Automated Tape Layer Processing for Composite Components

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Key Discussion Topics …….

◆ Automated Tape Layer Background
    …… development history

◆ Review of Automated Tape Layer Technology
    …… material delivery technology

◆ How Tape Layers Are Currently Used
    …… some aerospace applications

◆ Potential for Non-Aerospace Applications

◆ Presentation Summary
What is an Automated Tape Layer (ATL)?

- Tape Layers are “composites machine tools”
- Computer controlled machine movements
- Multi-axis gantry with rack & pinion drives
- Automated placement of prepreg tape materials on a tool surface
  
  Tape widths of 3” ... 6” ... 12”

Tape Layers are known as a high output process ........ with limited applications
Automated Tape Layer System

- Cross Rail Gantry (Y-axis)
- Machine Z-axis
- X-axis rail & supports
- Material Delivery Head

Cincinnati Machine ATL System
Taper Layers were developed specifically for laying a new material form …… uni-tape

ATL was first automated process for composite aircraft primary structure

Unidirectional tape invented in the early 60’s ………. ATL process development in the late 1960’s

First commercial machines available in late 1970’s
ATL Development ...........

ATL process was developed by a collaboration of aerospace companies and material suppliers.

First ATL systems were small, fixed bed machines similar to metal cutting "skin mills"
ATL History

- Tape Layers were used extensively in the 1980’s on military aircraft programs
  - B2 Stealth Bomber and other programs
- Machine sales were very good in the 1980’s ..... reached a peak in 1988
  - Eight (8) large systems installed in 1988
- Interest in ATL declined in the 1990’s due to lack of applications ... and aerospace industry focus on fiber placement and RTM processes
  - ATL was the forgotten process
In the last few years, interest in ATL has re-emerged in the aircraft industry. New aircraft programs are providing good applications for the ATL process. Companies who operate ATL systems have discovered new ways to use the machines and take advantage of their high output rates.

Automated Tape Layers will be used to build wing structure on the new Boeing 787.
Automated Tape Layer Technology
Tape Layer Technology ..........

**Contour Tape Layer Machine (CTLM)**

For laying tape on a contoured surface. CTLM’s lay 3 in and 6 in wide tape.

**Flat Tape Layer Machine (FTLM)**

For laying flat laminates ...... FTLM’s lay 6 in and 12 in wide tape. FTLM combined with a “hot forming” process makes the tape layer process very versatile.

Most tape layers operating in the industry today are contour layers.
ATL Material Delivery Technology 

**Single-Phase Process** ........... tape materials are processed through a delivery head that cuts individual courses to shape and length (industry standard)

**Two-Phase Process** ........... tape courses are cut off-line ..... re-spooled on a cassette ..... and transferred to a laying machine

**Dual-Phase Process** ........... combines the single and two phase processes on one delivery head

Dual-Phase processing is the most versatile and efficient form of automated tape laying
**Single-Phase Tape Laying ……**

Entire process is completed on the gantry machine …. the industry standard technology

Tape material is cut to size and shape as it passes through the delivery head ….. and applied to the tool with compaction pressure
Two-Phase Tape Laying ......

Tape courses are cut to shape and size “off-line”... re-spooled on a cassette ... transferred to a laying machine

Off-Line Cutting System
Off-line cutting system will create a wide variety of shapes .......

Triangles, Arcs, Cutouts, Square cuts, Angle cuts
Dual-Phase Tape Laying

Dual-Phase tape layers will be used to build the Boeing 787 wing box.
Example of Dual-Phase ATL Processing

Two-Phase processing is faster than Single-Phase as the machine does not slow or stop for material cuts.

Horizontal Stabilizer Skin
Suppliers of ATL Systems .......

**Cincinnati Machine** .. the leading supplier

**Forest-Line** ............. European company .... has all (3) material delivery systems ... unique gantry

**Torres Machine** ........ European company .... most sales in Europe

**American GFM** ........ small ATL system
**Unique ATL Technology ……**

Forest-Line Tape Layers are the most unique machines in the composites industry

- Gantry machine tool has Linear motor drives on X, Y, and Z axis
- Faster axis speeds
- Quiet operation
- X-axis rails are supported by concrete piers
- Integral with machine foundation
## Who Uses ATL Processing .......

### NORTH AMERICA

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Automated Tape Layer Applications
Airbus uses tape layers for fabrication of the vertical and horizontal stabilizer on most aircraft.

- A330 / A340
- A340-500 / 600
- A318 / A319 / A320
  - A321
- A380
- A350 (most likely)
Boeing Tape Layer Applications

Boeing is the USA leader in tape layer processing
- 777 Empennage
- B2 Bomber
- F-22 Raptor
- 787 Dreamliner

Boeing 777 Empennage skin lay up on CTLM
Mitsubishi Heavy Industries will build 787 wing box with ATL

Fuji Heavy Industries will build 787 center wing box with ATL
Summary of ATL Processing ……

- Tape Layers have built more large primary structural components than any other aerospace industry composites process
  Mostly aircraft empennage structure
- Pre-plying / hot forming process has opened up a wide variety of parts that can be made with automated tape layers

Automated Tape Layer processing may be applicable to non-aerospace applications
Potential for Non-Aerospace Applications
A large ATL system combined with a “hot forming” process could produce enough parts for a low rate production automobile (sports car)

- Fast lay up of 120 ft x 20 ft tape laminate
  Machine also lays localized doublers/stiffeners
- Process is compatible with low cost prepregs
  “Golf shaft” prepreg materials ($10 - $12 per lb)
- ATL system could also be used as a “cutting table” to kit laminate into individual parts

Approximately 200 - 300 formable panels could be produced daily on 3-shift operation
**ATL for Non-Aerospace Applications**

- Parts should be low complexity shapes ..... specifically designed for the process
  - Minimize compound curvature
  - Hood .......... Top ............ Body Panels
- Laminate could be a combination of fabric and **tape** (Fabric on inside and outside surface)
- Autoclave cure .... oven cure may be feasible

*The bad news ...... this process would require a lot of individual tools .... but composite cure tools could be made off a master model*
ATL system can also function as a “kitting” machine … cut laminate into individual parts.

130 ft x 23 ft version of this gantry machine has already been built.

Top panel with stiffening strips.

Tooling and cure issues would need development.
Automated Tape Layers have excellent material lay up rate capabilities

ATL can process a variety of materials

Tape layers can be built in large sizes to produce a volume of parts required for some auto parts

Efficient lay up of large flat laminates

The combination of huge machine sizes, excellent lay up rates, and hot forming processes may be attractive for some automotive parts