AERODYNAMIC SURFACE DESIGN METHODOLOGY

Transonic CFD Peer Review

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CURRENT TRANSONIC DESIGN METHODS

- Shock-free design
  - Hodograph
  - Fictitious gas

- General transonic design
  - Inverse
  - Direct iterative
DIRECT ITERATIVE SURFACE CURVATURE (DISC) DESIGN METHOD

Start

Flow conditions
Initial geometry

Aerodynamic
analysis module

Pressure distribution
current geometry

Design cycle
limit

Yes
Stop

No

Aeroelastic analysis module

Target pressures

New geometry

Design module
HYBRID DESIGN ALGORITHM

- Subsonic regions
  \[ \Delta C = \Delta C_p \ A \ (1 + C^2)^B \]

- Supersonic regions \( (M > 1.15) \)
  \[ \Delta C = \frac{0.05 A}{(1 + (y')^2)^{1.5}} \frac{d}{dx} \ (\Delta C_p) \]
AIRFOIL GEOMETRY MODIFICATION PROCEDURE

a) CHANGE CURVATURE AT A POINT

b) ROTATE ABOUT LEADING EDGE
DESIGN CONSTRAINT OPTIONS

- Limit extent of design region
- Constrain surface curvature
- Specify airfoil thickness
- Modify flow characteristics
AIRFOIL PRESSURE-GEOMETRY RELATIONSHIPS

THICKER

M_{1}

BLUNTER


CONSTRAINED DESIGN TARGET PRESSURES

--- ORIGINAL

--- --- MODIFIED

Cp

x/c

0 0.2 0.4 0.6 0.8 1.0
CONSTRAINED DESIGN RESULTS - PRESSURES

TARGET

INITIAL

FINAL

Cp

x/c
CONSTRAINED DESIGN RESULTS - AIRFOILS

--- INITIAL

--- FINAL
POWERED NACELLE DESIGN RESULTS

TARGET

INITIAL

FINAL
HSCT Geometry

design station
Supersonic Wing Design Results

Mach = 3.0 \quad \alpha = 1.5

\begin{align*}
\text{--- initial} \\
\text{--- final} \\
\text{+++ target}
\end{align*}
CONCLUDING REMARKS

- DISC method developed for design to specified pressures
- Design module is easily coupled with analysis codes
- Constrained design capability has been added
- Method has been applied to several aircraft components
- Approach is valid for attached flows, subsonic - supersonic