UNSTRUCTURED GRID RESEARCH AND USE AT NASA LEWIS RESEARCH CENTER

MARK G. POTAPCZUK
NASA LEWIS RESEARCH CENTER
CFD Applications at Lewis Research Center

- Inlets, Nozzles, and Ducts

- Turbomachinery

- Propellers - Ducted and Unducted

- Aircraft Icing

Grid Generation Development and Use at Lewis Research Center

- Inlets and Nozzles
  - GRIDGEN
  - TURBO-I/SG

- Turbomachinery and Propellers
  - TIGER
  - TGRID
  - TIGMIC
  - IGB
  - TIGGERC
  - HGRID
  - TRBGRD

- General
  - GENIE
  - RAMPANT
  - ICEM

- Aircraft Icing
  - HYPGRID
  - GRAPE
  - MINMESH
Some Issues related to Internal Flow Grid Generation

- Resolution requirements on several boundaries
- Shock resolution vs. grid periodicity
- Grid spacing at blade/shroud gap
- Grid generation in turbine blade passages
- Grid generation for Inlet/Nozzle geometries

Resolution Requirements on Several Boundaries

- Internal flow problems may have many intersecting surfaces
- Resolution requirements along surfaces may vary
- Structured grid generators can have great difficulty in meeting both requirements simultaneously
Resolution Requirements on Several Boundaries

Shock Resolution vs. Grid Periodicity

- Shock locations on upper and lower blade surfaces of cascade occur at different chordwise locations

- Geometry of shock does not correspond to direction of grid lines

- These two requirements result in highly skewed grids and in an excessive number of grid points
Grid Spacing at Blade/Shroud Gap

- Small gap (<.2% of blade span) exists between rotor blades and surrounding shroud

- Attempts at modeling gap result in high grid skewing and large number of grid points

- Many structured grid solutions neglect the gap region

Surface Triangulation of Oxidizer Turbine Rotor
Grid Generation in Turbine Blade Passages

- Complex geometry and viscous flow modeling results in:
  - Multi-block grid
  - Large number of grid points
  - Labor-intensive grid generation effort

- Automatic generation of internal grid points is required
Grid Generation in Turbine Blade Passages

Grid Generation for Inlet/Nozzle Geometries

- Rapidly varying flow passage geometries can result in difficult blocking schemes

- Interfacing of blocks at regions of rapid geometry change can be difficult to achieve

- Geometry and flow phenomena resolution requirements can be conflicting and result in excessively large grids

- Grid development time can be extensive
PRATT & WHITNEY 2D MIXER-EJECTOR NOZZLE GEOMETRY

CROSS SECTION MODELED

AXIAL CUTS THROUGH 3-D GRID

X = 2.13  X = 4.06  X = 5.67  X = 6.62  X = 15.35  X = 17.08
Aircraft Icing Grid Generation Issues

- Small structures relative to airfoil chord must be resolved
- Excessive number of grid points in far-field using structured grid
- Grid must be re-created as ice shape grows

NACA 0012 Airfoil with Simulated Glaze Ice

\(M_\infty = 0.12, \alpha = 4^\circ\)
LEWICE/UE Ice Shape Prediction for Iced NACA 0012 Airfoil
Example 2, Clean Airfoil Calculation
\( \text{Mach} = 0.4, \alpha = 4^\circ \)

Mesh

Normalized Pressure
\( \frac{P}{P_\infty} \)

LEWICE/UE Ice Shape Prediction for Iced NACA 0012 Airfoil
Example 2, Time = 60 sec.
\( \text{Mach} = 0.4, \alpha = 4^\circ \)

Mesh

Normalized Pressure
\( \frac{P}{P_\infty} \)
Concluding Remarks

- LeRC has several general-purpose and many application-specific grid generators for internal flow CFD analysis

- LeRC has some unstructured grid generation development activities in-house targeted at internal flow problems

- Unstructured grids can simplify and in some cases enable CFD analysis of internal flow geometries

- Unstructured grids are ideally suited for complex, changing geometries such as ice growth on aircraft surfaces