GPPS Global Power & Propulsion Society Workshop

NORTHWESTERN POLYTECHNICAL UNIVERSITY

Effects of mesh configurations on the analyses results of the TUDa compressor

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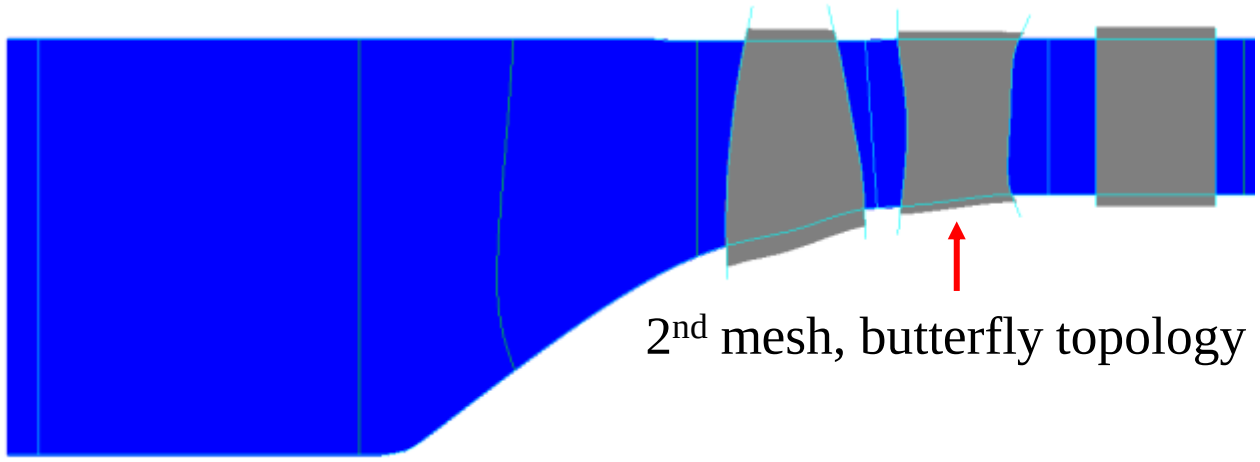
动力与能源学院 SCHOOL OF POWER AND ENERGY

Mesh configurations

1st geometry, released in the 1st CFD Workshop
1st geometry, 1st mesh
1st geometry, 2nd mesh

The fine mesh is considered.

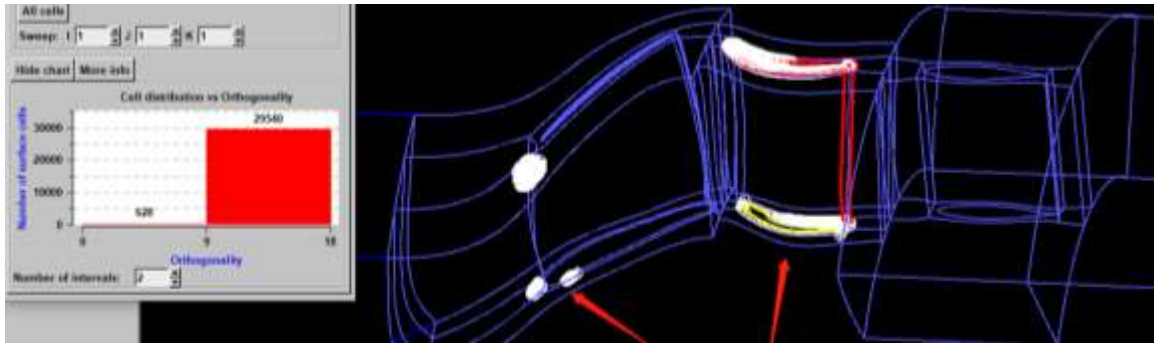
Mesh difference: Butterfly topology applied for the fillets



2nd mesh, butterfly topology

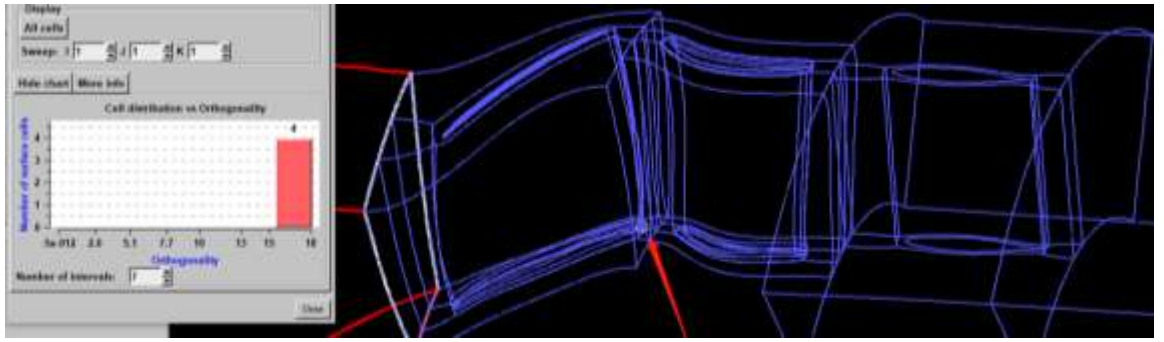
1st geometry, 1st mesh

Quality Field	Nb of Pts	Neg. Cells	Nb levels	Min. Skewness	Max. Asp. Ratio	Max. Exp. Ratio	Span. Ang. Dev.	Span. ER
Entire Mesh	6013571	0	2	5.6491	5415.9	7.8552	74.38	3.168
row 1	3363360	0	2	16.302	2274.4	2.3903	38.16	1.689
row 2	1803057	0	2	5.6491	456.01	3.1677	74.38	3.168
row 3	847154	0	3	21.608	5415.9	7.8552	16.81	1.294



1st geometry, 2nd mesh

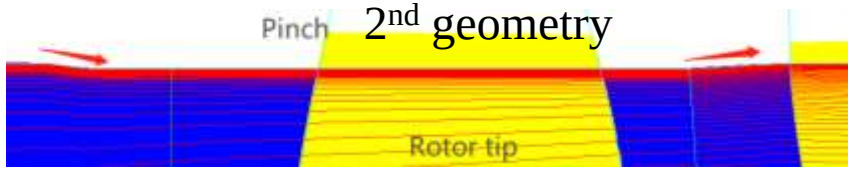
Quality Field	Nb of Pts	Neg. Cells	Nb levels	Min. Skewness	Max. Asp. Ratio	Max. Exp. Ratio	Span. Ang. Dev.	Span. ER
Entire Mesh	5916733	0	2	17.763	6337.4	4.2234	30.26	1.621
row 1	3313906	0	3	17.763	1804.4	2.5675	30.26	1.585
row 2	1671561	0	2	23.792	512.04	1.918	22.87	1.621
row 3	931266	0	3	25.893	6337.4	4.2234	0.21	1.441



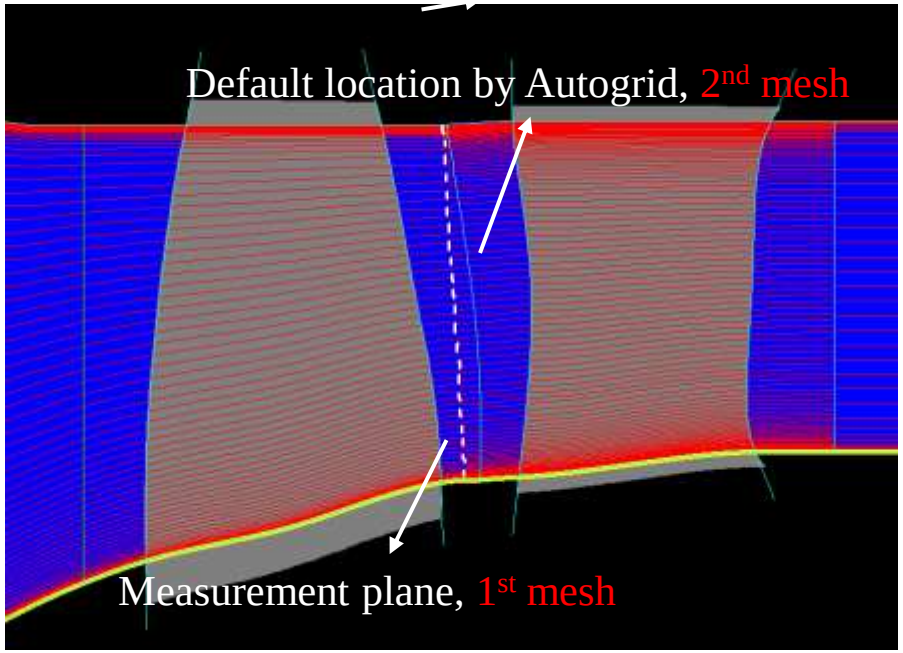
Mesh configurations

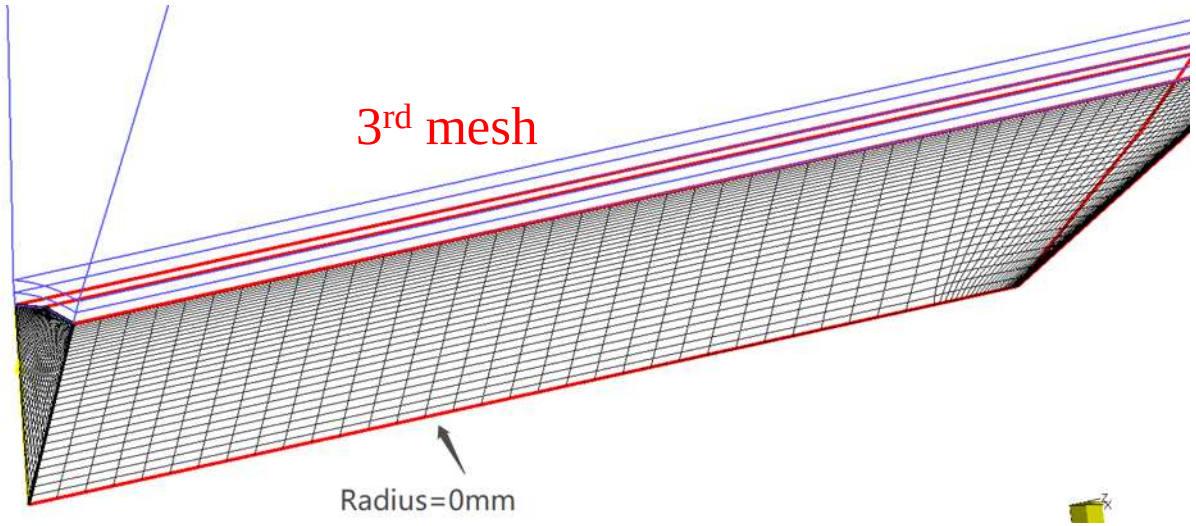
With butterfly topology applied to the fillets:

Major geometry difference: Pinch at rotor tip.



2nd geometry, 1st mesh (mixing plane at measurement plane between R1 and S1)
2nd geometry, 2nd mesh (default mixing plane between R1 and S1)
2nd geometry, 3rd mesh (mixing plane at measurement plane between R1 and S1, with an inlet bulb)





Numerical analyses

NUMECA Fine/Turbo v13.2

Boundary conditions:
Inlet total pressure, inlet total temperature, axial flow direction at the inlet
Static pressure at the outlet

SA turbulence model

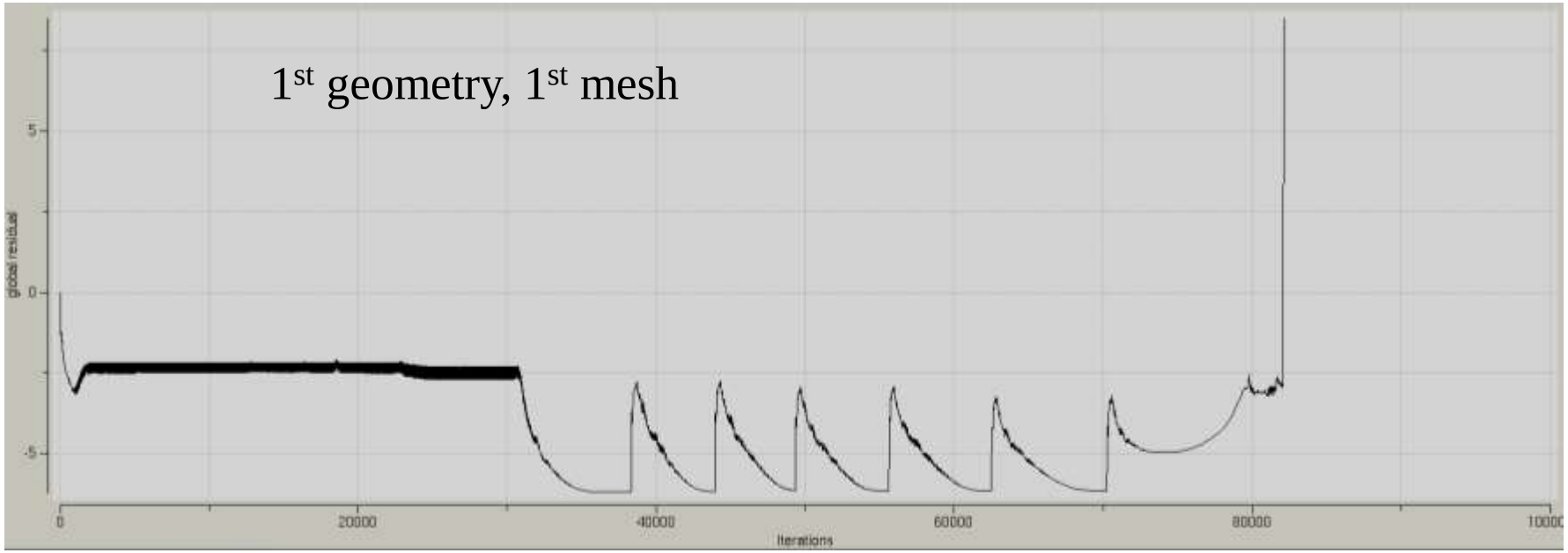
CFL number: 3

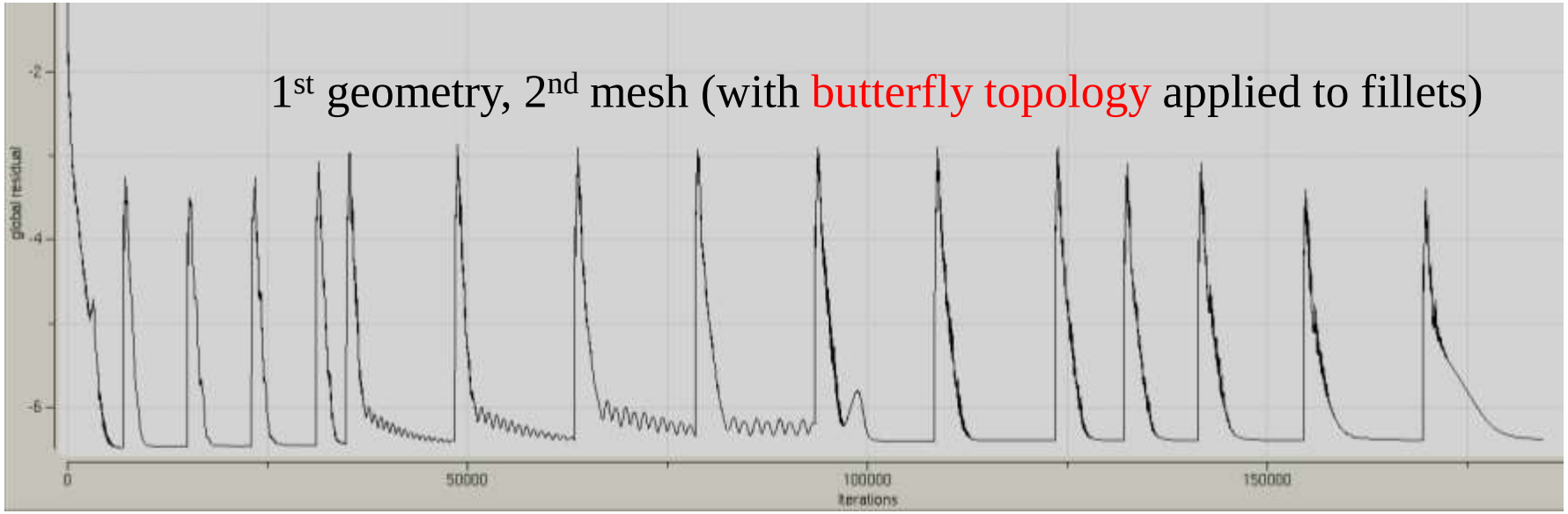
Others: default settings

Numerical analyses

Same initializations,
Same solver settings.

Better convergence at near choke points can be obtained with the 2nd mesh.





Speedline

The step for increasing the back pressure at near stall points is 1000Pa. Convergence criteria: -6

Maximum back pressure:

1st geometry, 1st mesh: 141kPa

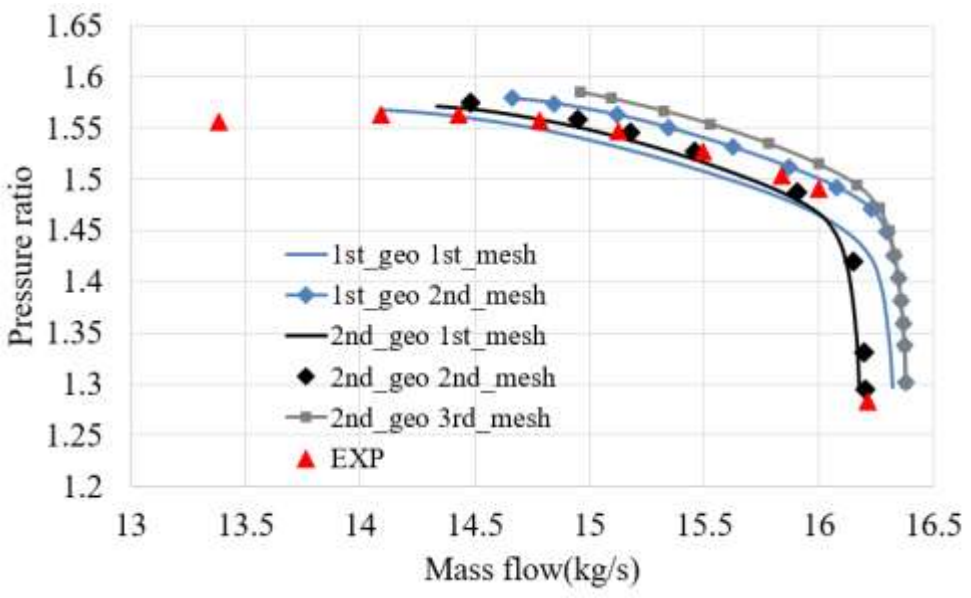
1st geometry, 2nd mesh: 142kpa

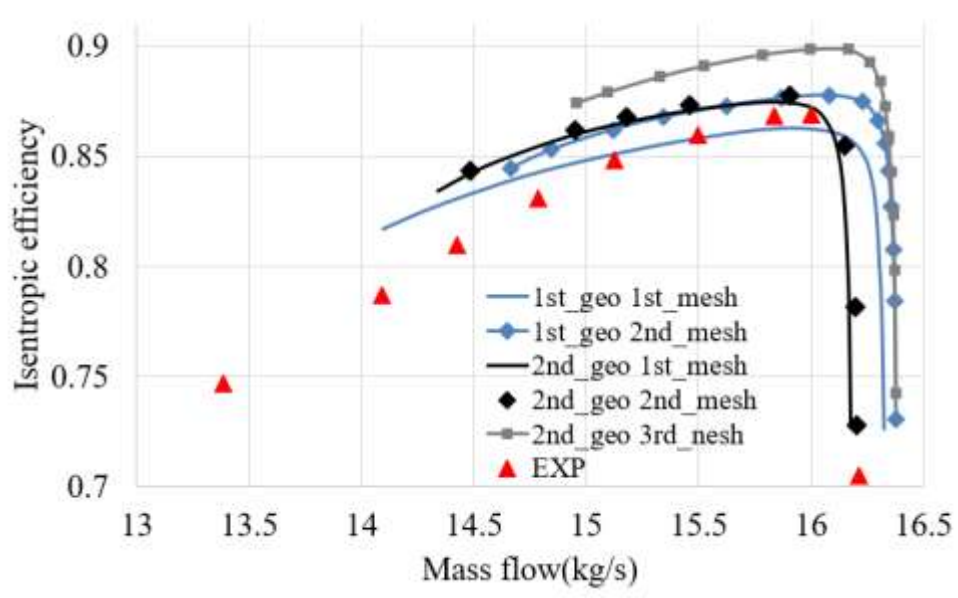
2nd geometry, 1st mesh: 142kPa

2nd geometry, 2nd mesh (default ME21 location): 142kPa

2nd geometry, 3rd mesh (with an inlet bulb): 140kpa

maximum back pressure=141kpa

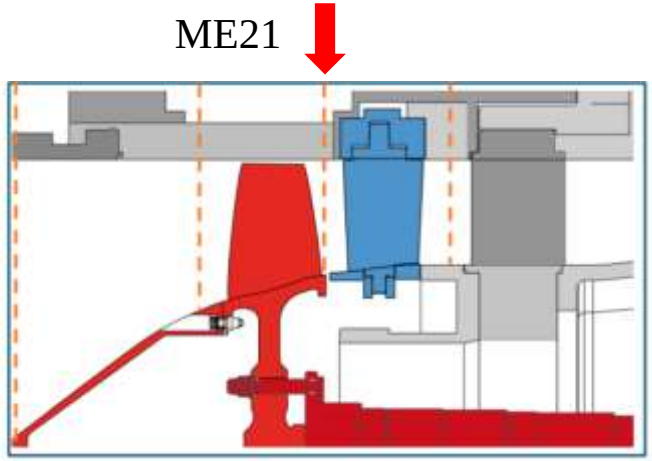


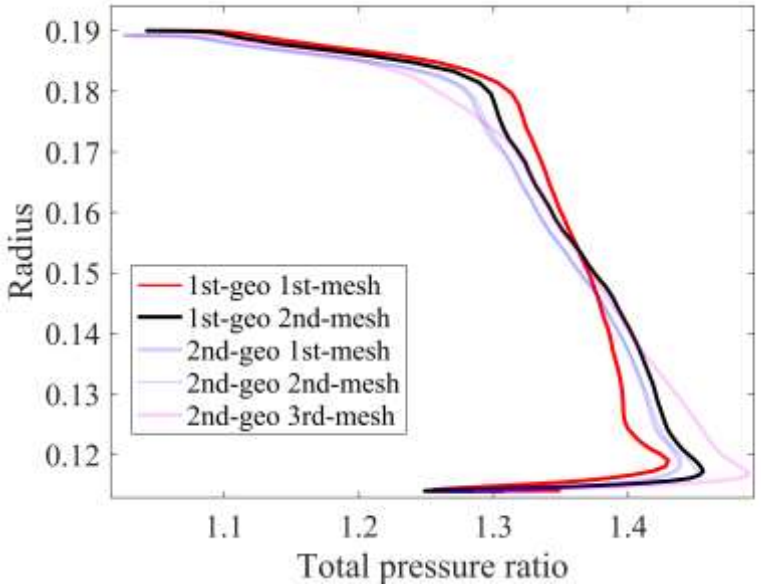


1D profile@ME21

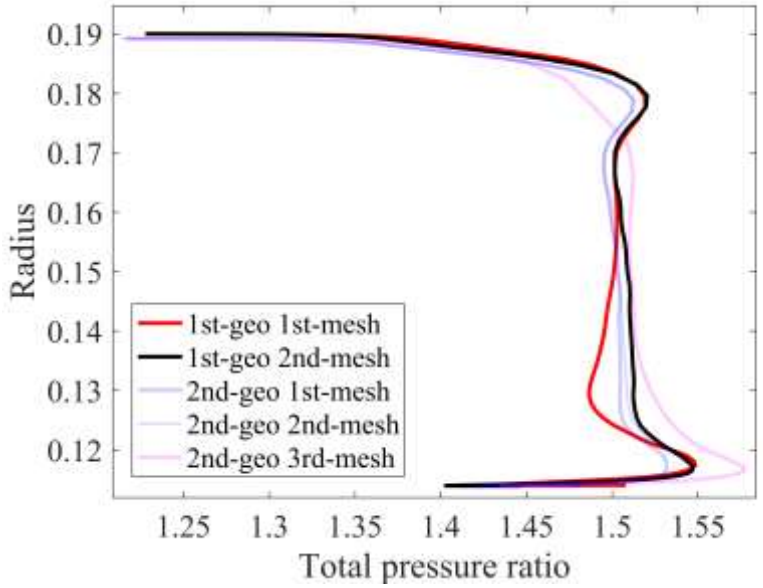
Total pressure distribution, based on the operating points with the same pressure ratio:

ME21: measurement plane between R1 and S1

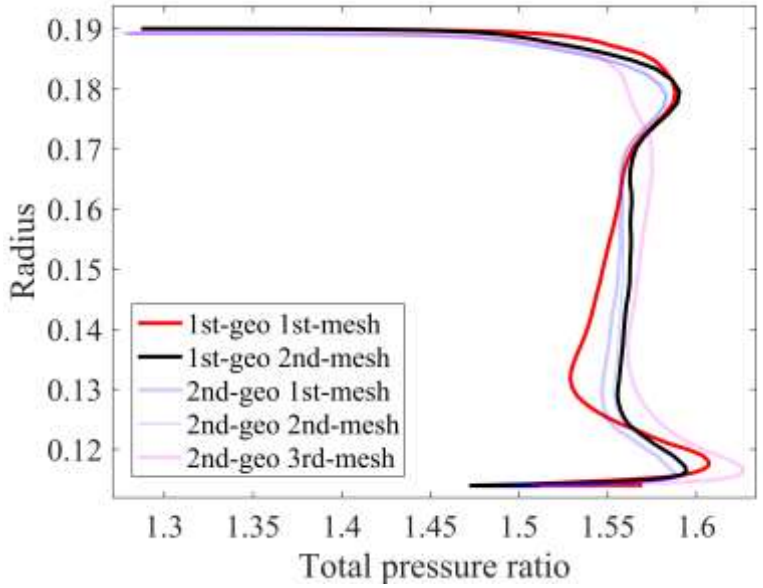




101kpa



127kpa

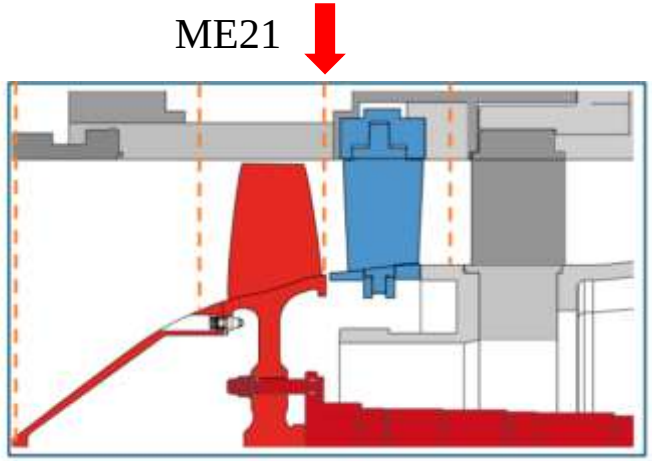


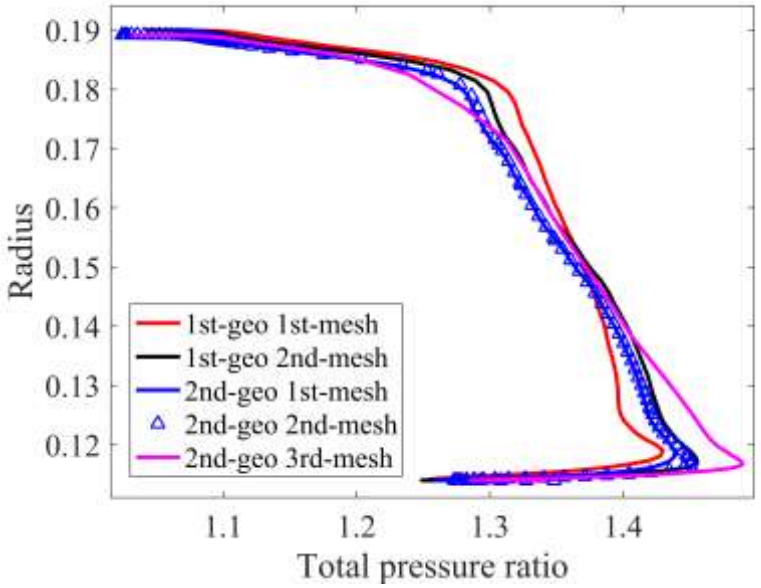
136kpa

1D profile@ME21

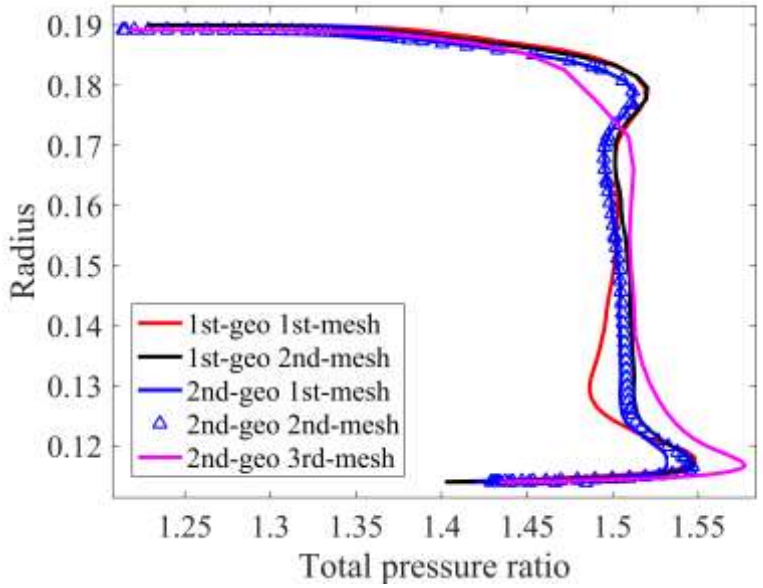
Total pressure distribution, based on the operating points with the same pressure ratio:

ME21: measurement plane between R1 and S1

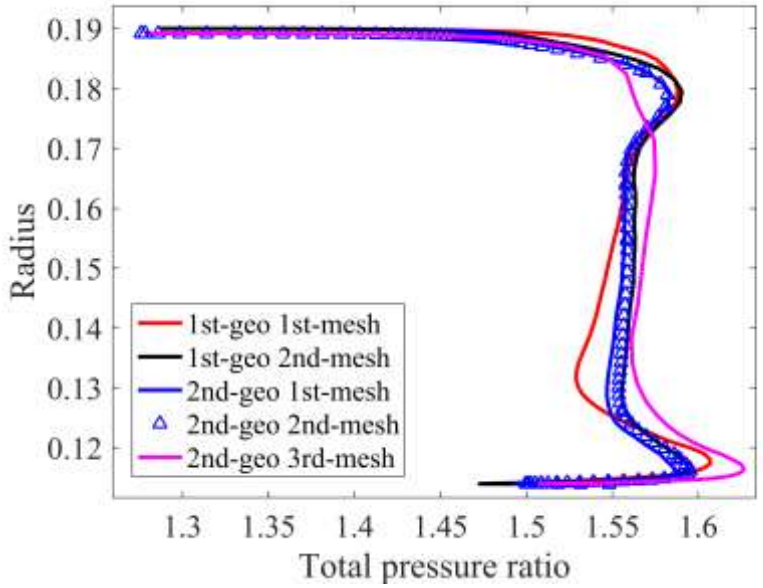




101kpa



127kpa

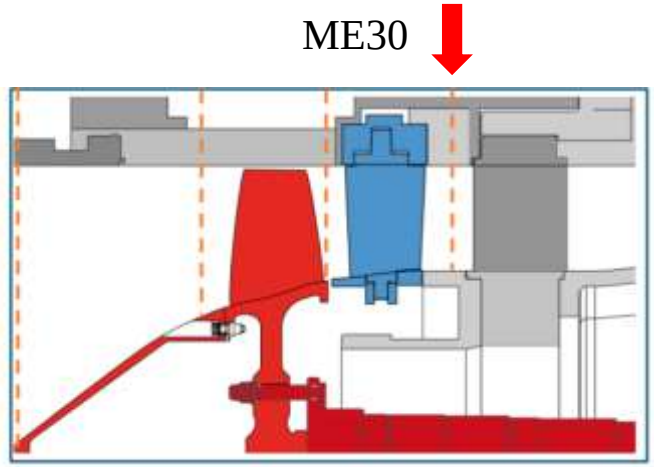


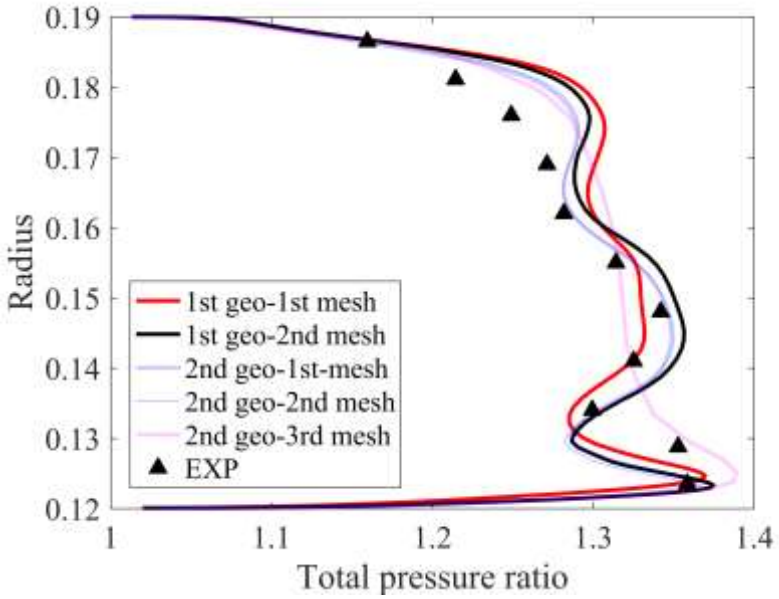
136kpa

1D profile@ME30

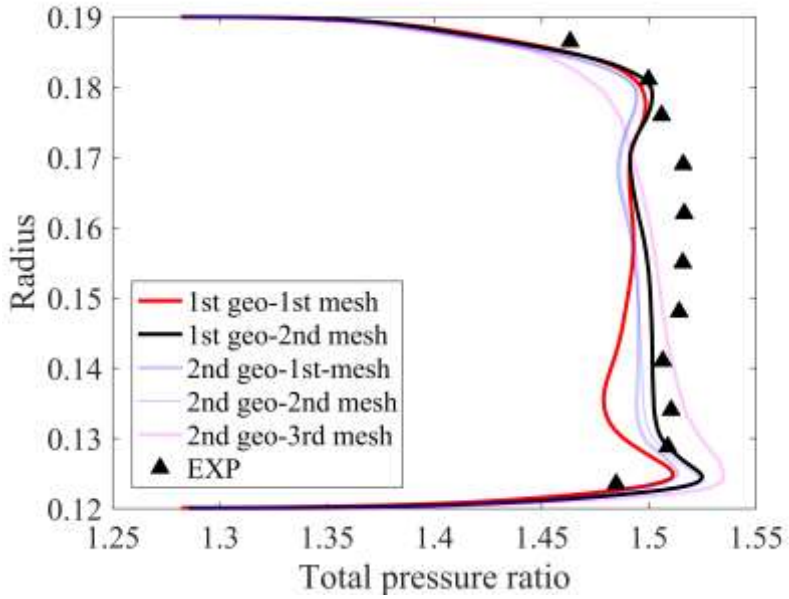
Total pressure distribution, based on the operating points with the same pressure ratio:

ME30: measurement plane at S1 outlet

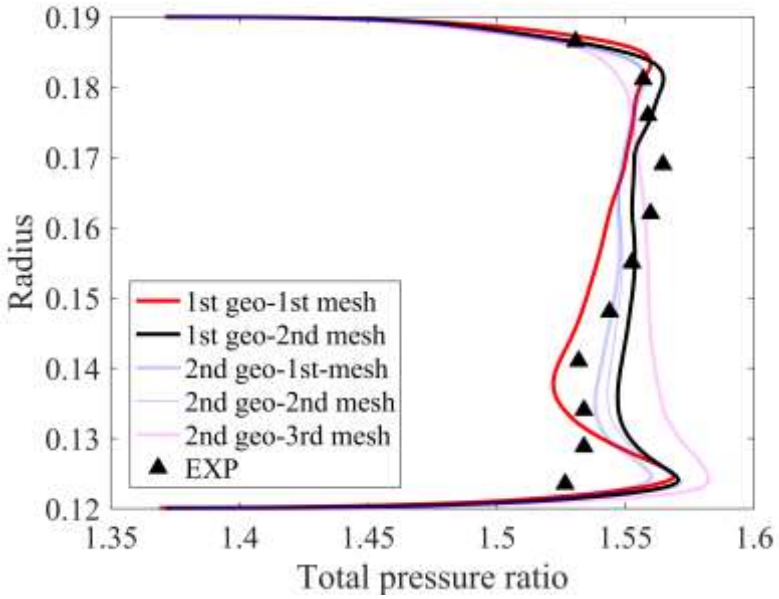




101kpa



127kpa

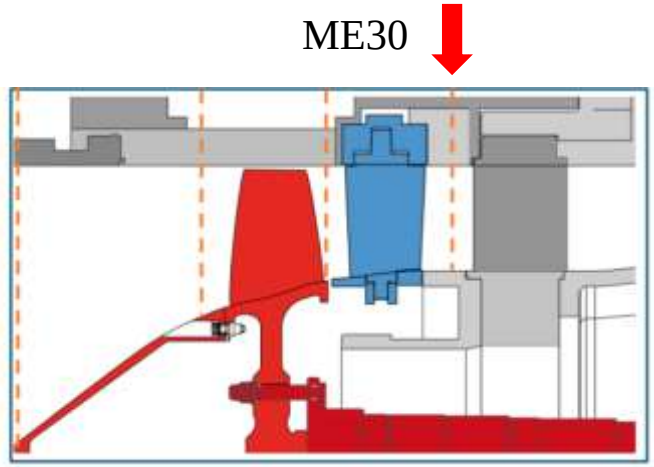


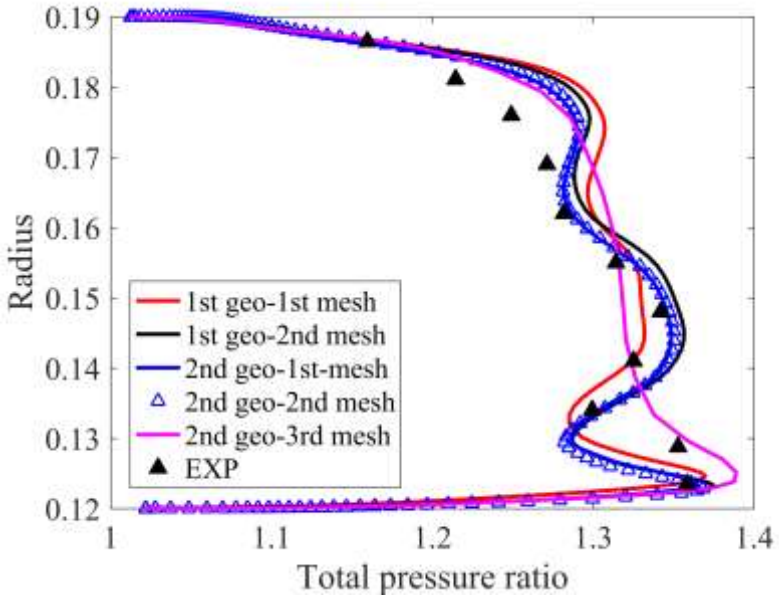
136kpa

1D profile@ME30

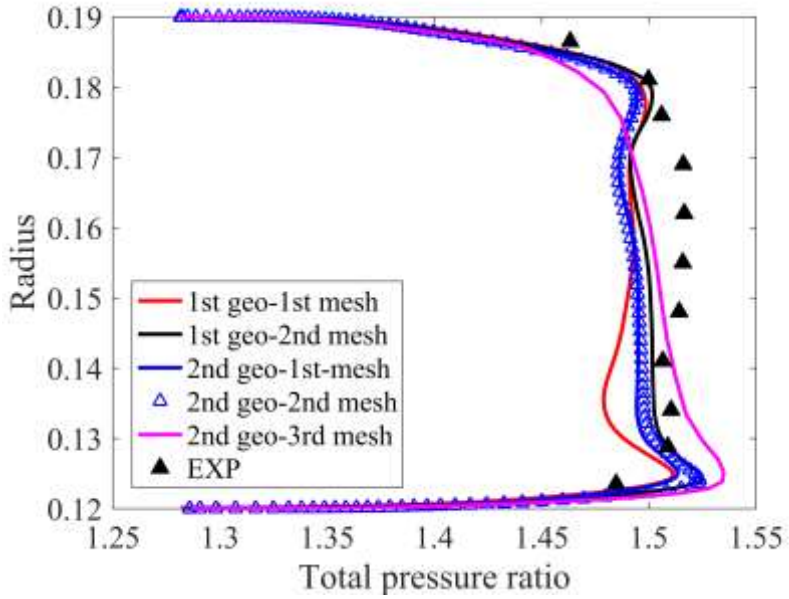
Total pressure distribution, based on the operating points with the same pressure ratio:

ME30: measurement plane at S1 outlet

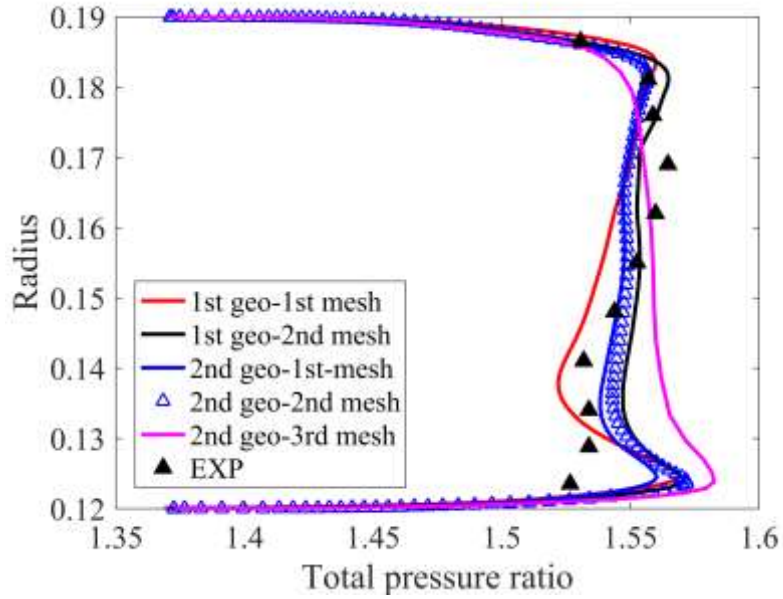




101kpa



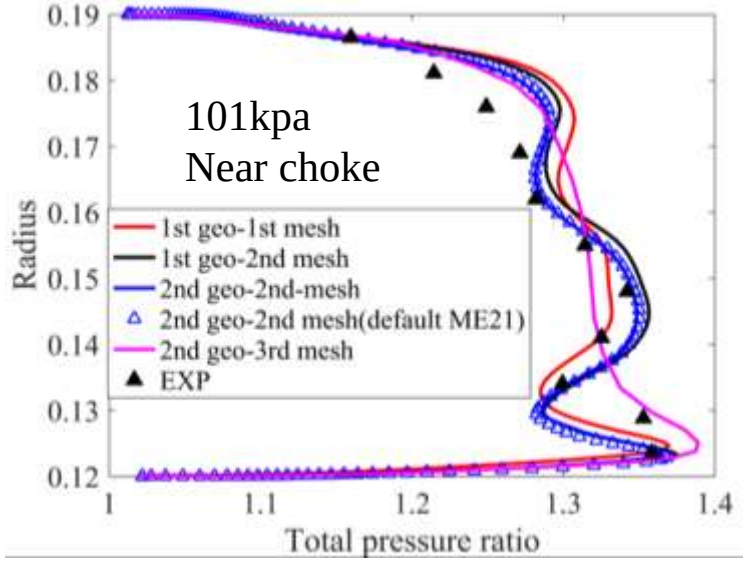
127kpa

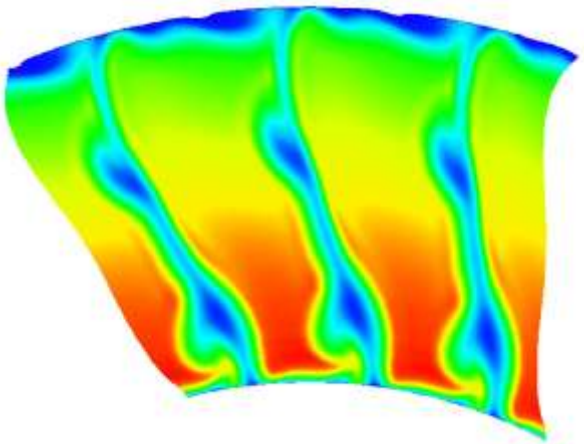


136kpa

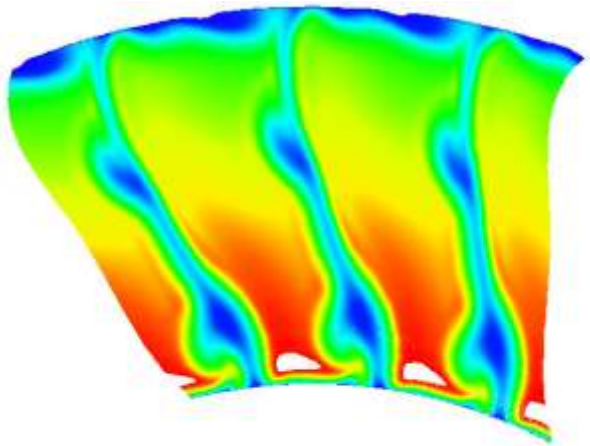
2D distribution @ME30

Total pressure distribution, based on the operating points with the same pressure ratio:

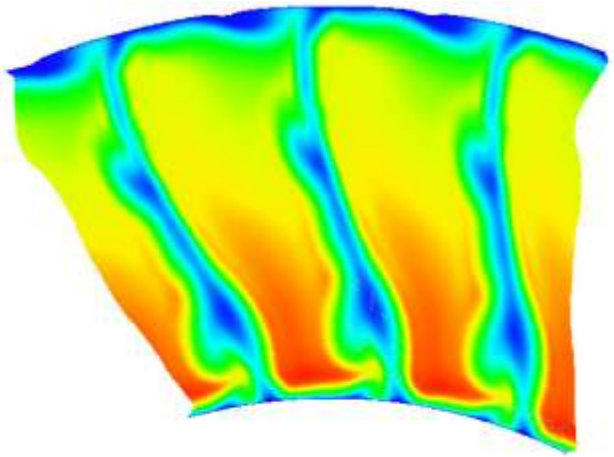




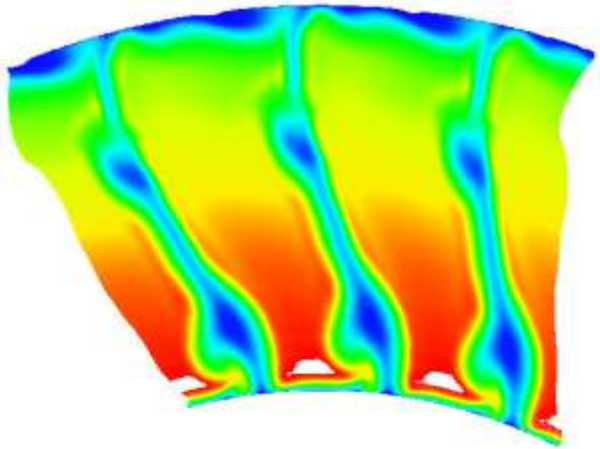
2nd geo 2nd mesh



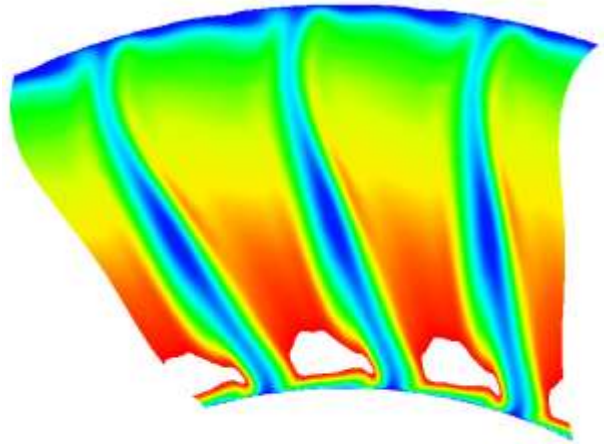
2nd geo 2nd mesh (default ME21)



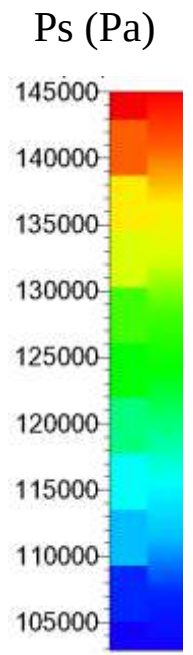
1st geo 1st mesh



1st geo 2nd mesh

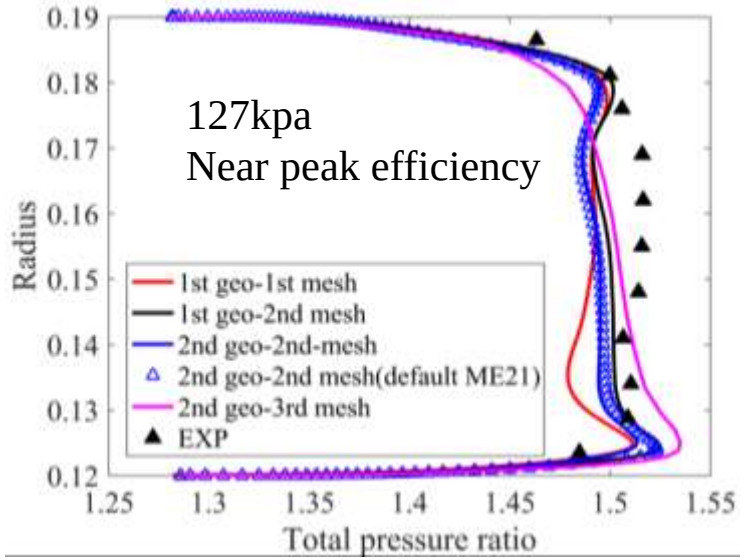


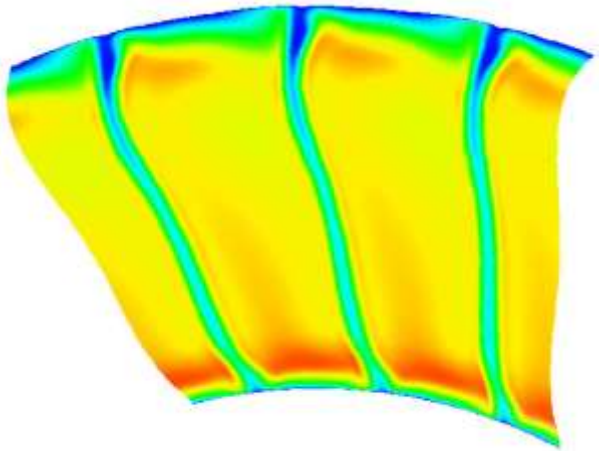
1st geo 3rd mesh (with inlet bulb)



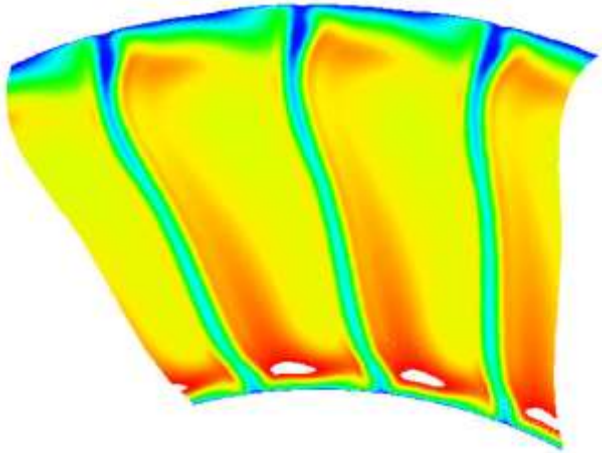
2D distribution @ME30 Near peak efficiency point

Total pressure distribution, based on the operating points with the same pressure ratio:

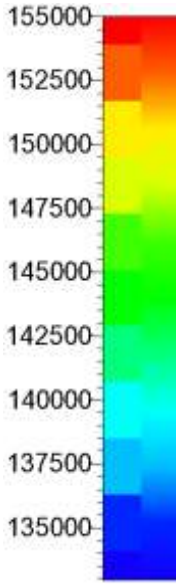


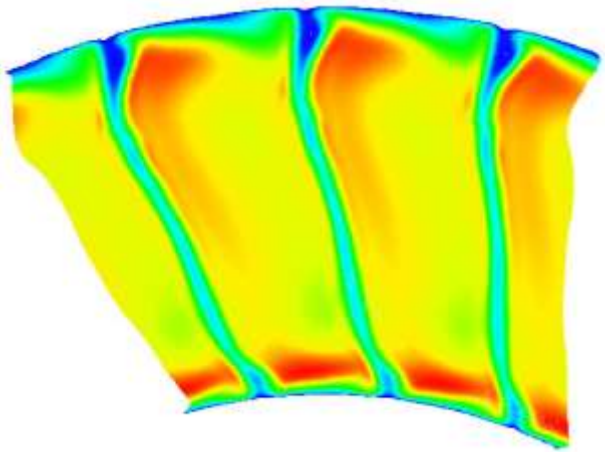


2nd geo 2nd mesh

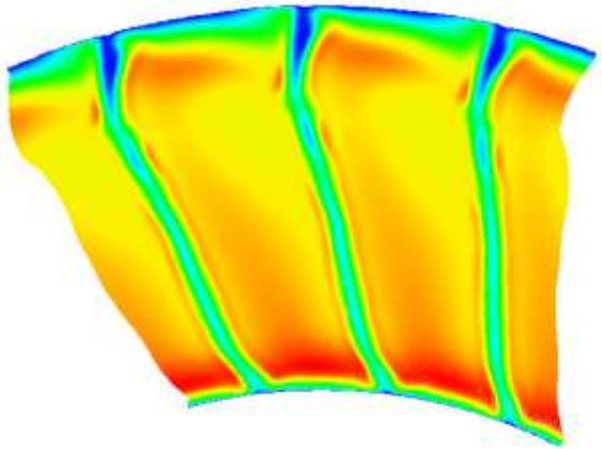


2nd geo 2nd mesh (default ME21)

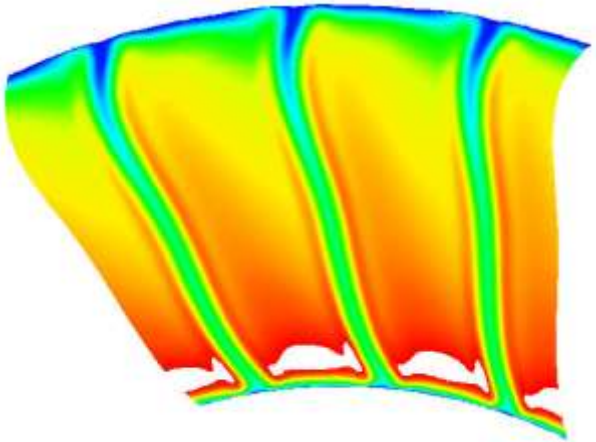




1st geo 1st mesh



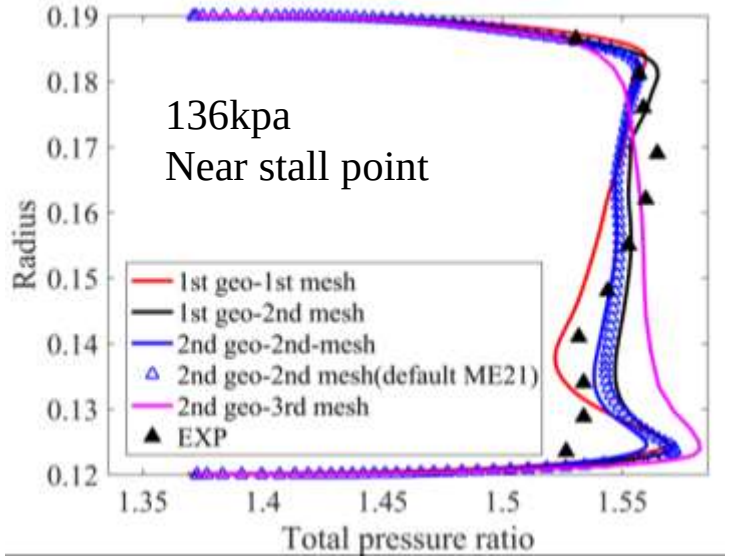
1st geo 2nd mesh

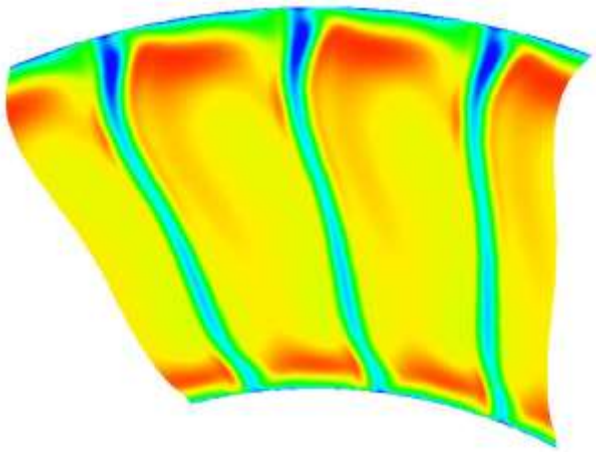


1st geo 3rd mesh (with inlet bulb)

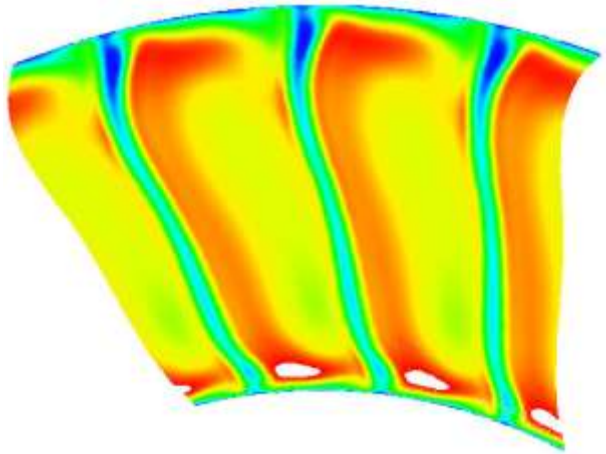
2D distribution @ME30 Near stall

Total pressure distribution, based on the operating points with the same pressure ratio:

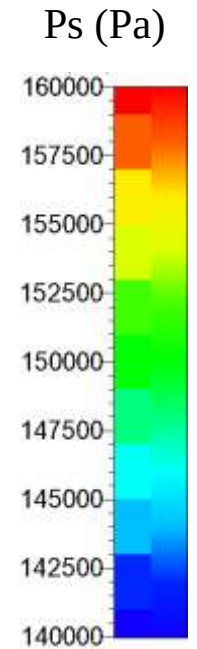


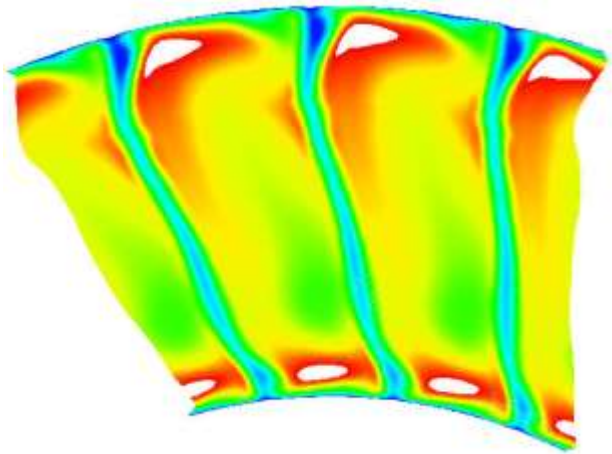


2nd geo 2nd mesh

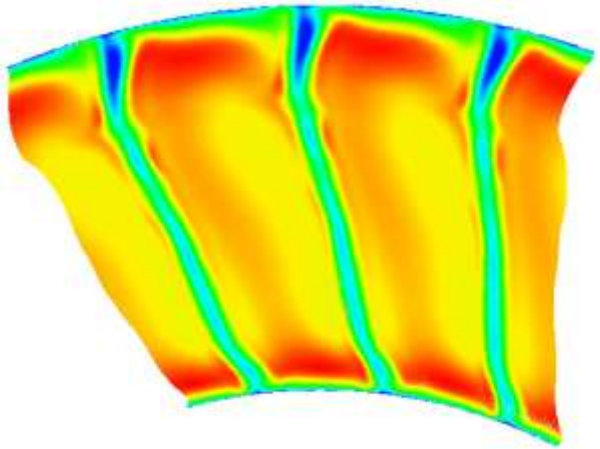


2nd geo 2nd mesh (default ME21)

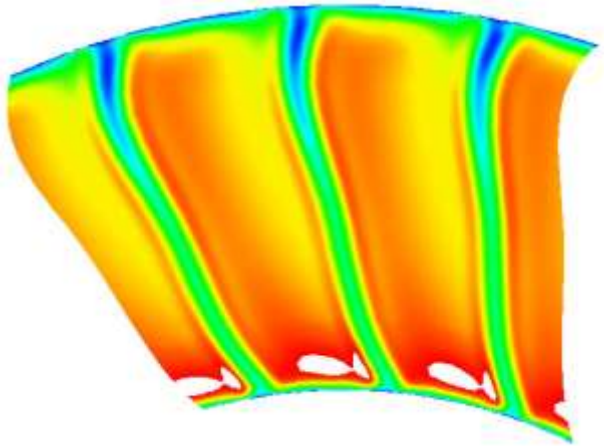




1st geo 1st mesh



1st geo 2nd mesh



1st geo 3rd mesh (with inlet bulb)

Summary

1. For the first geometry, better convergence at near choke points can be obtained with the second mesh. The PR-mass and Efficiency-mass speed lines of the second mesh are shifted towards the right and top.
2. For the second geometry with a pinched rotor tip, the choke mass flow is closer to the test data when compared with that of the first geometry.
3. The analysis results of the two considered mixing planes between R1 and S1 have little differences.
4. The third mesh with an inlet bulb has a larger choke mass flow than the second mesh. The PR-mass and Efficiency-mass speed lines of the mesh with an inlet bulb are shifted towards the right and top when compared with that of the second mesh.

Thanks for your attention!