composite parts.”

Mike Smoot – ORNL 4/6/17
Thank You!