BeiHang University

能源与动力工程学院
School of Energy and Power Engineering

Simulation of TUDa-GLR-OpenStage by HGAE

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HGAE(hybrid grid aeroelasticity environment)

A three-dimensional (3D) unstructured finite-volume compressible flow solver

- Modeling complex geometry with high fidelity based on a hybrid grid method
- Solving RANS equations in the rotating frame
- Roe's upwind scheme with MUSCL extrapolation(second-order accuracy)
- Implicit temporal discretization and dual time-stepping technique(second-order accuracy)
- One-equation Spalart-Allmaras (S-A) turbulence model
- Massively Parallel Processing: MPI2(Win/LINUX)
- ……

The HGAE code has been developed and used more than 15 years, and has been validated for various aerodynamic and aeroelastic cases.

CFD—Setup

Grid Information

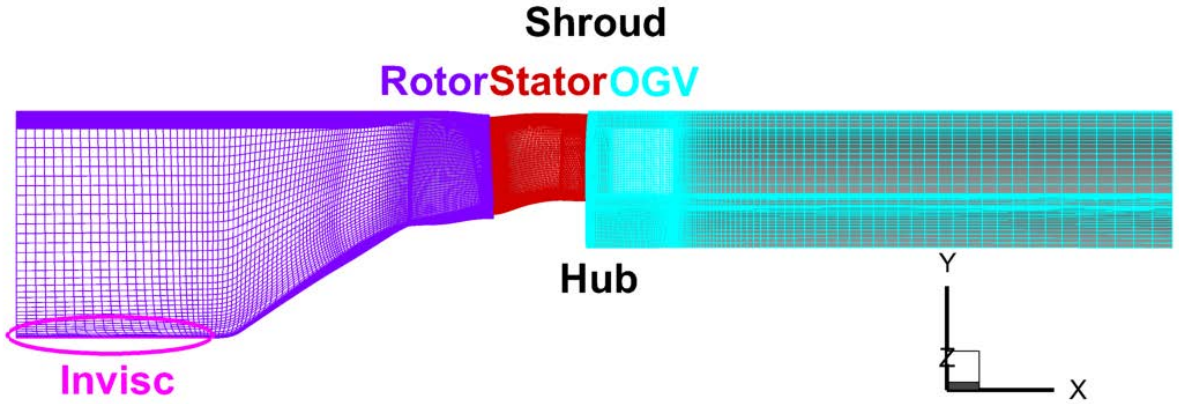
- Official medium grid

RANS Flow Solver Information

- Roe scheme
- SA turbulence model
- No use of wall function
- Mixing plane for rotor-stator interface
- Idea gas
- Jacobi solver

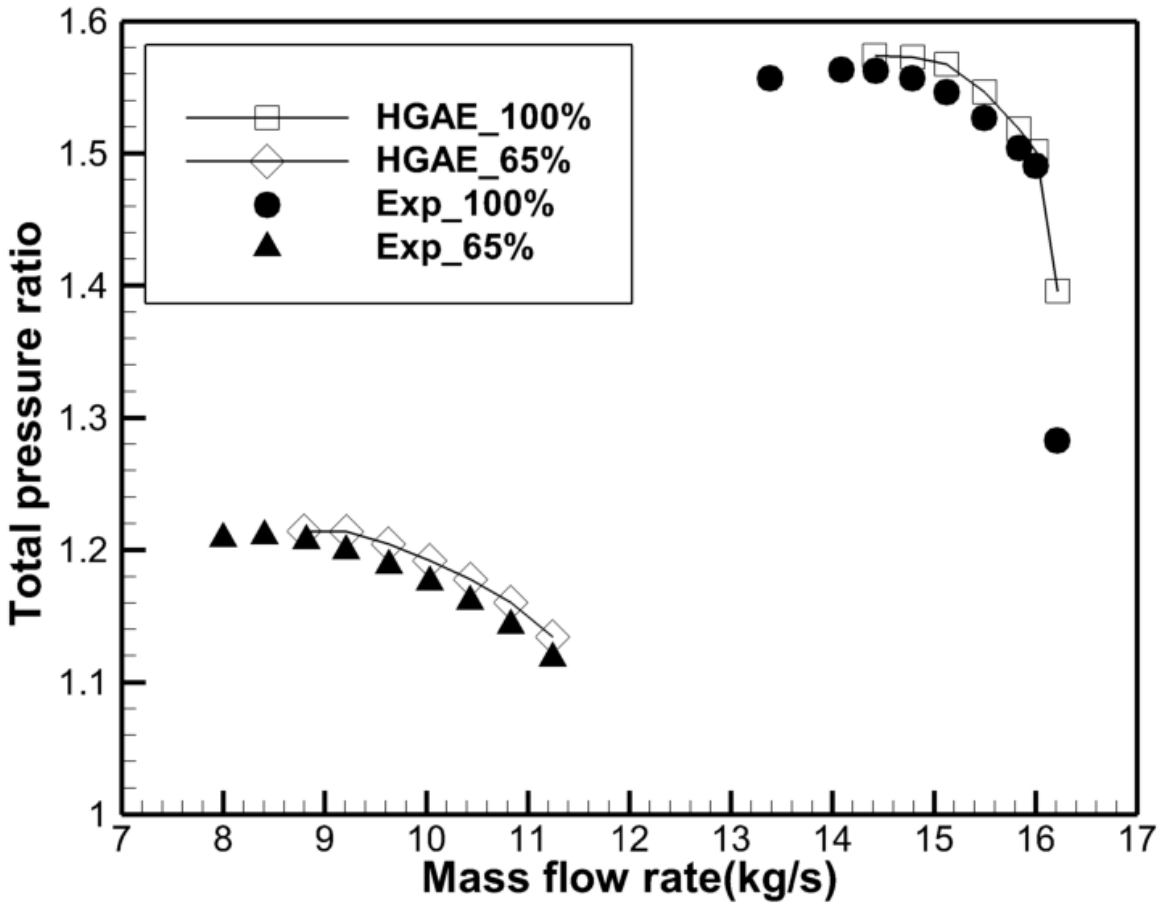
Boundary conditions

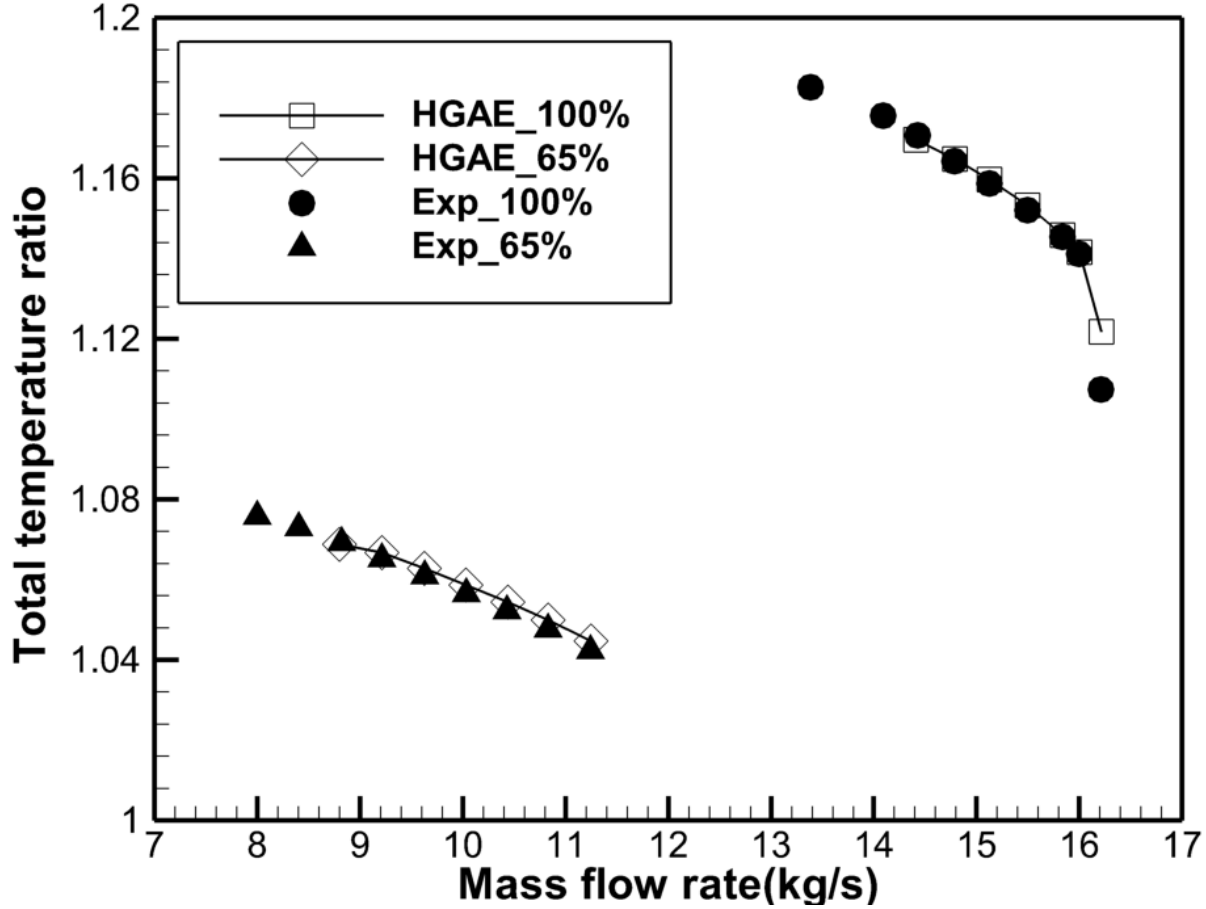
- Inlet: from InletBC.input file $\tilde{v}$ =0.198508e-4
- Outlet: radial equilibrium backpressure



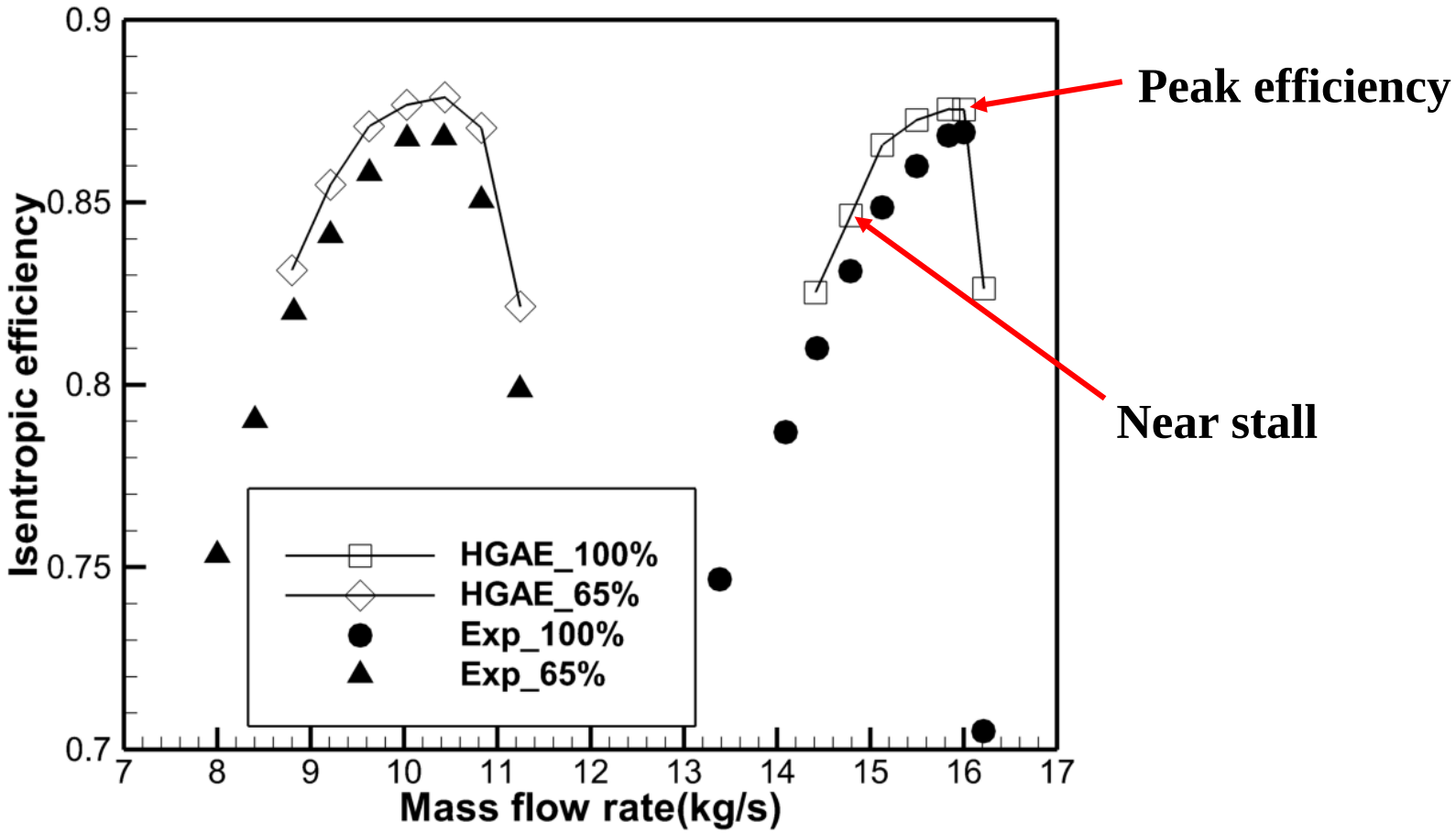
1.5 Stage computational domain

Compressor Characteristics

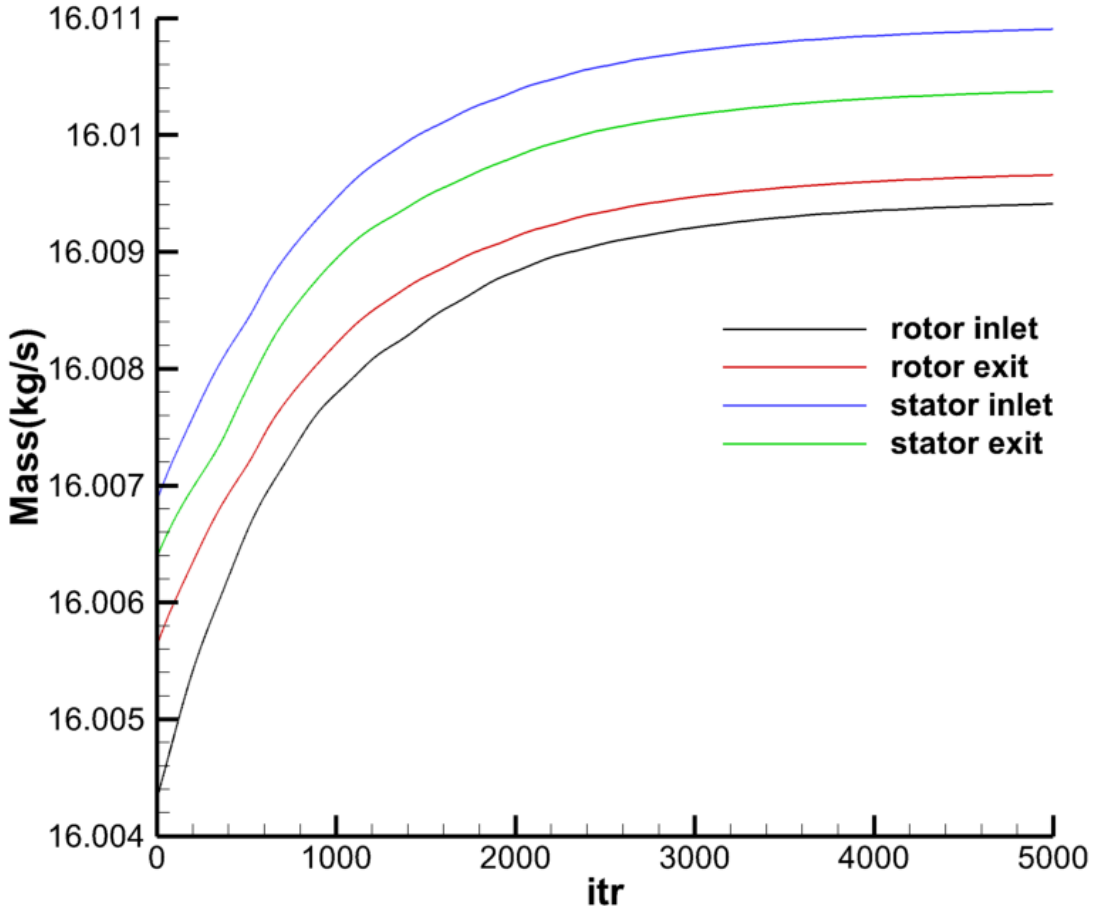




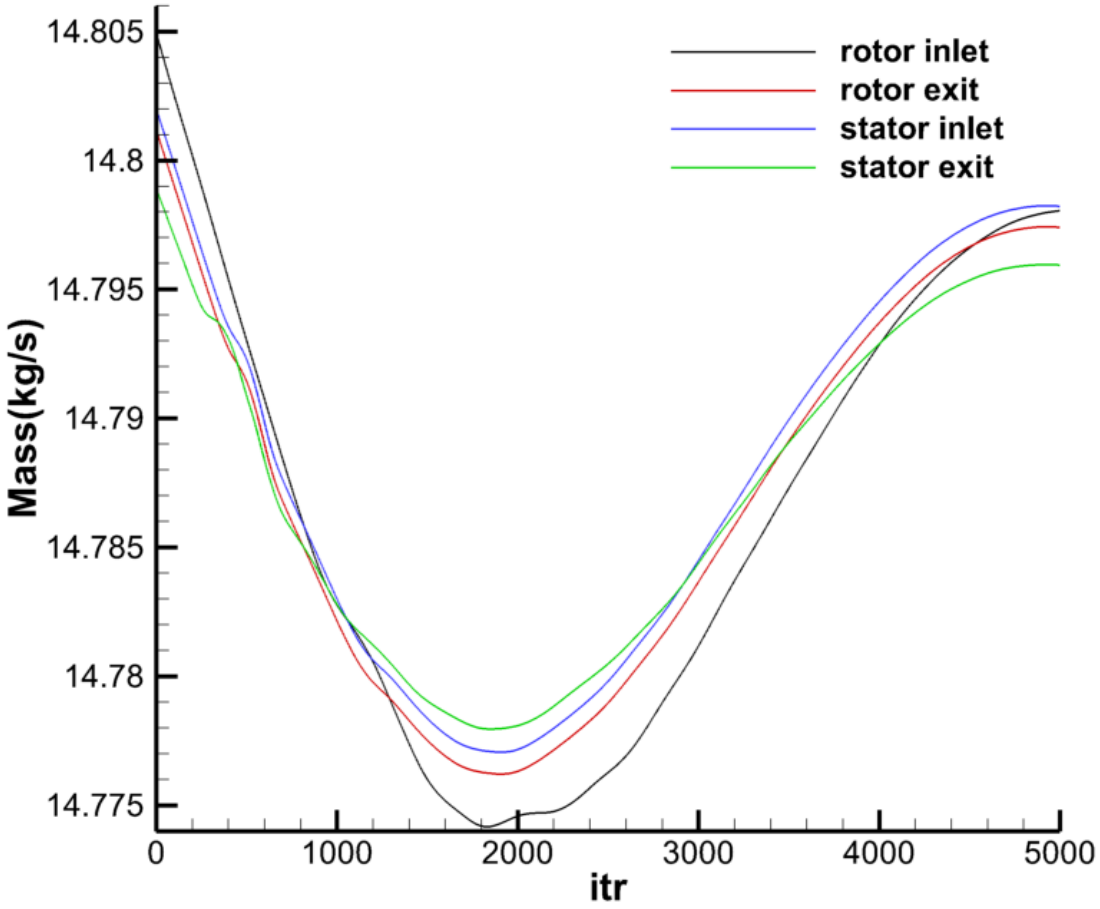
Compressor Characteristics



Convergence History(100% speed)

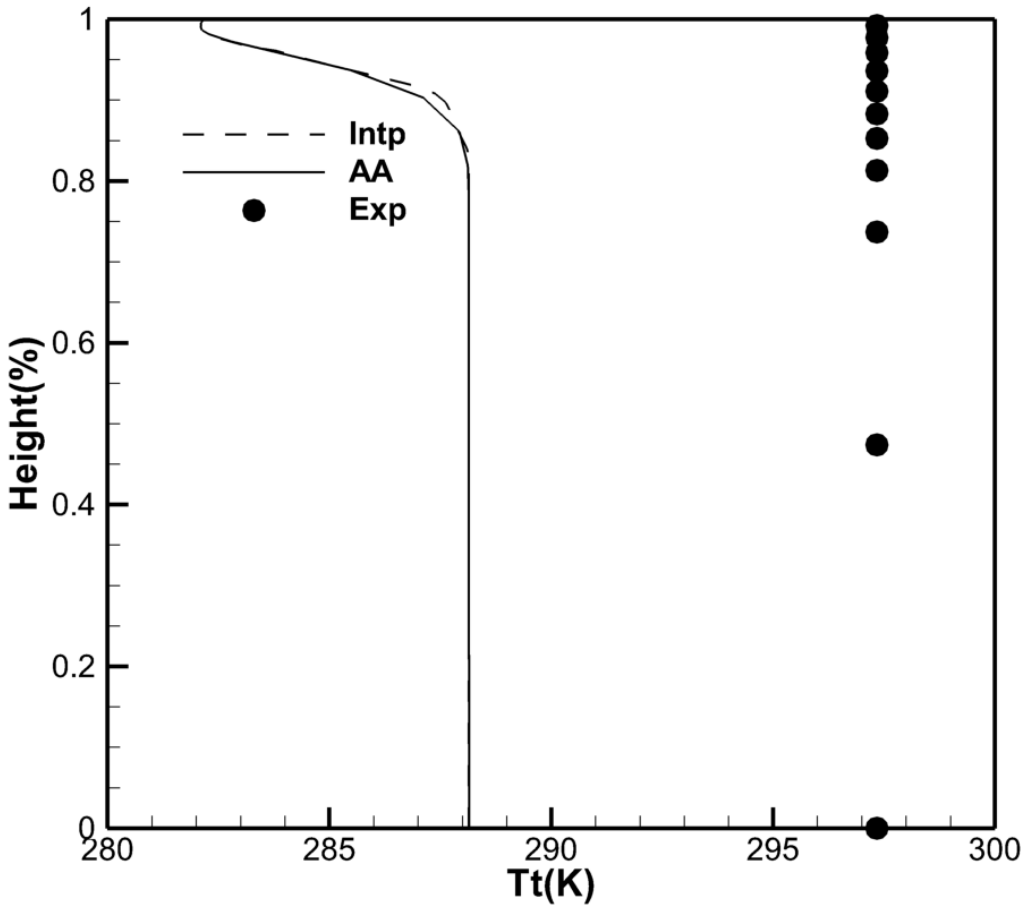


Peak efficiency condition (16.00 ± 0.10 kg/s)

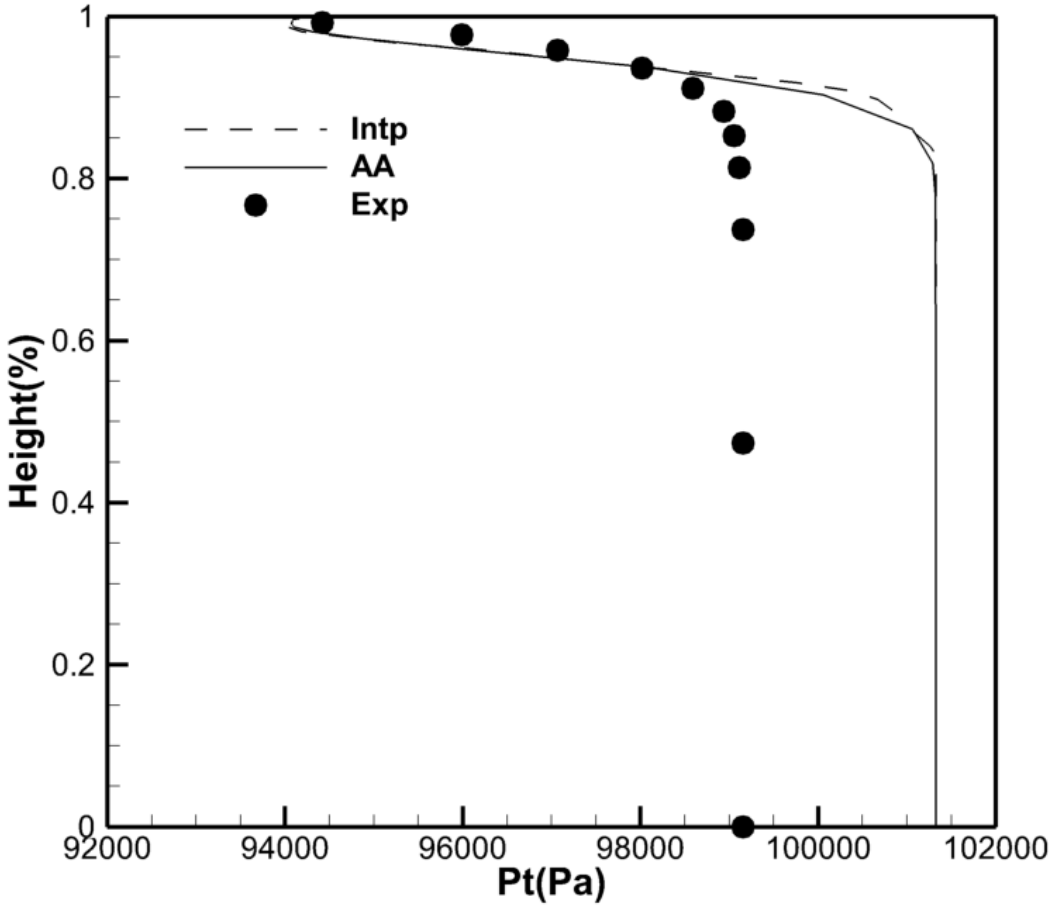


Near stall condition (14.78 ± 0.10 kg/s)

ME15—PE100%

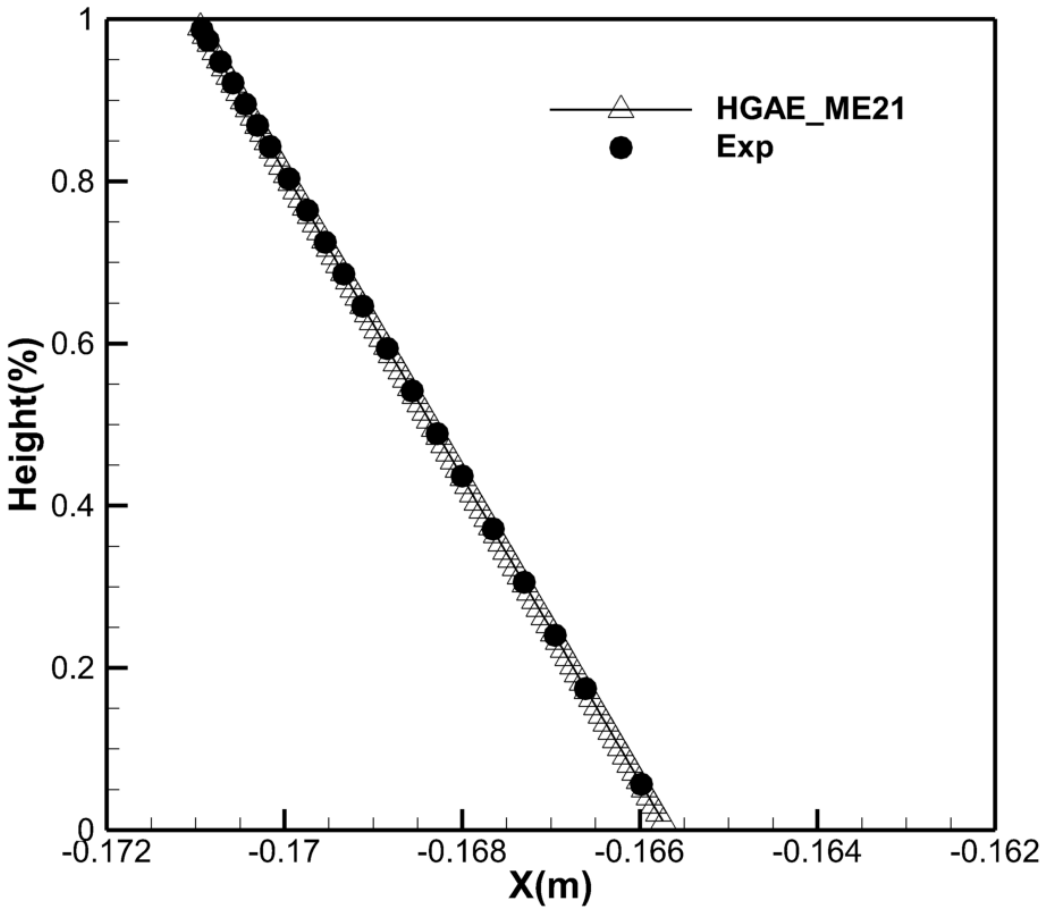


Total temperature

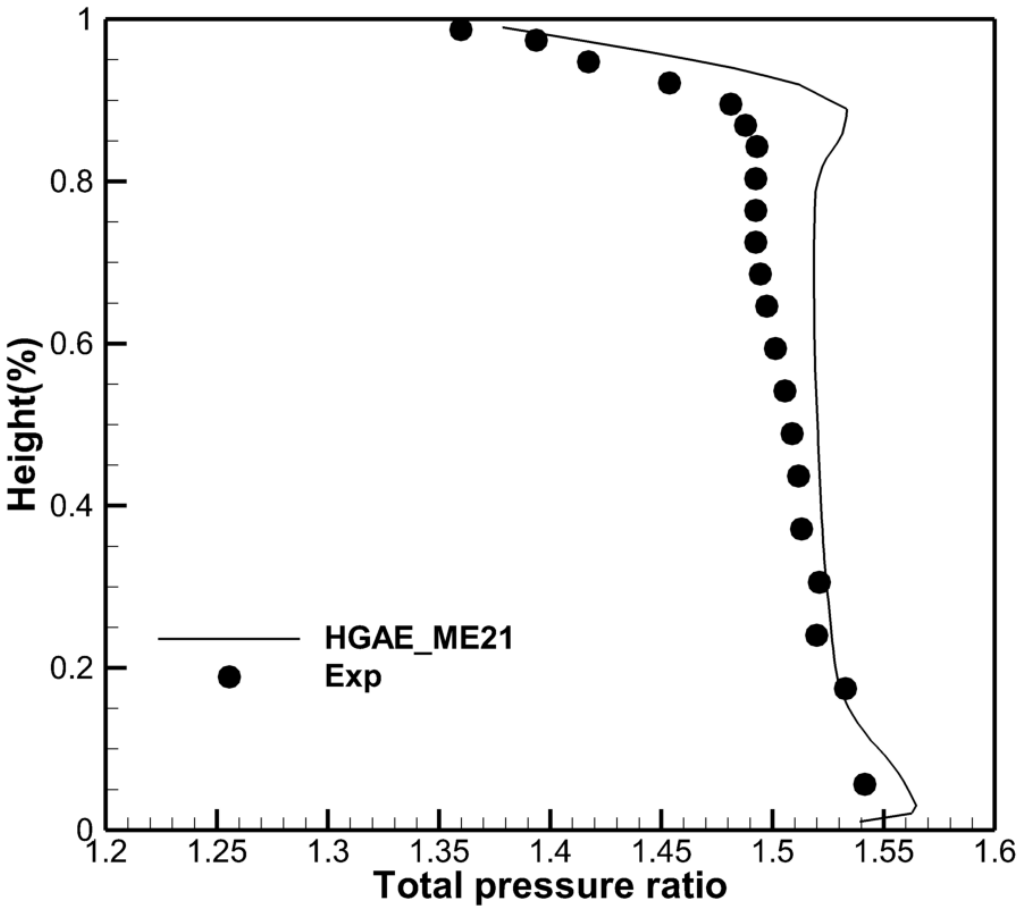


Total pressure

ME21—PE100%

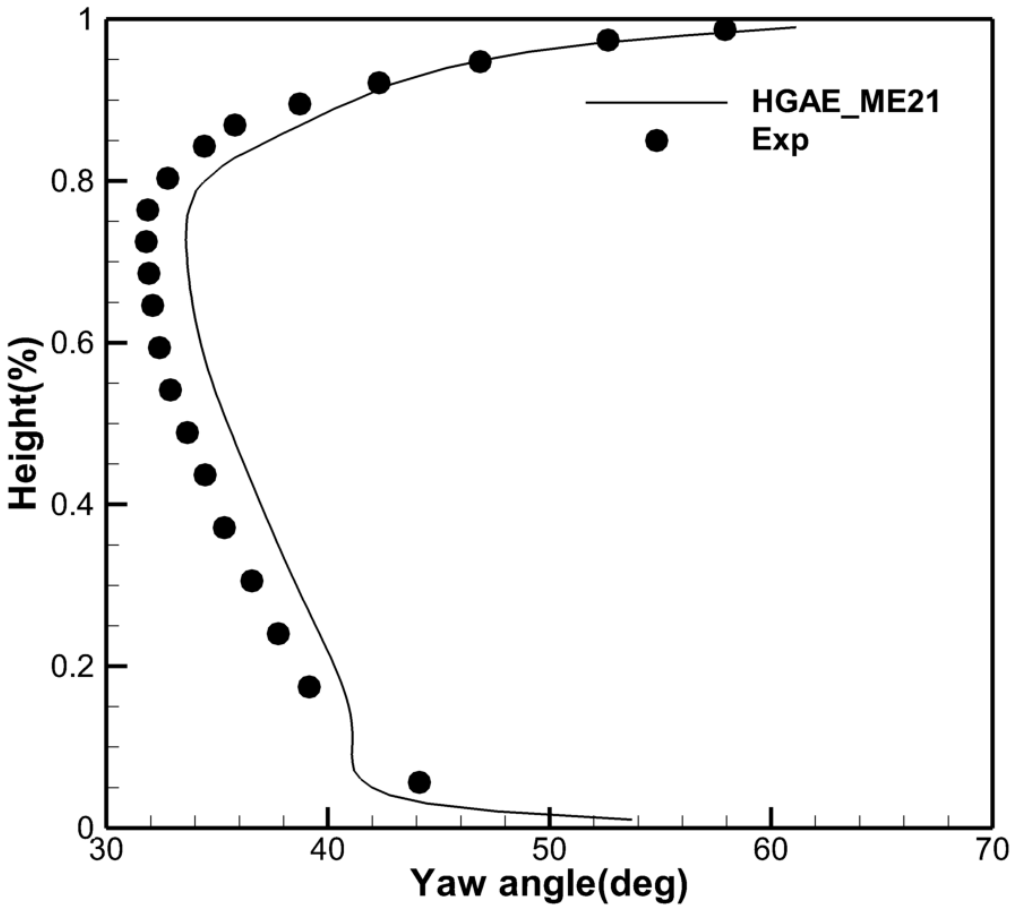


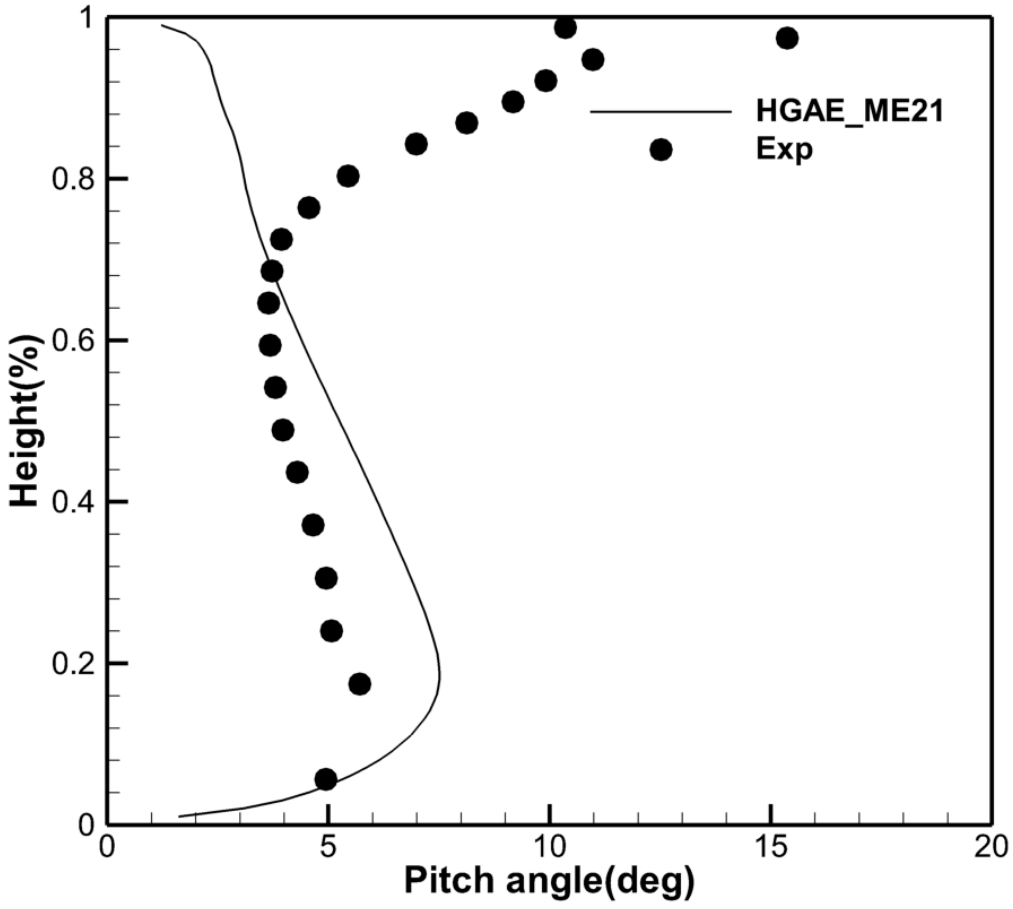
Axial location



Total pressure ratio

ME21—PE100%



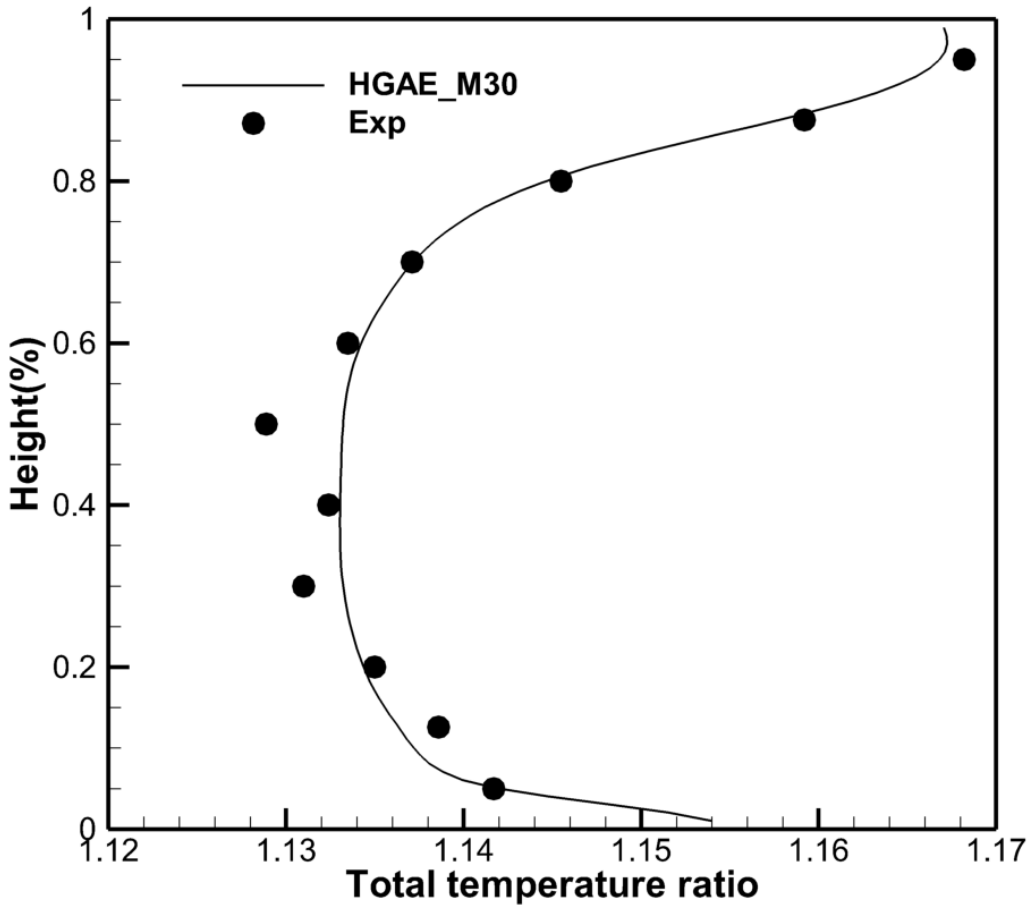


Yaw angle= $arctan(vt/vx)$

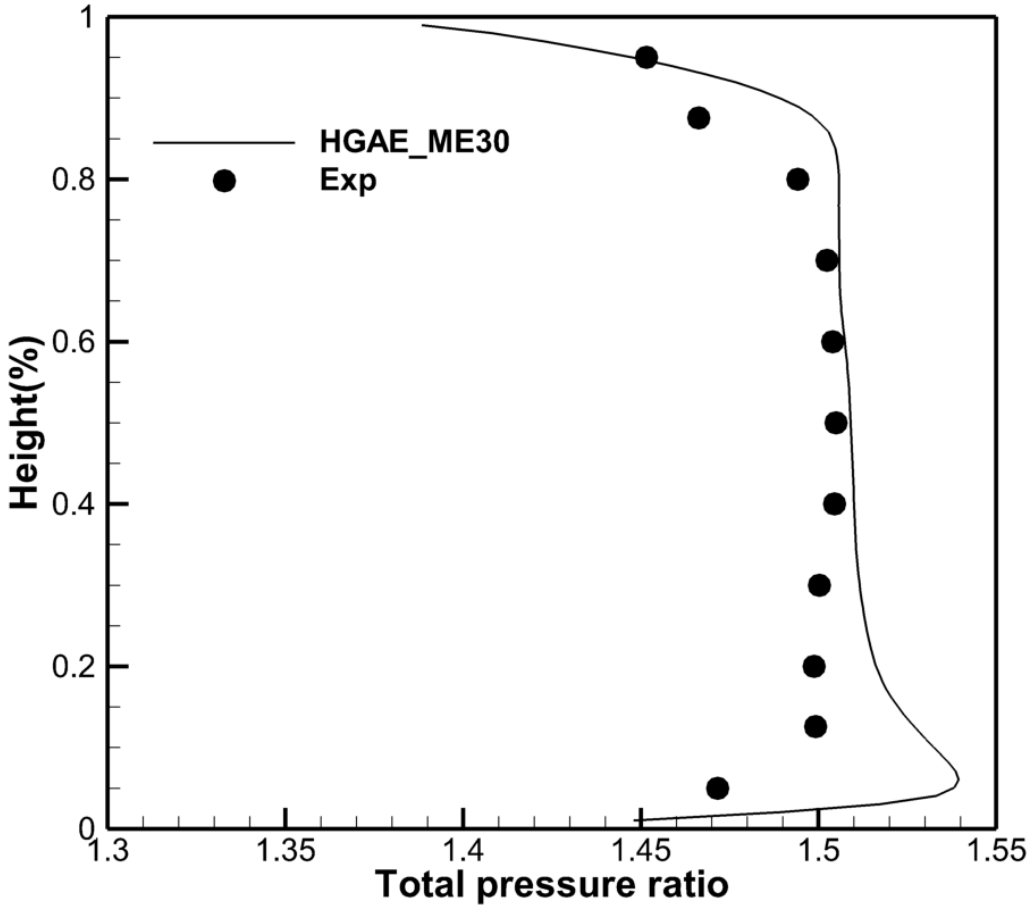
Pitch angle = $arctan(vr/vx)$

vx、vt and vr : axial, tangential and radial velocities in cylindrical coordinates.

ME30—PE100%

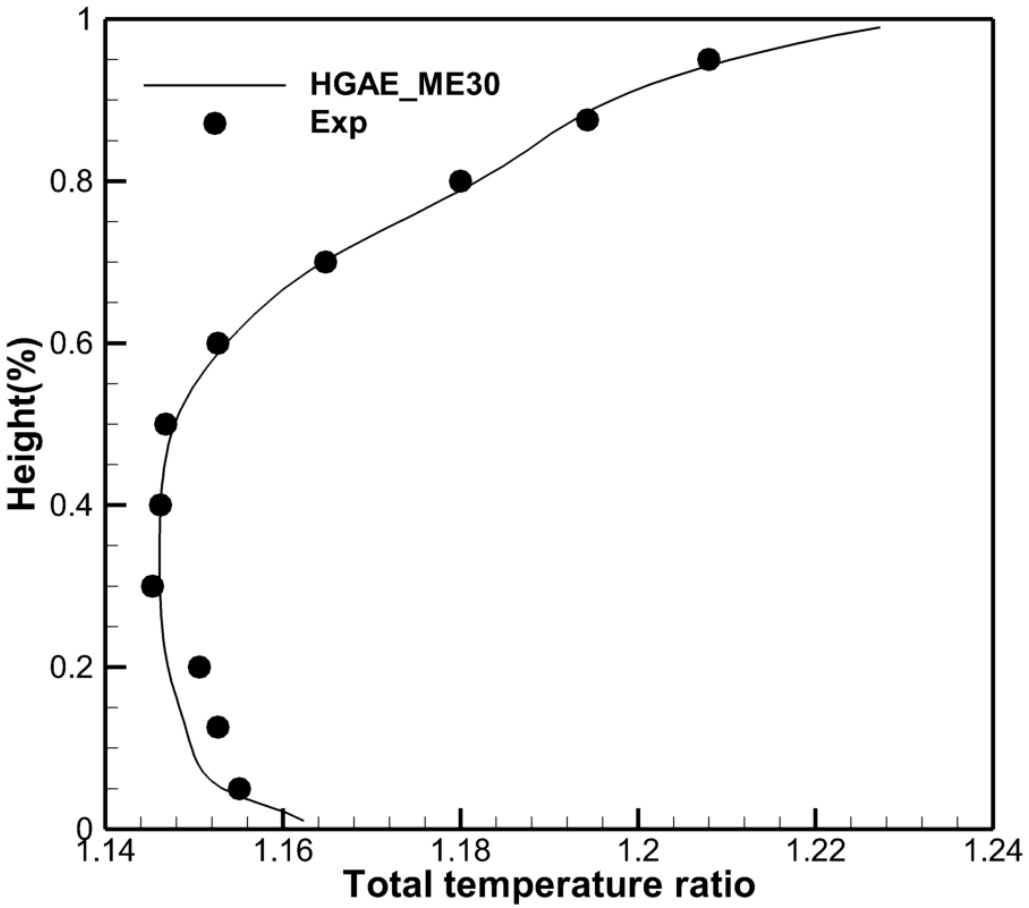


Total temperature ratio

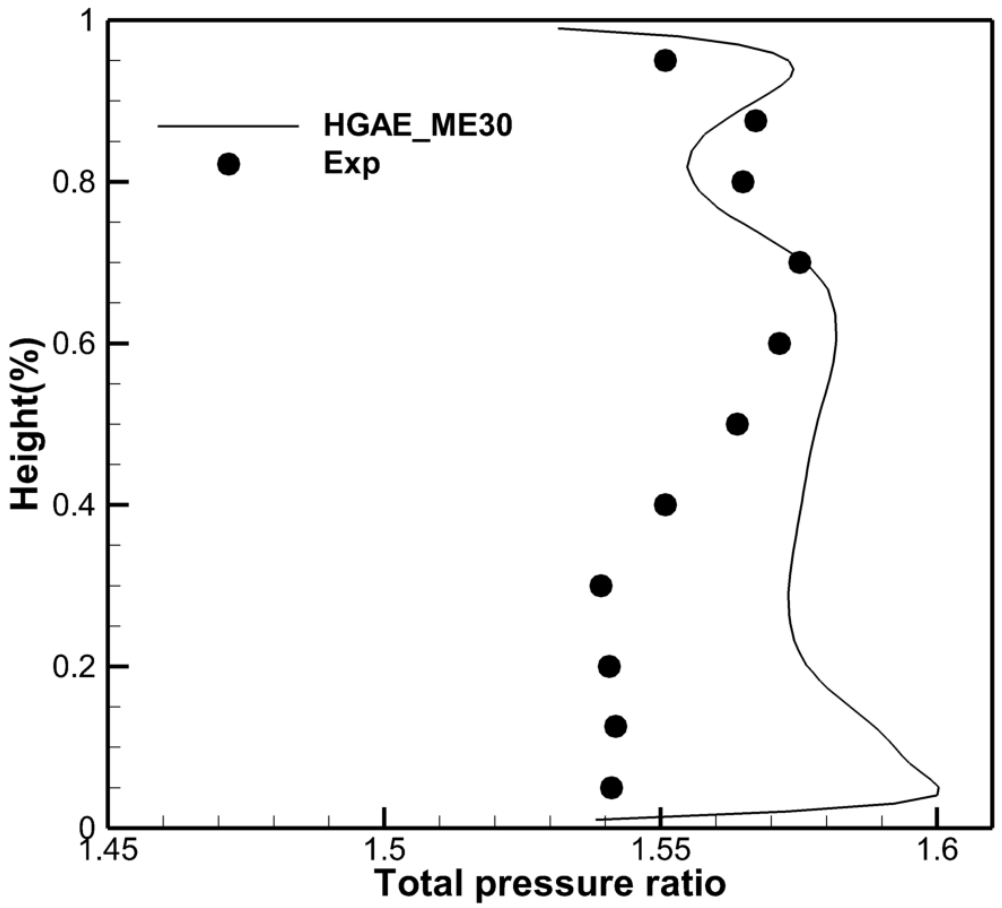


Total pressure ratio

ME30—NS100%



Total temperature ratio



Total pressure ratio

Conclusions

1. With respect to the overall characteristics, the total temperature ratio calculated by HGAE shows a good agreement with the experimental results, while the total pressure ratio and isentropic efficiency are higher than the experimental results.

2. The compressor characteristics at the peak efficiency of the design speed agree well with the experimental results, whereas there are some deviations from the experimental results at the near stall point.

3. At the peak efficiency of the design speed, the total pressure ratio at 90% span and the pitch angle profiles have clear discrepancies with the experimental results at ME21 and the total pressure ratio at near 5% span is obviously different from the experimental results at ME30, which can also be found at the near stall point.

Thanks