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Test cases of Fourth Aerodynamics Prediction Challenge (APC-IV)

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Test case of APC-IV

- Aerodynamics/Aeroacoustics prediction of 30P30N
  Case１：Prediction of aerodynamics
  Case２：Prediction of flow separation at flap
  Case３：Prediction of aeroacoustics（near/far field）

- Geometry
  30P30N（modified_slat_configF）
  30P35N（modified_slat_configF）

- Flow condition（same with BANC workshop※1）
  M = 0.17, Re = 1.71 x 10^6, Tinf=295.56K
  α = 5.5deg, 9.5deg

※1 URL http://aeroacoustics2016.com/banc-iv-workshop/

Case1：Prediction of aerodynamics

- Aims
  - Compare Cp/CL obtained by 2D steady or 2.5D steady/unsteady flow simulation with experimental data[1]
  - Check the dependency of flow solver, grid, and turbulence model

- Recommendation
  - use periodic boundary condition to spanwise direction in case of 2.5D simulation[2]

[1] Murayama, M., Nakakita, K., Yamamoto, k., Ura, H., Ito, Y., and Choudhari, M.M., "Experimental Study on Slat Noise from 30P30N Three-Element High-Lift Airfoil at JAXA Hard-Wall Lowspeed Wind Tunnel", AIAA 2014-2080
[2] Sakai, R., Ishida, T., Murayama, M., Ito, Y., and Yamamoto, K., “Effect of Subgrid Length Scale in DDES on Aeroacoustic Simulation around Three-Element Airfoil,” AIAA 2018-0756, 2018.

Case1-1：2D steady flow simulation

• Geometry	30P30N_modified_slat_configF
• Grid※1	provided（required：L2，optional：L1,L3~L5）or custom
• Condition	M = 0.17，Re = 1.71 x 10^6
• AoA[degree]	0/4/5.5/8/9.5/12/14/16/20/22/24/26 （red: required, black：optional）
• Turbulence model	free
• List of data※2	①Aerodynamic coefficients (C_D,C_L,C_m),C_p,C_f ②Contours of $\tilde{\nu}/\nu$ ③Spatial streamlines ④Velocity profiles

※1	The size of custom grid should be equivalent to provided grids.
※2	②～④ are required for AoA=5.5 and 9.5. Submit aerodynamic coefficients for each component.

Case1-2 : 2.5D steady flow simulation

- Geometry: 30P30N_modified_slat_configF
- Grid※1: provided (required : L2, optional : L1,L3~L5) or custom
- Condition: M = 0.17, Re = 1.71 x 10^6
- AoA[degree]: 0/4/5.5/8/9.5/12/14/16/20/22/24/26
  (red : required, black : optional)
- Turbulence model: free
- List of data※2:
  ①Aerodynamic coefficients(C_D,C_L,C_m),C_p,C_f
  ②Surface contours of C_p,C_f
  ③Surface streamlines
  ④Contours of $\tilde{\nu}/\nu$
  ⑤Spatial streamlines
  ⑥Velocity profiles

※1 The size of custom grid should be equivalent to provided grids.

※2 ②～⑥ are required for AoA=5.5 and 9.5.
Submit aerodynamic coefficients for each component.

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Case1-3 : 2.5D unsteady flow simulation

- Geometry: 30P30N_modified_slat_configF
- Grid※1: provided (required : L2, optional : L1,L3~L5) or custom
- Condition: M = 0.17, Re = 1.71 x 10^6
- AoA[degree]: 5.5/9.5
- Turbulence model: free
- List of data※2:
  ①Aerodynamic coefficients(C_D,C_L,C_m),C_p,C_f
  ②Surface contours of C_p,C_f
  ③Surface streamlines
  ④Contours of $\tilde{\nu}/\nu$
  ⑤Spatial streamlines
  ⑥Velocity profiles

※1 The size of custom grid should be equivalent to provided grids.

※2 Submit aerodynamic coefficients for each component.
Submit time-averaged data.
Cp and Cf are desirable to take both time and spanwise average.

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Case2：Prediction of flow separation at flap

- Aim
  - Predict flow separation at flap to change flap deflection angle
  - Compare the result of 2D steady or 2.5D steady/unsteady flow simulation [1]

[1]Terracol, M., and Manoha, M., "Wall-resolved Large Eddy Simulation of a highlift airfoil: detailed flow analysis and noise generation study", AIAA 2014-3050

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Case2-1：2D steady flow simulation

• Geometry	30P35N_modified_slat_configF
• Grid※1	provided（required：L2, optional：L1,L3~L5） or custom
• Condition	M = 0.17, Re = 1.71 x 10^6
• AoA[degree]	5.5
• Turbulence model	Free
• List of data※2	①Aerodynamic coefficients (C_D,C_L,C_m),C_p,C_f ②Contours of $\tilde{\nu}/\nu$ ③Spatial streamlines ④Velocity profiles

※1	The size of custom grid should be equivalent to provided grids.
※2	Submit aerodynamic coefficients for each component.

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Case2-2 : 2.5D steady flow simulation

- Geometry: 30P35N_modified_slat_configF
- Grid※1: provided (required : L2, optional : L1,L3~L5) or custom
- Condition: M = 0.17, Re = 1.71 x 10^6
- AoA[degree]: 5.5
- Turbulence model: free
- List of data※2:
  ①Aerodynamic coefficients(C_D,C_L,C_m),C_p,C_f
  ②Surface contours of C_p,C_f
  ③Surface streamlines
  ④Contours of $\tilde{\nu}/\nu$
  ⑤Spatial streamlines
  ⑥Velocity profiles

※1 The size of custom grid should be equivalent to provided grids.

※2 Submit aerodynamic coefficients for each component.
Cp and Cf are desirable to take spanwise average.

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Case2-3 : 2.5D unsteady flow simulation

- Geometry: 30P35N_modified_slat_configF
- Grid※1: provided (required : L2, optional : L1,L3~L5) or custom
- Condition: M = 0.17, Re = 1.71 x 10^6
- AoA[degree]: 5.5
- Turbulence model: free
- List of data※2:
  ①Aerodynamic coefficients(C_D,C_L,C_m),C_p,C_f
  ②Surface contours of C_p,C_f
  ③Surface streamlines
  ④Contours of $\tilde{\nu}/\nu$
  ⑤Spatial streamlines
  ⑥Velocity profiles

※1 The size of custom grid should be equivalent to provided grids.

※2 Submit aerodynamic coefficients for each component.
Submit time-averaged data.
Cp and Cf are desirable to take both time and spanwise average.

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Case3：Prediction of aeroacoustics

- Aims
  - Compare the wall pressure variation at slat/main by 2.5D unsteady flow simulation with experiment[1,2]
  - Compare the far field acoustics by FW-H with experiment[3]
  - Check the effect of AoA for the Narrow Band Peaks (NBPs) and the peak from slat trailing edge

- Recommendation
  - use periodic boundary condition to spanwise direction [4]

[1] Murayama, M., Nakakita, K., Yamamoto, k., Ura, H., Ito, Y., and Choudhari, M.M., "Experimental Study on Slat Noise from 30P30N Three-Element High-Lift Airfoil at JAXA Hard-Wall Lowspeed Wind Tunnel", AIAA 2014-2080
[2] Terracol, M., Manoha, E., Murayama, M., and Yamamoto, K., "Aeroacoustic Calculations of the 30P30N High-lift Airfoil using Hybrid RANS/LES methods: Modeling and Grid Resolution Effects", AIAA 2015-3132
[3] Choudhari, M.M., and Lockard, D.P., "Assessment of Slat Noise Predictions for 30P30N High-Lift Configuration from BANC-III Workshop", AIAA 2015-2844
[4] Sakai, R., Ishida, T., Murayama, M., Ito, Y., and Yamamoto, K., “Effect of Subgrid Length Scale in DDES on Aeroacoustic Simulation around Three-Element Airfoil,” AIAA 2018-0756, 2018.

Case3-1：Near field acoustics

- Geometry　30P30N_modified_slat_configF
- Grid※1　provided（required:L2, optional：L3）or custom
- Condition　M = 0.17, Re = 1.71 x 10^6
- AoA[degree]　5.5/9.5/14（red: required, black: optional）
- Turbulence model　Free
- List of data※2　①PSD of wall pressure@S10, S11, S12, S13, M7, F1, P1, P7
  ②Contours of spanwise vorticity
  ③Contours of time-averaged 2D TKE
  ④Contours of Cp_{rms}

※1　The size of custom grid should be equivalent to provided grids.

※2　Submit PSD data obtained at the center cross section in the spanwise direction.

Case3-2 : Far field acoustics

- Geometry 30P30N_modified_slat_configF
- Grid※1 provided (required : L2, optional : L3) or custom
- Condition M = 0.17, Re = 1.71 x 10^6
- AoA[degree] 5.5/9.5/14 (red: required, black: optional)
- Turbulence model Free
- List of data PSD@135deg,249deg, 270deg, 291deg at 10c position

※1 The size of custom grid should be equivalent to provided L2 grid.

Guideline for unsteady flow simulation

Parameters

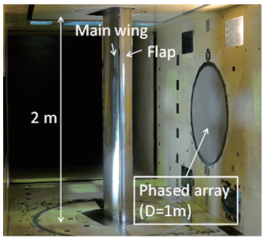
- Dt CFL=O(1) at slat cove region
- Transient computation monitor the history of aerodynamic coefficients and judge after initial unphysical pulse pass through flap
- Sampling time more than 80ms (~10c/Uinf)

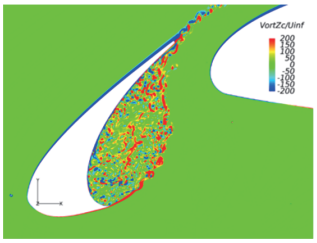
PSD processing

- Data overlapping 50%
- Window function Hanning
- Averaging data more than 10

APC Website

- Geometry (formats: .igs, .stp, .crv)
  - 30P30N and 30P35N are available
- Grid (structured type, formats: .p3d, .fsgrid, .cgns)
  - 30P30N and 30P35N are available
- Please see the APC website for more information
  - https://cfdws.chofu.jaxa.jp/apc/





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