Method to Generate Full-Span Ice Shape on Swept Wing Using Icing Tunnel Data

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Introduction

• Current collaborative research program to improve the fidelity of experimental and computational simulation methods for swept-wing ice accretion formulations.
  • NASA, FAA, ONERA, and university partners.
• Utilize 65% scale Common Research Model.
  • Ice shapes obtained in NASA Icing Research Tunnel
  • Hybrid models from 20%, 64%, and 83% span used
  • Models have full-scale leading edge
• Full-span ice shapes required for aerodynamic testing.
Introduction (cont’d)

- Each IRT models can generate 1 ft span of ice.
- Full-span ice shapes require 75 ft of ice.
- Large gaps between the three spanwise ice sections.
- Method developed to generate full-span ice shapes from the three 1 ft span ice shapes
Introduction (cont’d)

IRT Test Section

CRM - 65%
Ice Scan Data Acquisition Procedure

The IRT scanner data acquisition procedure:

1. Accrete ice on the test article
2. Spray the ice with white paint
3. Install and set up the scanner
4. Scan the ice shape
Ice Scan Data Processing Procedure

The IRT scanner data processing procedure consisted of the following five steps:

1. Align/combine scan passes
2. Reduce data set
3. Wrap surface
4. Repair mesh/fill holes
5. Coordinate transformation
3D Ice Shape Scanning Methodology


Ice Interpolation Methodology

• Interpolate ice shapes between the scanned sections.
  • Utilize weighted averaging function in Geomagic Studio.
  • Results in “morphing” of ice shape from scanned section into an unscanned section.

• Demonstrated using existing scanned ice shapes from a swept NACA 0012 airfoil
Begin with rime ice shape

- Trim rime ice shape

Average the rime and scalloped ice shapes in layers using a weighting technique

- Line up averaged layers to create a smooth transition

Combine layers to create a single object

Begin with scalloped ice shape

- Trim scalloped ice shape

Ice Interpolation Methodology
Ice Generation Methodology

• A variety of combinations of rime, horn, and scalloped ice were morphed
• 3 main categories
  – Basic morphing on a straight wing
  – Twist and taper without morphing
  – Twist and taper with morphing
Rime to Horn
Rime to Scallop
Horn With Twist

5° twist
Rime to Scallop With Twist and Taper

5° twist & 0.5 scale taper
Comparison of Interpolation Method to Real Ice

NACA 0012, $\alpha = 0^\circ$, $\Lambda = 45^\circ$
Comparison of Interpolation Method to Real Ice
Areas for Improvement

- Spikes
- Seams
Conclusion

• Method developed to generate a full-span ice shape from partial spanwise section.
• Interpolated the ice shapes between the scanned sections using the weighted averaging function in Geomagic Studio.
• This procedure demonstrated using existing scanned ice shapes from a swept NACA 0012 airfoil.
• Initial results are promising.
• It was used to interpolate ice shapes between horn and rime shapes as well as scallop and rime shapes. This could also work with twisted and tapered wing.
• The ability to interpolate between two very different types of ice shape demonstrated.
Conclusion (cont’d)

• The resultant interpolated or “morphed” ice shape usually contains some surface artifacts, such as spikes or repeated patterns.
• These will be removed using a commercially available software called Geomagic Freeform.
• This software allows the user to hand-manipulate the interpolated ice shapes and will be used to remove these artifacts and also perform final touch-up on the ice shapes.