Composite Safety Meeting and Workshop [CAANZ, Wellington, New Zealand]

MHI composite technology - Status and Future -

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Achievement and Challenge – MHI Composite Application History

【MHI Composite Application History and Achievement】
Since early 1980’s, Started Composite application in aircraft structure. Aggressive development activities led by Japan’s self-defense force has borne much fruit, such as co-cured wing-box in F-2 Support Fighter. Turning into 21st Century, composite application has been spread out into commercial airplane. MHI has been contributing to develop / produce wing-box on Boeing 787 and now making composite empennage on next coming MRJ.

◆ Achievement
To realize co-cured and co-bonded composite structure

◆ Challenge = Low Cost Volume Production

Cost Contributor
* Material / Fabrication Process - Too expensive compared to Metal
* Parts Fabrication - Bunch of elaboration compared to Metal counterparts
* Assembly - Bunch of Fasteners needed
Today — Composite Structure Production

- Parts Fabrication & Assembly are two major cost drivers, even though all processes hold high cost issues.
- High Cost & Low Produce-ability compared to Metallic structure.

<Material>
Too Expensive

<Assembly>
- Hole Prep. Fastening, EME Protection
  - Weight Up
  - High Cost

<Sub Assy>
- Skin-Stringer Panel
- Shim Operation due to poor geometry
- Time & Cost Issue
  - Measure
  - Shim Prep.
- High Cost

<Parts>
- Gigantic Jigs for realizing geometrical accuracy
- Complicated Fabrication
- High Cost

<Shimming>
- Crack Delam. Prevention Feature
  - Hole Prep.
  - Fastening
- High Cost
- Strength Down

Cost Distribution
- Material Cost
- Energy
- Bunch of Bolts

Inside of the Tank
Sealant Coverage

MHI Proprietary

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Old Days ~2000

「Hand Craft Products」
◆ Hand Lay-up

Today 2003~ After Boeing787

「Industrial Products」
◆ Automated Lay-Down

SKIN

Ref : G. Hasko, An Introduction to Aerospace Composite Manufacturing Technology

Ref : http://www.compositesworld.com/

Stringer and other Skeletal Parts

● In-efficient and Low Produce-ability

Lay-down up to more than 100plies

Hot Drape Forming

Multi-Parts Assemble & Co-cure

Vacuuming

Even in similar geometrical Parts, Needed parts-by-parts procedures.

Half Day Curing

At last, One parts finished !!

Curing

Demolding

Machine & Finish

Part

出典: 三菱重工技報 Vol.51 No.4 (2014)
Cost Contributor – Parts Fabrication

Compared to Metal counterparts, **Bunch of elaboration = Cost** Needed in Today’s Composite Fabrication.

**Stringer and other Skeletal Parts**
- In-efficient and Low Produce-ability
  - Lay-down up to more than 100plies
- Even in similar geometrical Parts, Needed parts-by-parts procedures.

**Metal Stringer Fabrication (Example)**
- Standard Parts & Finishing
  - Extrusion (Ex.)
  - Standard Parts
  - Rolled & Tapped Forming
  - Part
  - Machine Finish
  - Finish !

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Composite application on aircraft have become popular.

But need pursue more aggressive cost target for meeting fierce market challenge.

Thus, future target on composite is

To realize head-to-head competitive production cost against traditional metallic structure

- **Material** DOWN
- **Parts Fabrication** DOWN
- **Assembly** DOWN
- **Less Usage** DOWN

Dramatically Cost Down!!

**<< Opportunity >>**

- Innovation on Parts Fabrication
- To realize Bonded Structure
How to achieve the Goal – Innovation on Parts Fab.

◆ Standardization

Today
Every single part has unique geometry.
Thus, Need independent fabrication tool / process even in very similar parts.

Quality Concerns, such as fiber wrinkles, due to aggressive contour, joggle … Long process time is also concern.

Future
Standardization needed for realizing Metal-equivalent fabrication cost.
Drape-ability suited for contour and joggle.
To realize short process time

Candidate Technology

Textile and Thermo-Plastic

Textile & CFRTP

CFRTP = Carbon Fiber Reinforced Thermo-Plastic

Future Aircraft
How to achieve the Goal – Bonded Structure

◆ To realize Bonded Structure

Today
Panel-level unified structure realized utilizing co-cure / co-bond technology.
Still, Need far trek toward realizing bonded construction due to less-reliable process
and lack in prevalent quality assurance procedures.

Future
To realize Bonded Structure and fully utilize composite advantage w/less Fastener counts.

Expected Technology ◆ Stable Bond w/Robust Process
◆ Quality Assurance for Weak/Kissing Bond

◆ Strength Degradation due to Hole Prep.

To eliminate / decrease Fastener counts using bonded technology
How to achieve the Goal – Bonded Structure

Bunch of parameters affects Quality and Strength on Bonded Joints

Assembly & Curing Process

- Time
- Parts Gap
- Pressure
- Curing Temperature
- Trapped Air
- Multiple Cure Cycles

Bond Strength
- Toughness & Failure Mode
- Shear & Flat-wise Strength

Void / Porosity

Wettability
- Adhesive Thickness

Surface preparation on Composite
- Surface Energy
- Contamination
- Pre-Bond Humidity
- Surface Roughness
- Adhesive Thickness

Parts Gap
- Time
- Pressure
- Curing Temperature
- Trapped Air
- Multiple Cure Cycles

MHI Proprietary
How to achieve the Goal – Bonded Structure

Process Parameters
- Contamination
- Humidity
- Pressure
- Temperature
- Surface Preparation
- Exposure Time after Surface Prep.
- etc.

Clarification of the Missing Link

Process

Chemical/Physical State of Bond Surface

Bonding Process to Enable Chemical Cross-link

Minimizing Variability by Process Automation

Statistics Based Strength Prediction from Process Record

Certification on Bonded Structure

Crack/Delam. Propagation Prevention Feature

Proof Test

Non-Destructive Inspection Method for Weak & Kissing Bond

Several Routs leading to the goal, or Certification.
⇒ Discuss & Find the Solution for future Aircraft !!

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Thank you for your attention!

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