The 53th Fluid Dynamics Conference/ The 39th Aerospace Numerical Simulation Symposium
30th June 2021

APC-7の課題説明
Test cases of Seventh Aerodynamics Prediction Challenge (APC-7)

橋本敦（JAXA）, APC有識者会議
Atsushi Hashimoto (JAXA), APC committee

Objective

- Predicting aerodynamic characteristics at low speeds and high angles of attack of aircraft is an important research subject. At low speeds and high angles of attack, a flow above the main wing is separated and this causes stall of aircraft, or a wake of the main wing interferes with the tail wing. If the aircraft vibrates, this determines the flight envelope, so it is required to accurately predict the phenomenon. In addition, as a safety requirement due to regulation, it is required that the pitch angle does not rise sharply even if the aircraft suddenly stalls. Therefore, it is also important to predict the pitching moment tendency near the stall.

- Since the aerodynamic prediction at low speeds and high angles of attack is important in any configurations of cruising, takeoff, and landing, the APC-7 targets the characteristics of the cruise, which is the base shape of these configurations. The objective of APC-7 is to understand the prediction accuracy of the current CFD by comparing the CFD with the experiment.

Test cases of APC-7

- Aerodynamics prediction of NASA-CRM

  Case1：Steady computation

  Case2：Unsteady computation

- Geometry

  NASA-CRM (Wing/Body/Horizontal Tail)

- Flow conditions

  M = 0.168, Re_c = 1.06 x 10^6, T_{ref}=310K

3

Case1：Steady computation

- Aims
  – Understand the prediction accuracy of aerodynamic performance such as CL, CD, Cm at low speeds and separation characteristics (beginning of separation, separated area).
  – Understand the dependency of turbulence model, grid.

- Conditions
  – M = 0.168, Re_c = 1.06 x 10^6, T_{ref}=310K
  – AoA=-3.22, -0.67, 2.89, 5.95, 9.01, 10.03, 11.05, 12.06, 13.08, 14.08, 18.08deg

4

Case2 : Unsteady computation

- Aims
  - Understand the prediction accuracy of unsteady computation by comparing the unsteady computation with the steady computation.
  - Understand the dependency of turbulence model, grid, time step.

- Conditions
  - M = 0.168, Re_c = 1.06 x 10^6, T_{ref}=310K
  - AoA=11.05, 13.08deg

5

Point of focus

- The test cases of APC-7 are same as those of APC-6. In APC-7, we focus on the following points. The participants are expected to investigate the sensitivities of the phenomena and propose a best practice. Application of AI, ML, and data mining techniques are also encouraged.
  - **Prediction of the main-wing separation**
    - Effect of numerical methods on the leading-edge separation
    - Effect of numerical methods on the trailing-edge separation
  - **Prediction of the interference between main-wing wake and tail wing**
    - Effect of numerical methods on the wake

Examples of the numerical methods:
- Type of grids (mixed-element or hexahedral), grid resolution(number of nodes or cells)
- Accuracy and dissipation of the numerical schemes
- Turbulence models (Steady: SA, SST, Unsteady: DES, IDDES, WMLES)
- Conditions of unsteady computation: Initial conditions (Uniform flow or lower-AoA solution), time step, number of inner iteration, time evolution method(local time step or global time step)
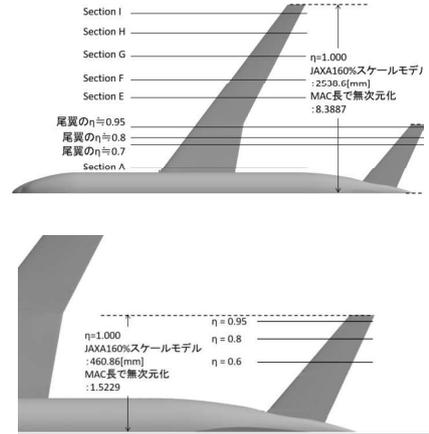
6

Submitted Data

| Test Case	Value	AoA	Remark
1	Grid	-	Picture Image (Only for custom grids)
	Aerodynamic coefficients	All angles	Data for plots Converged value (decomposed by pressure and skin friction, by components)
	Surface Cp	All angles	Data for plots Converged value Cross sections on main and tail wings.
	Surface streamline	11.05, 13.08deg	Picture image Converged value Surfaces of main and tail wings.
	Velocity contours		Picture image Converged value
2	Grid	-	Picture Image (Only for custom grids)
	Aerodynamic coefficients		Data for plots Converged value (decomposed by pressure and skin friction, by components)
	Surface Cp	11.05, 13.08deg	Data for plots Averaged and RMS values Cross sections on main and tail wings.
	Surface streamline		Picture image Averaged value Surfaces of main and tail wings.
	Velocity contours		Picture image Averaged values

Cross sections for Cp distributions

7

Submitted Data

Test Case	Value	AoA	Remark
1	Grid	-	Picture Image (Only for custom grids)
	Aerodynamic coefficients	All angles	Data for plots Converged value (decomposed by pressure and skin friction, by components)
	Surface Cp	All angles	Data for plots Converged value Cross sections on main and tail wings.
	Surface streamline	11.05, 13.08deg	Picture image Converged value Surfaces of main and tail wings.
	Velocity contours		Picture image Converged value
2	Grid	-	Picture Image (Only for custom grids)
	Aerodynamic coefficients		Data for plots Converged value (decomposed by pressure and skin friction, by components)
	Surface Cp	11.05, 13.08deg	Data for plots Averaged and RMS values Cross sections on main and tail wings.
	Surface streamline		Picture image Averaged value Surfaces of main and tail wings.
	Velocity contours		Picture image Averaged values

Cross sections for velocity contours
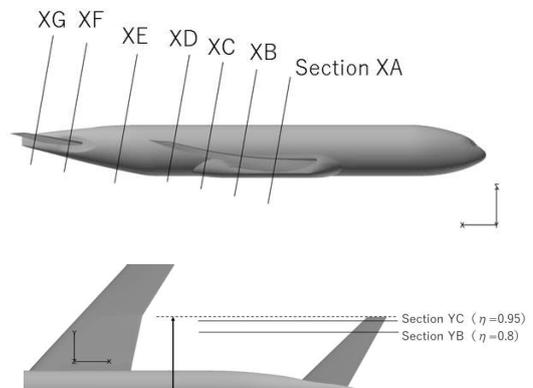
The data of cross sections are provided as csv and plot3d formats

8

APC Website

- Geometry (formats: stl)
  - NASA-CRM geometry data are available
- Grid (formats: fsgrid, cgns)
  - HexaGrid and BOXFUN grids are available
- Please see the APC website for more information
  - https://cfdws.chofu.jaxa.jp/apc/

9