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航空发动机研究院
Research Institute of Aero-Engine

Steady RANS Simulation of the TUDa-GLR-OpenStage Using an In-house Code MAP

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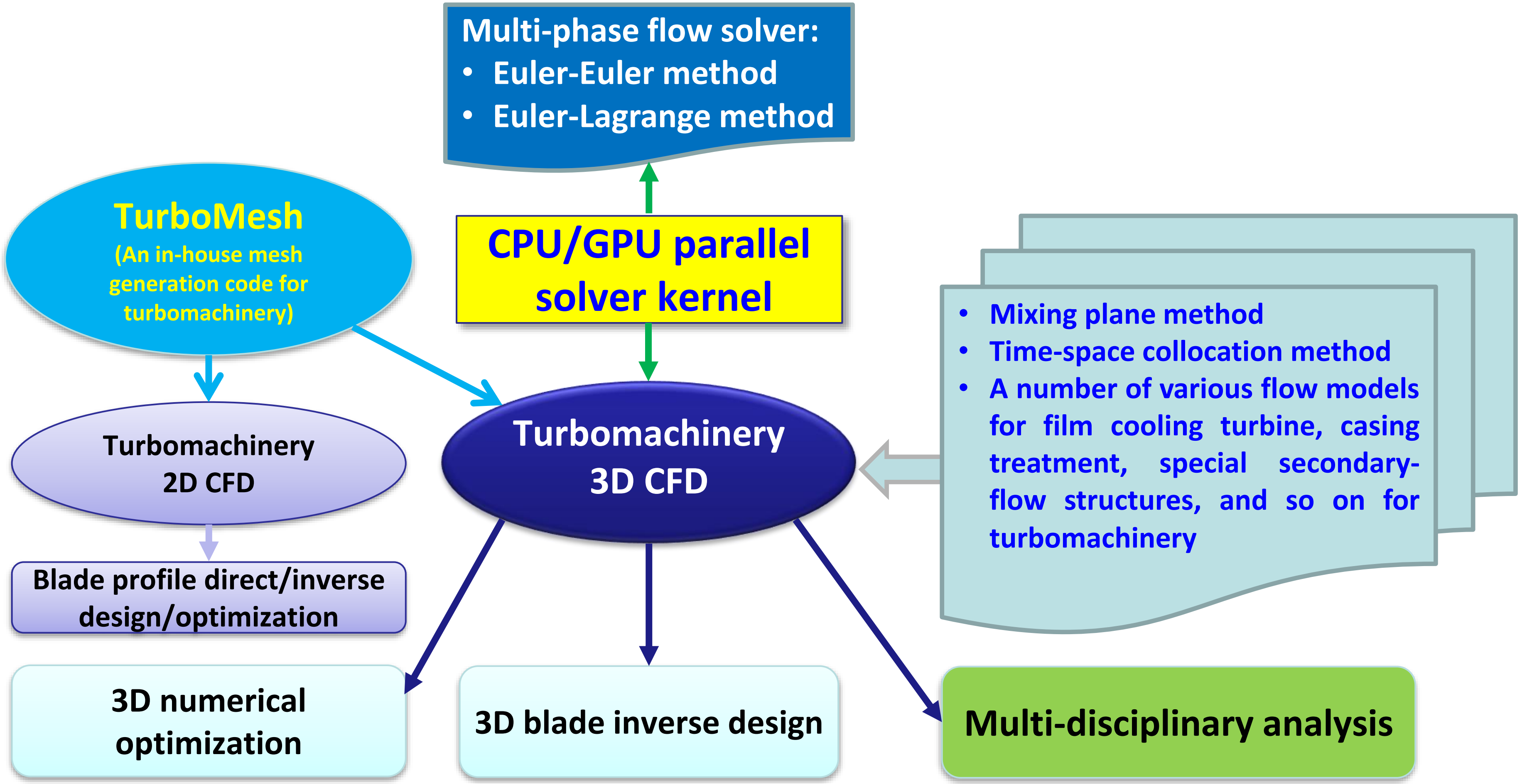
1. The Outline of MAP package

MAP: Multi-purpose Advanced Prediction code for fluid dynamics[1]

—Has been continuously supported and widely used by Chinese aero-engine institutes for over ten years

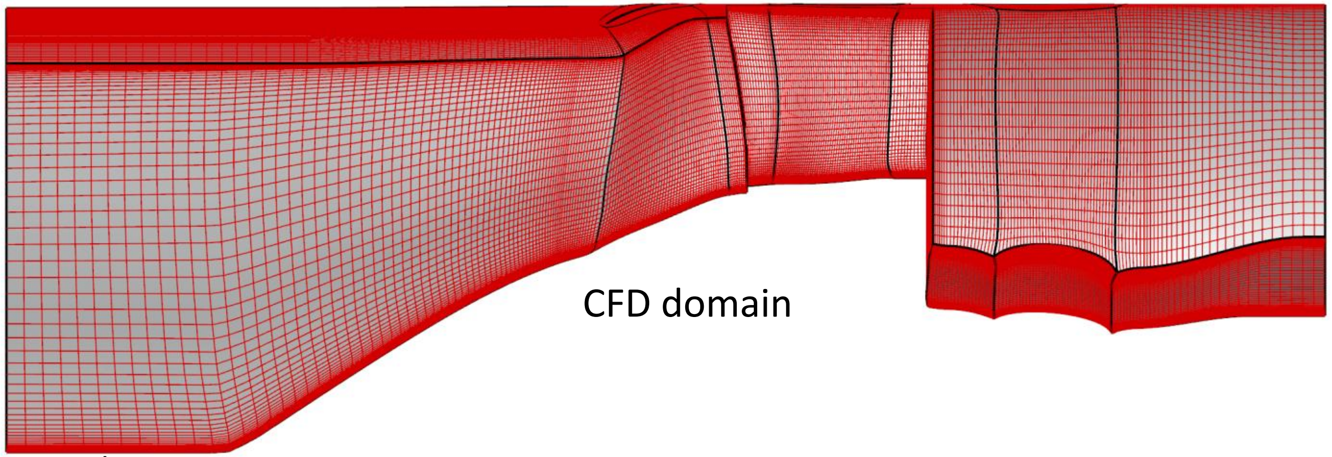


[1] Fangfei Ning, MAP: A CFD Package for Turbomachinery Flow Simulation and Aerodynamic Design Optimization[R]. ASME paper GT2014-26515.

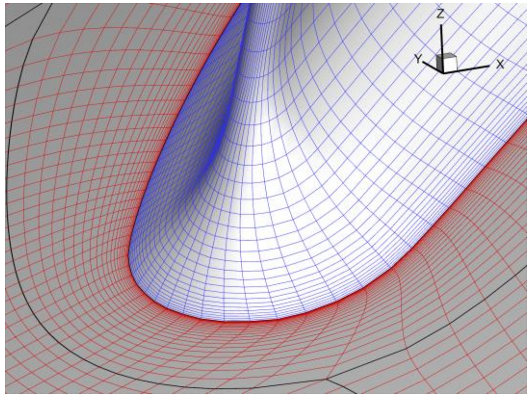
2. Mesh Generation

- **TurboMesh V3.3**

  An in-house multi-block structured mesh generation code for turbomachinery

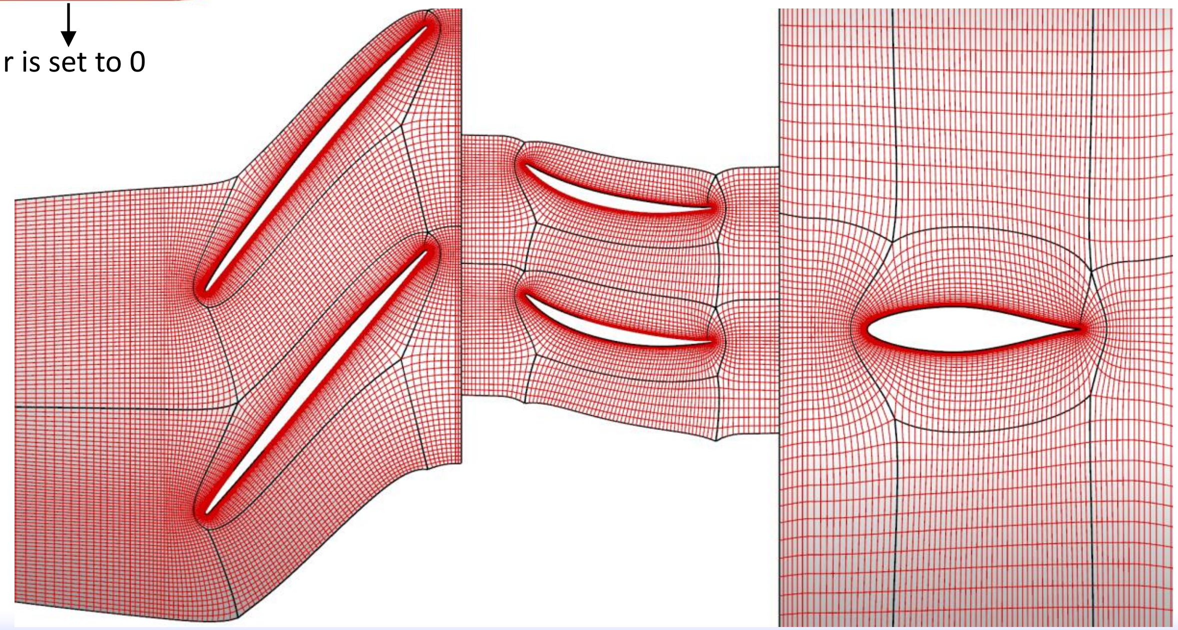


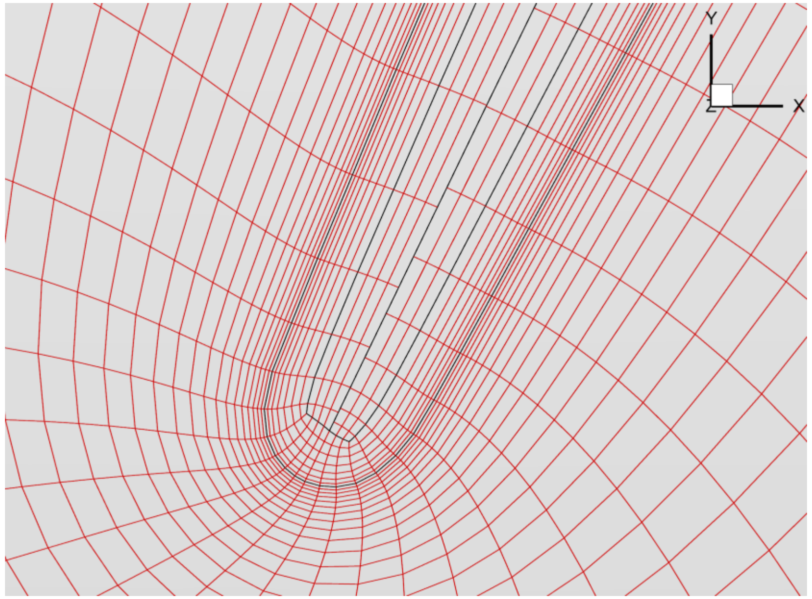
CFD domain



rotor endwall fillet

r is set to 0





rotor tip gap mesh

2. Mesh Generation

		MAP					official grid		
		axial	circumferential	radial	total grid points (million)	y+	axial	circumferential	radial
ultra coarse	rotor	35	29	30	0.07	9.0	40	29	37
	stator	31	20	30	0.03		32	17	41
coarse	rotor	45	41	59	0.24	7.0	56	41	53
	stator	41	29	59	0.09		44	29	65
medium	rotor	71	65	81	0.81	4.0	88	65	81
	stator	71	41	81	0.31		68	41	93
fine	rotor	121	93	121	2.90	2.5	125	93	121
	stator	111	69	121	1.18		108	69	137
ultra fine	rotor	151	145	181	8.35	2.0	195	145	181
	stator	130	101	181	2.94		155	101	201

note: axial refers to from leading edge to trailing edge of the blade

3. Flow Solver

- **MAP version6.0**

discretization of advective flux	LDFSS + 3rd-order MUSCL reconstruction with geometrical correction for non-uniform mesh
discretization of diffusive flux	Conventional 2nd-order central differencing with geometrical correction for non-uniform mesh
Turbulence Model	Near wall improved Spalart-Allmaras model [2] & Menter’s SST model (Both models apply the curvature and rotation corrections[3,4])
R/S Interface Model	A novel mixing plane method[5]
Linear System Solver	Matrix-free Gauss-Seidel iteration
parallelization	MPI & block-cutting method

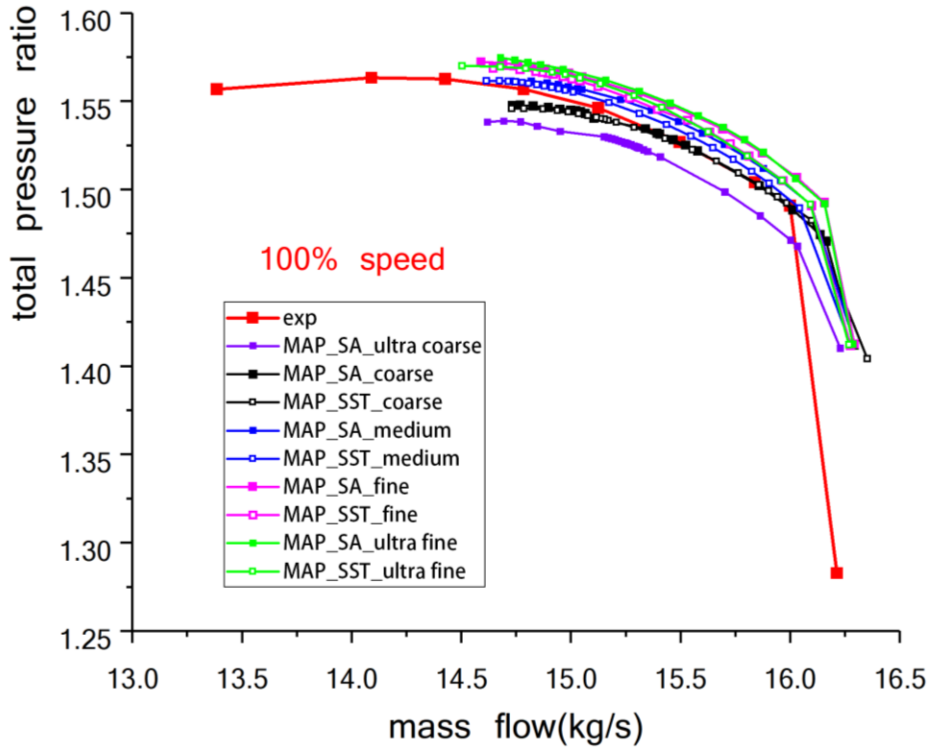
[2] Fangfei Ning, Numerical investigations of flows in transonic compressors with real geometrical complexities[D]. Ph.D. thesis, BeiHang University, 2002.

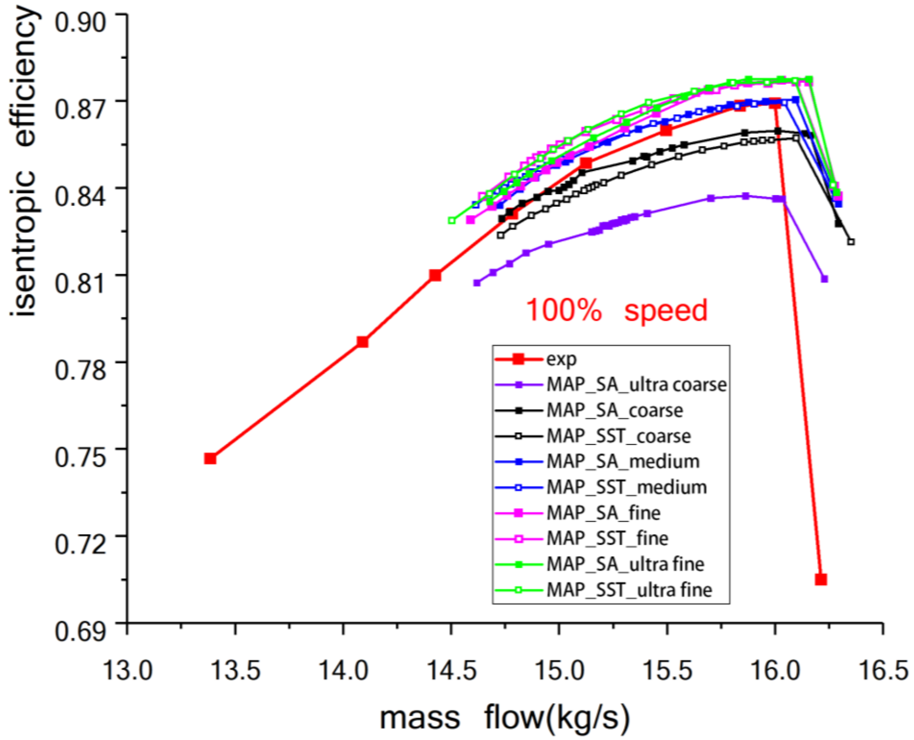
[3] P. R. Spalart, M. Shur, On the Sensitization of Turbulence Models to Rotation and Curvature, Aerospace Science and Technology, 1997

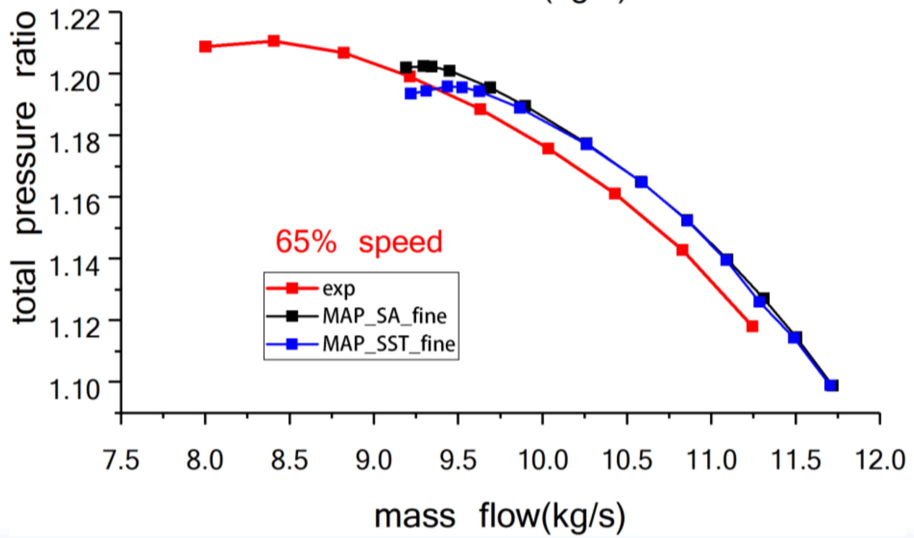
[4] P. E. Smirnov, F. R. Menter, Sensitization of the SST Turbulence Model to Rotation and Curvature by Applying the Spalart-Shur Correction Term, Journal of Turbomachinery, 2009.

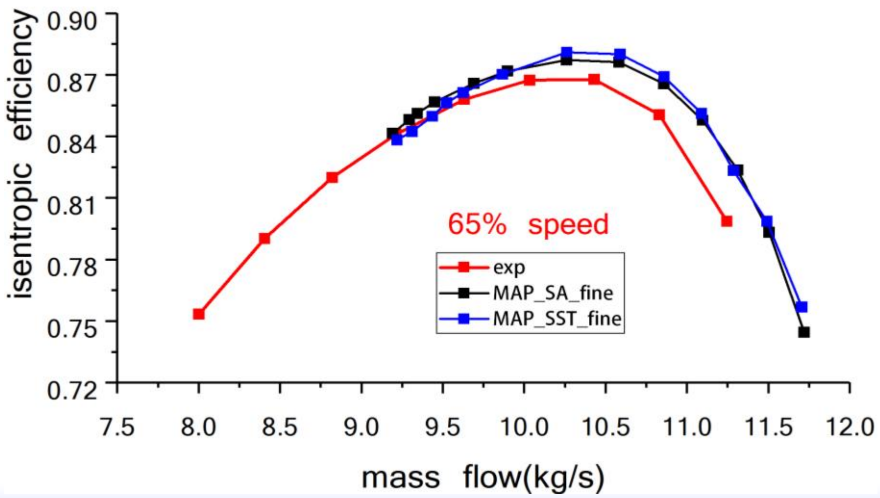
[5] Pengcheng Du, Fangfei Ning, Validation of a novel mixing-plane method for multistage turbomachinery steady flow analysis[J]. Chinese Journal of Aeronautics,2016.

4. Characteristics

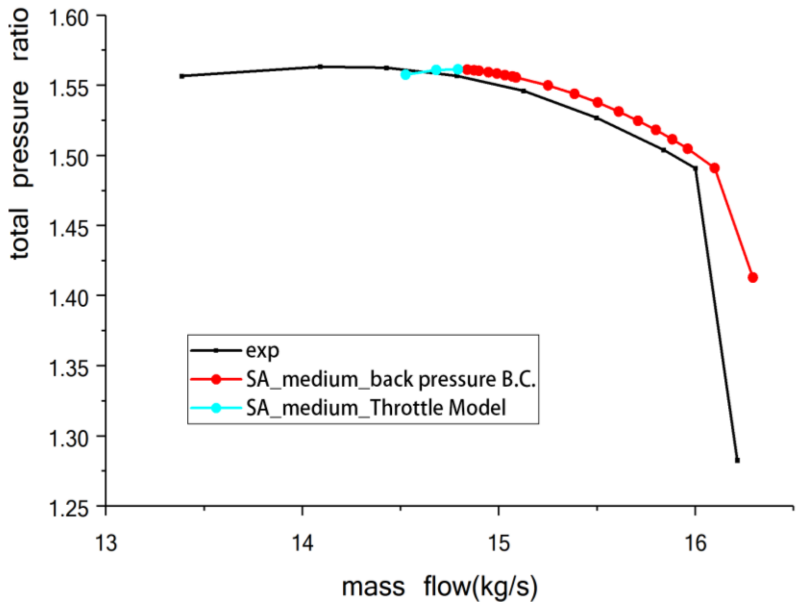


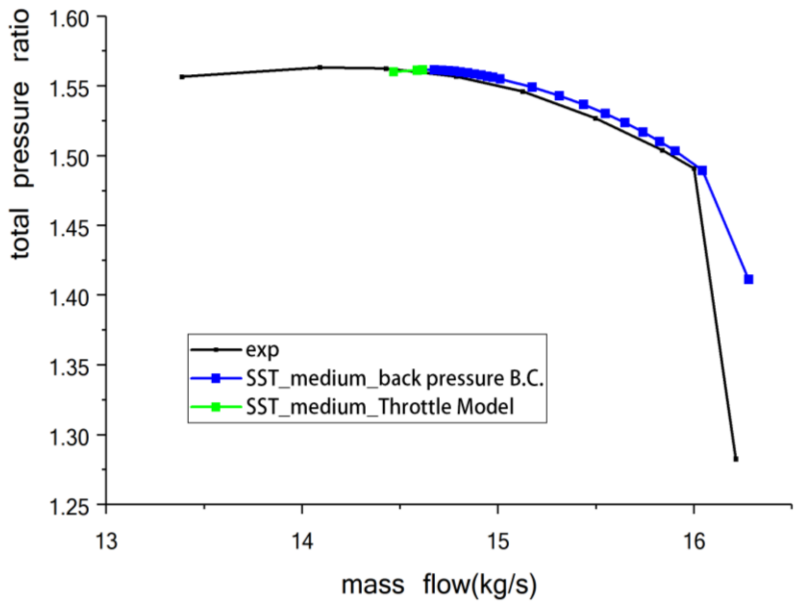


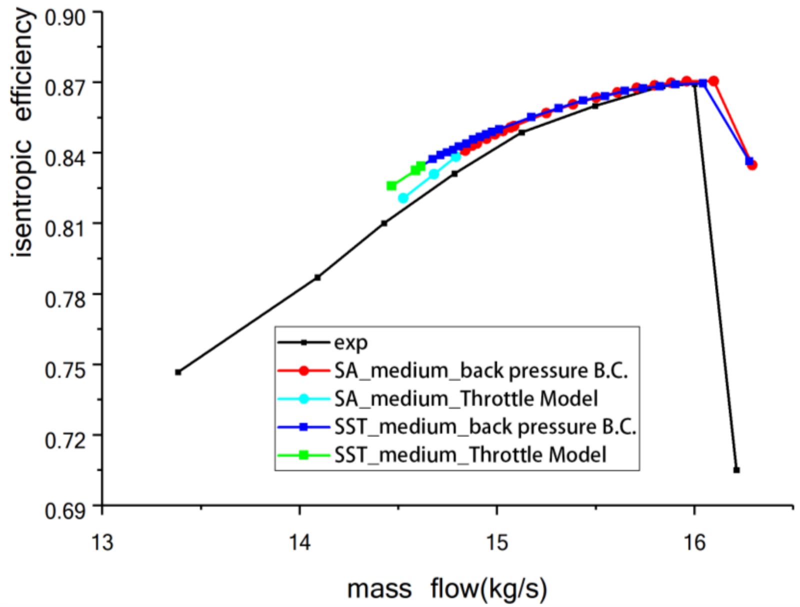


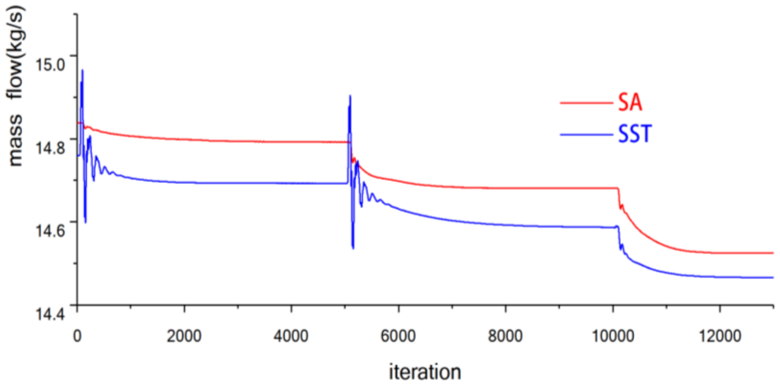


5. Throttle Model



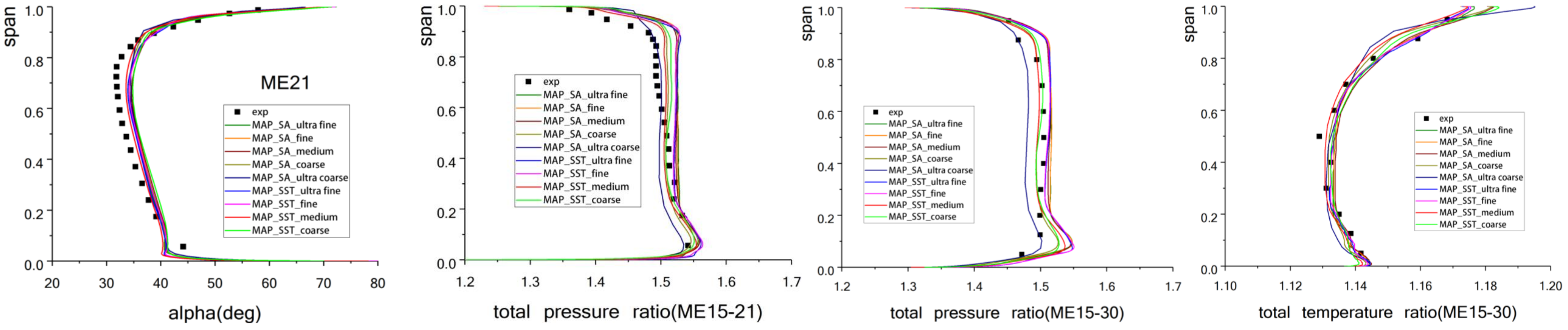




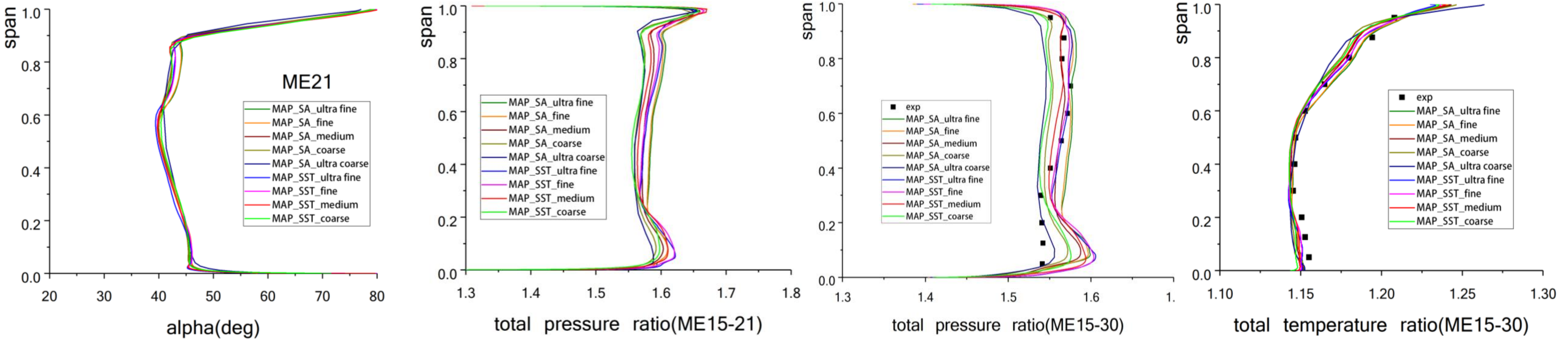


mass flow convergence history of throttle model

6. Span Distributions

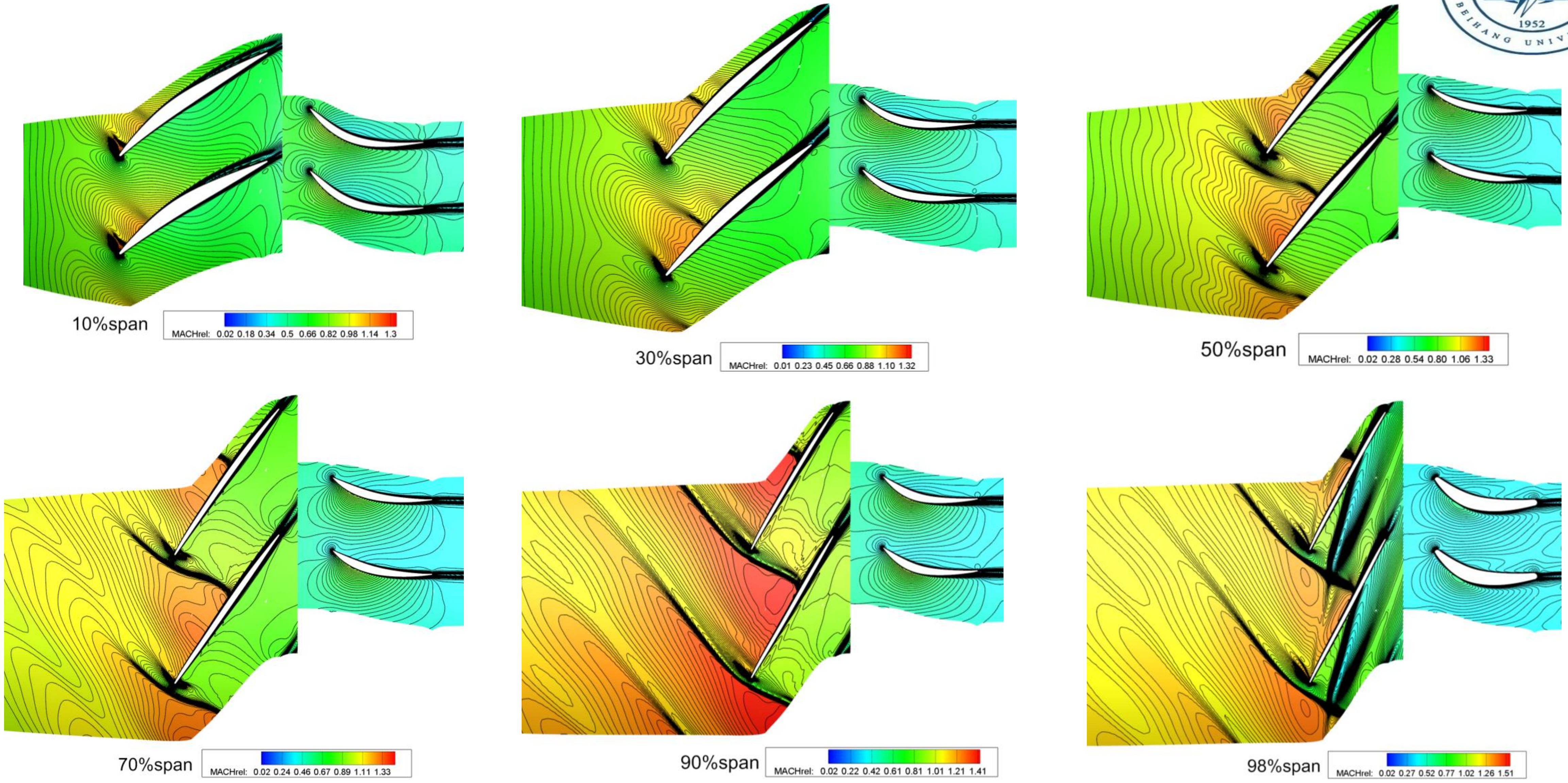


Peak efficiency point



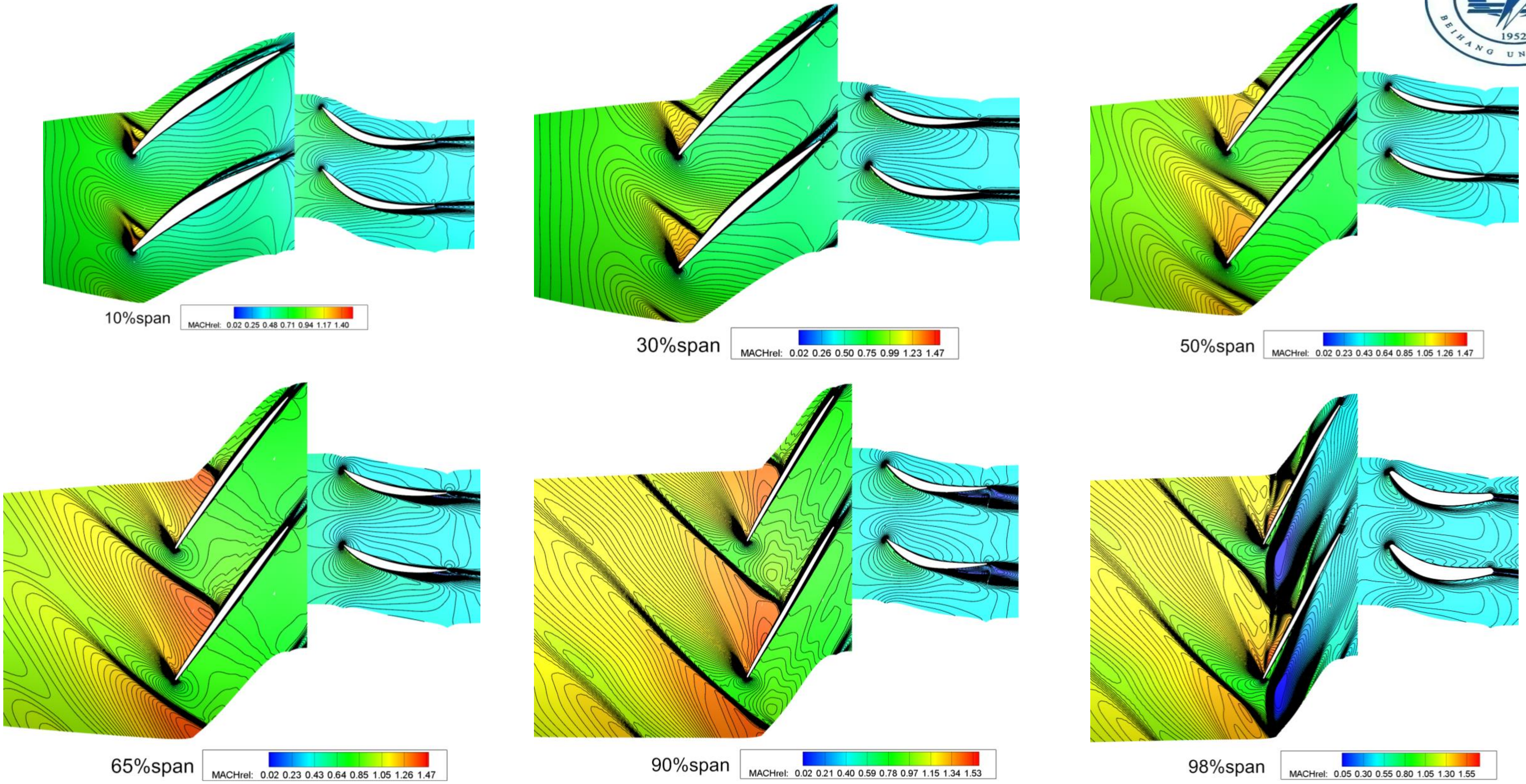
Near stall point

7. Flow Fields at Peak Efficiency Point



relative Mach number distributions

8. Flow Fields at Near Stall Point



relative Mach number distributions

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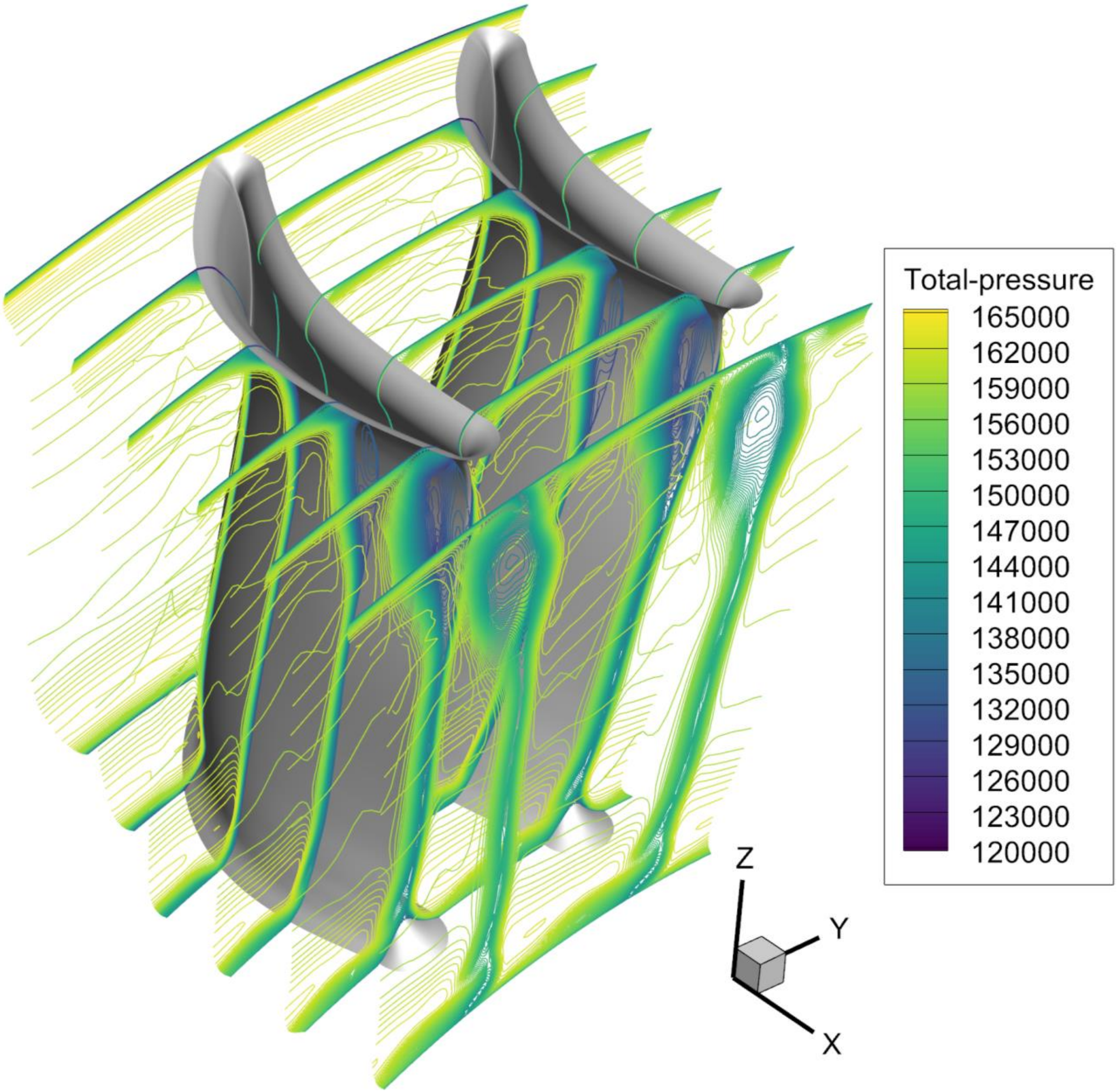

thank you