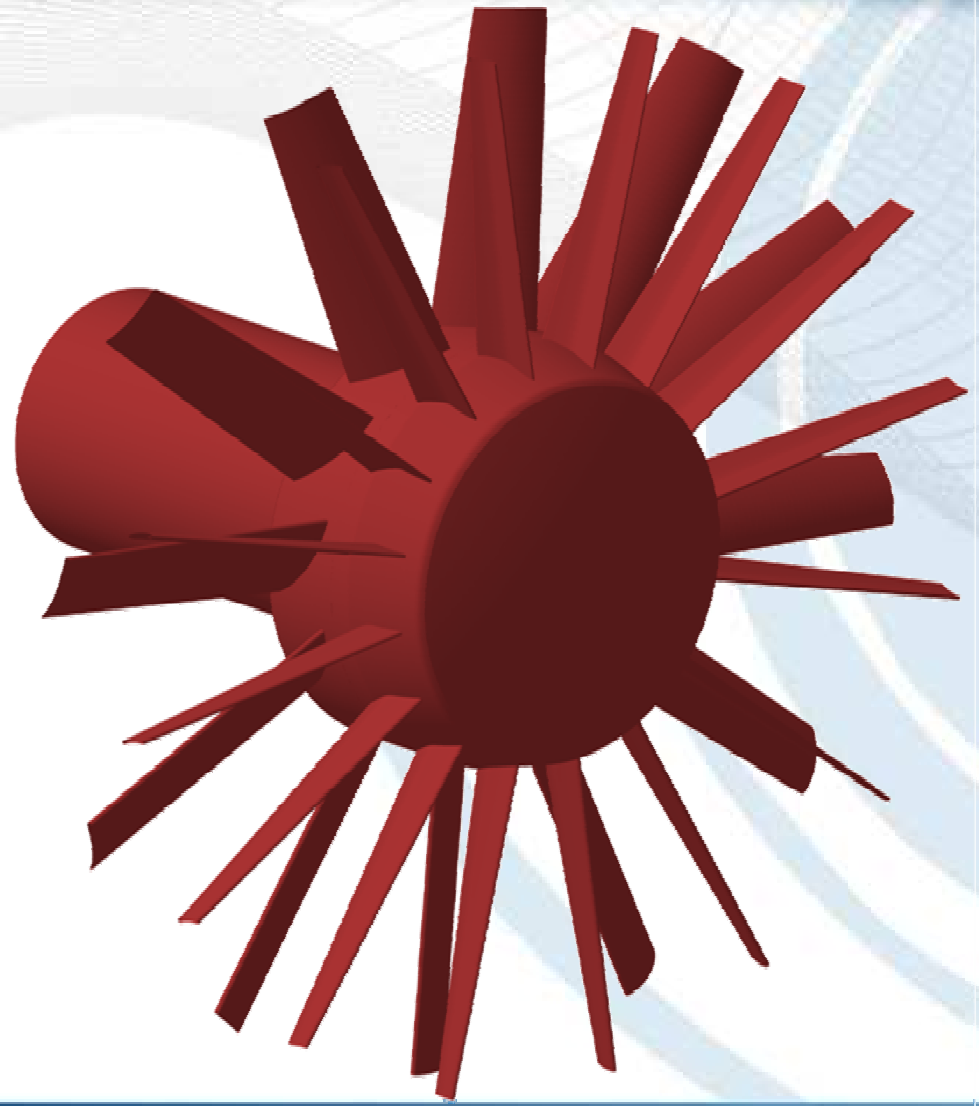
INVENIO

DOCEO

PROGREDI

...thinks in advance!!!

CFD ANALYSIS OF AN AXIAL FAN



SAVIO s.r.l.
AIR TECHNOLOGY

Submitted to:

SAVIO

By

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DOCUMENT ID.: 014_NUMIT_001

DATE: Tuesday, December 20, 2016

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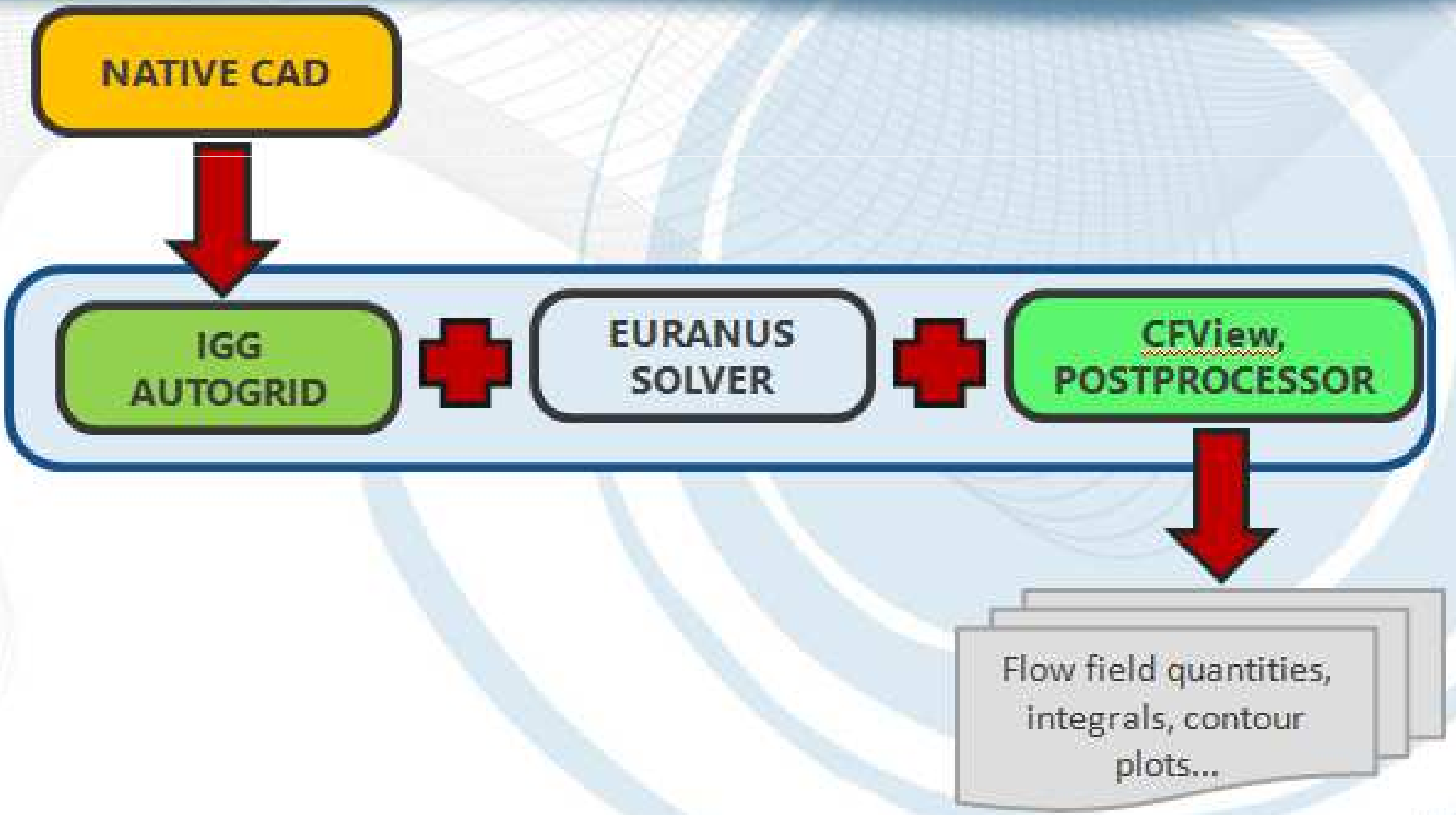
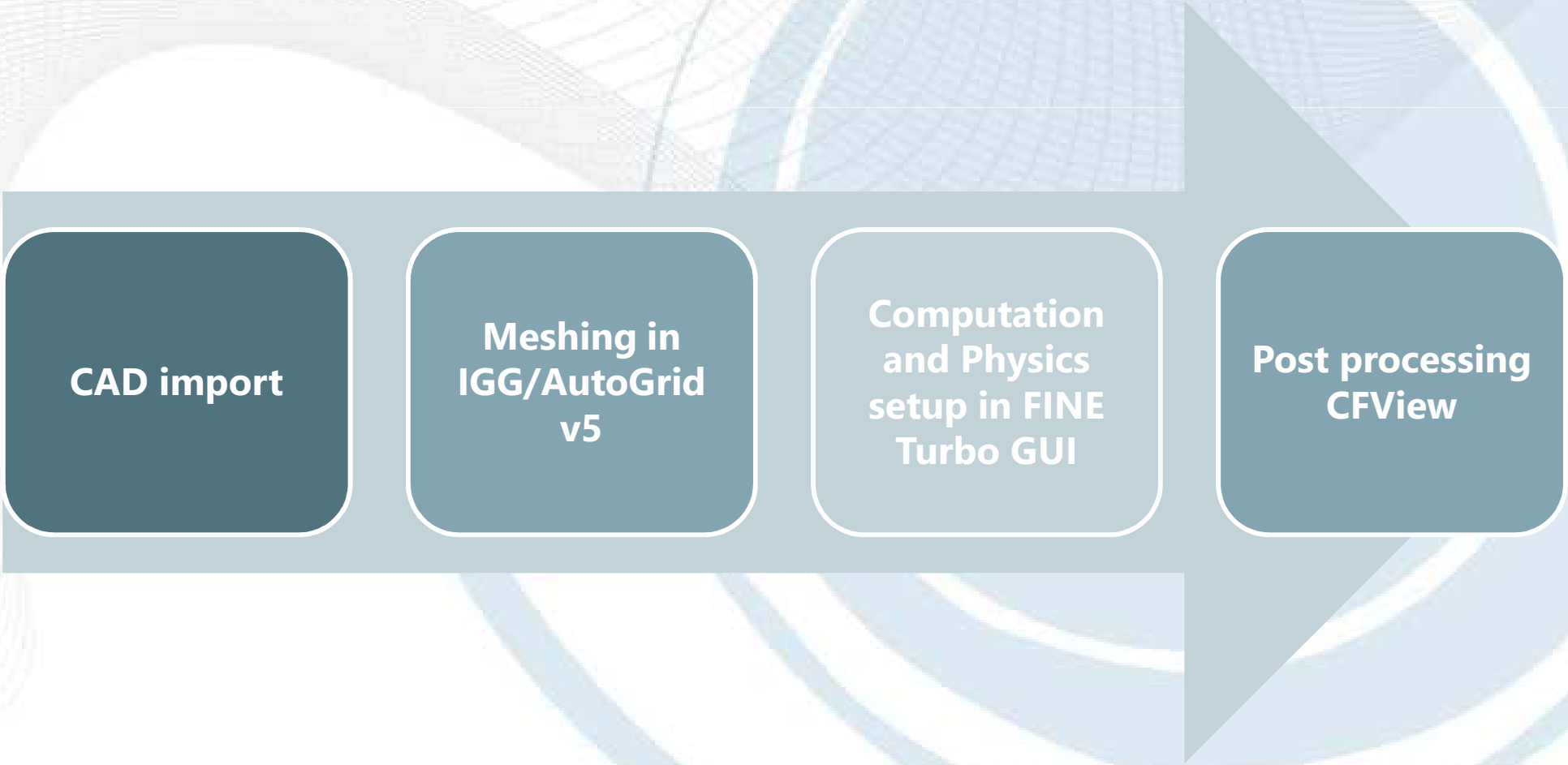
EXECUTIVE SUMMARY

The document here presented by Numitalia to SAVIO srl summarize all the main steps performed aiming to simulate the performances of an axial flow fan installed in a vertical wind tunnel plant.
The documente rapresent just the intent to benchmark NUMITALIA skill to the Customer with the objective of furter possible cooperations.
All the geometries provided by Customer were treated in order to get a model compliant with Numeca International standars whose CFD code was use to perform all the computations.
Numeca FINE Turbo Suite was used successfully and the result will be herewith presented

NUMECA FINE/Turbo Flow Process



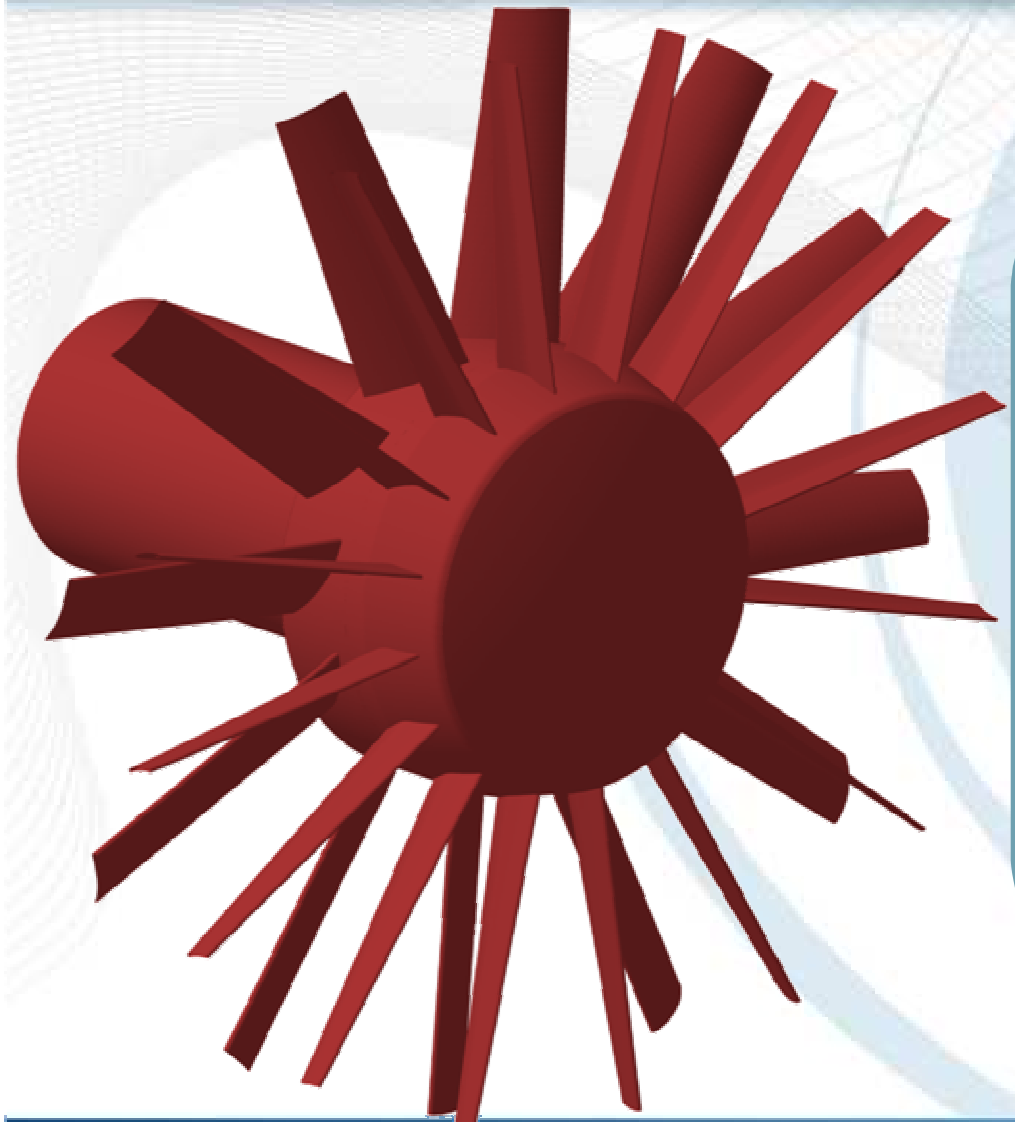
EXECUTIVE SUMMARY: NUMECA FINE TURBO Wokflow



1

TEST CASE DESCRIPTION

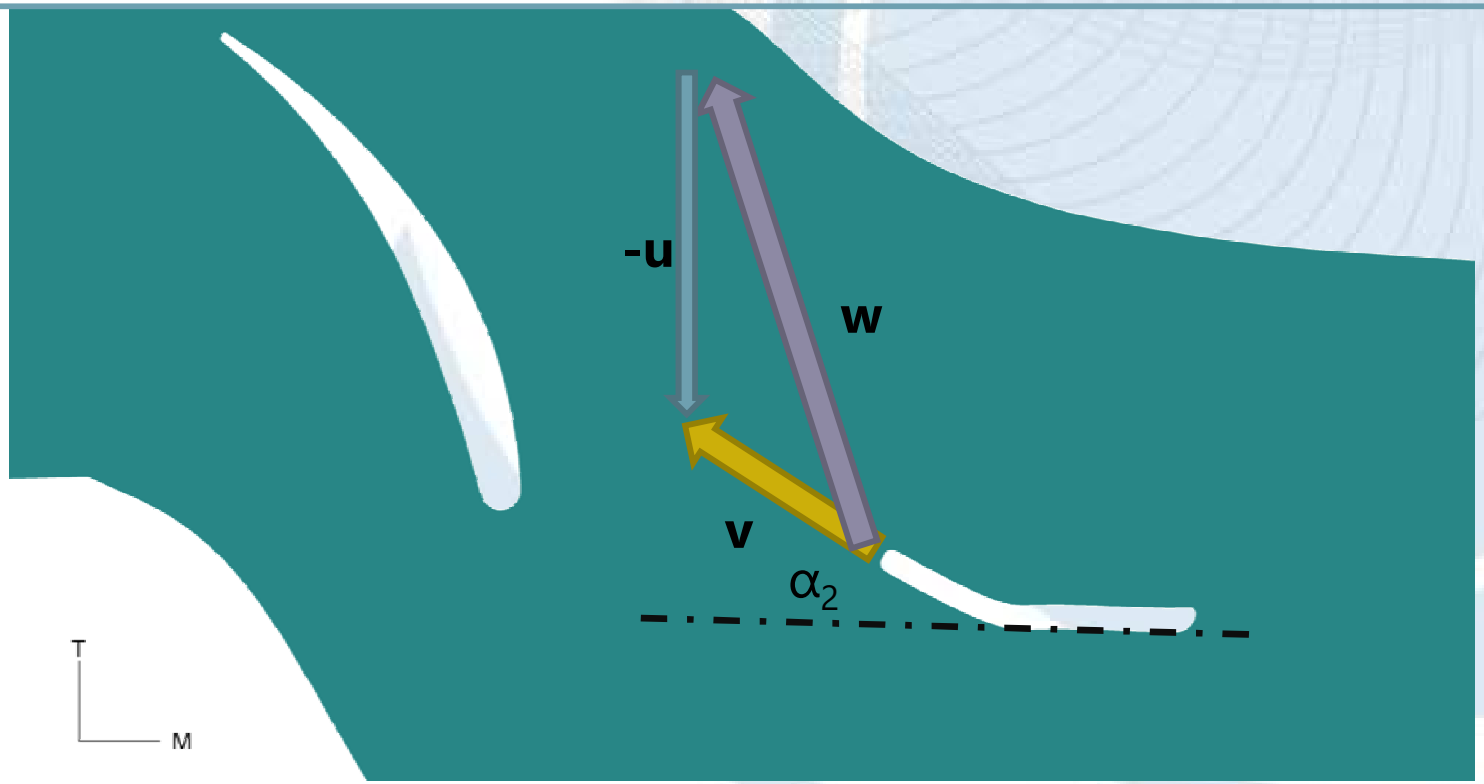
EXECUTIVE SUMMARY: NUMECA FINE TURBO Wokflow



Geometry at hands consist in two row of an axial fan sizing 1744mm at shroud, wile 700mm at hub. The resulting geometry is an assembly of two row, a stator and a rotor fan spinning at 750rpm. The attained speed corresponds to have an axial flow of 612kg/s producing an axial velocity of 53.4m/s. Since no geometry of the stator existed as 3D model, Numitalia provided a starting point geometry defined by means of velocity triangled based on free vortex theory

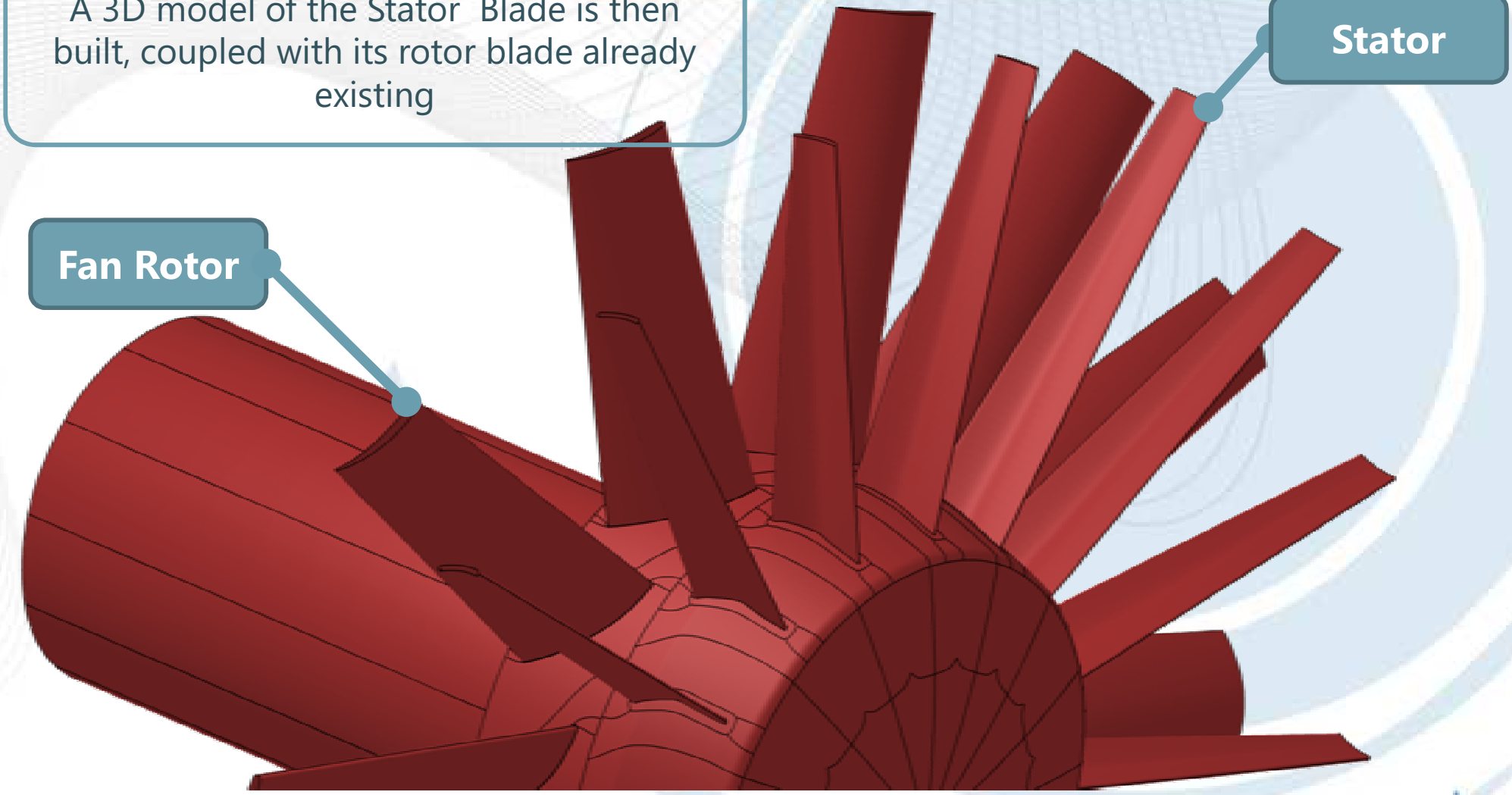
Reconstruction of the stator

It's handy to underline that CAD model of the stator existed except of a sketch. Since the axial speed is common for absolute and relative frame and since, for the theory of free vortex the azimuthal component of velocity times radius has to be constant at any span section the α_2 angle can be retrieved via some trigonometric calculations



Reconstruction of the stator

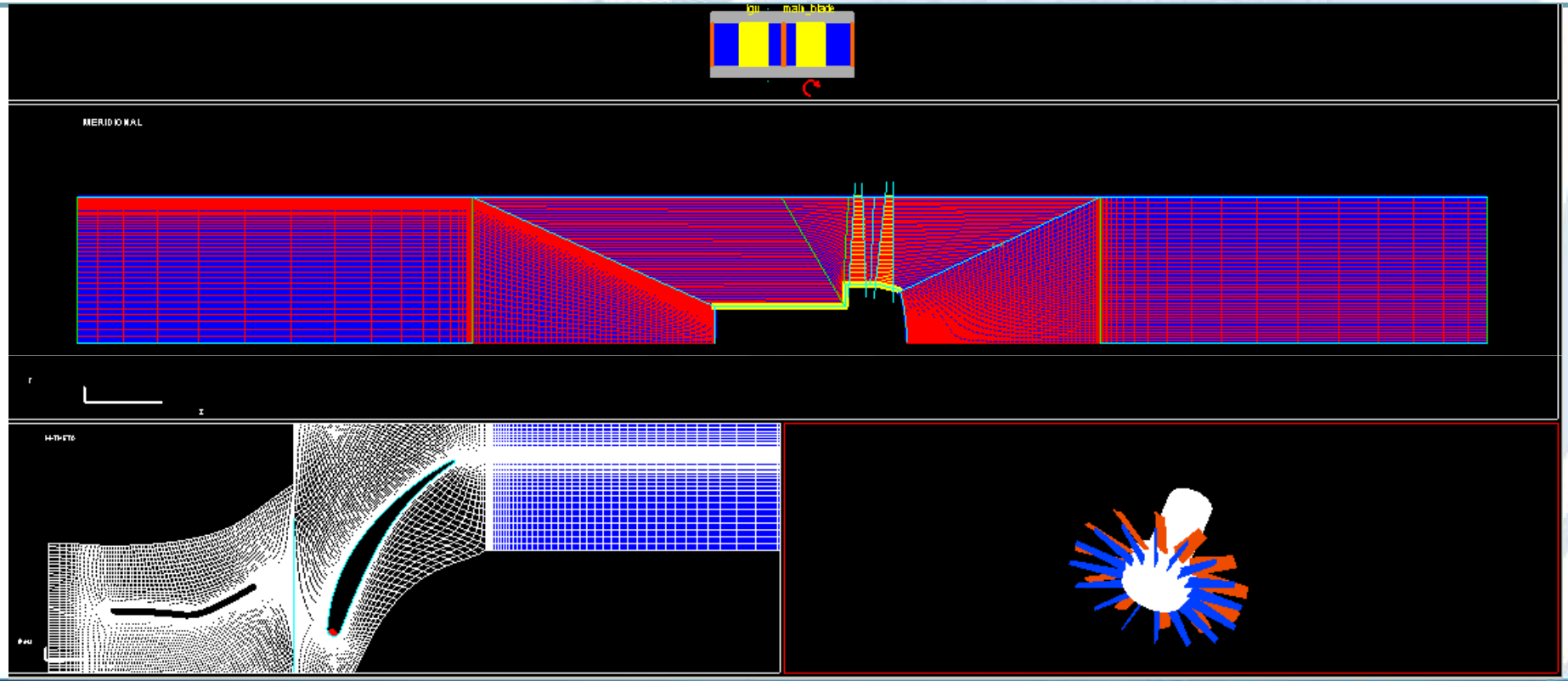
A 3D model of the Stator Blade is then built, coupled with its rotor blade already existing



2 MESH GENERATION

Mesh generation .#1

Mesh generation consists in the discretization of one passage B2B of the periodicity. Grid takes into account, blading, hub contour and shroud duct. ***Shroud gap has been modeled***. No hub fillet was considered, since it didn't exist in the original geometry. Considering the specification of keeping y^+close to 1 a first cell high of 0.07mm has been considered. The whole grid has been generated inside AutoGrid v5

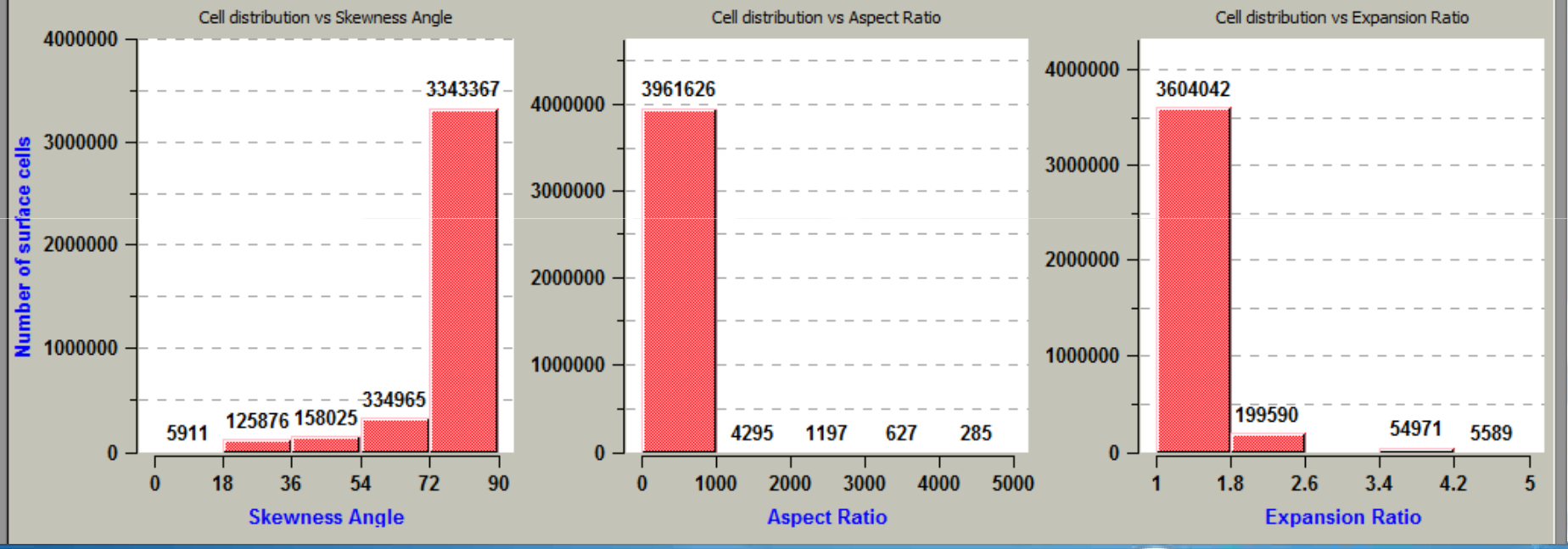


Mesh generation .#2

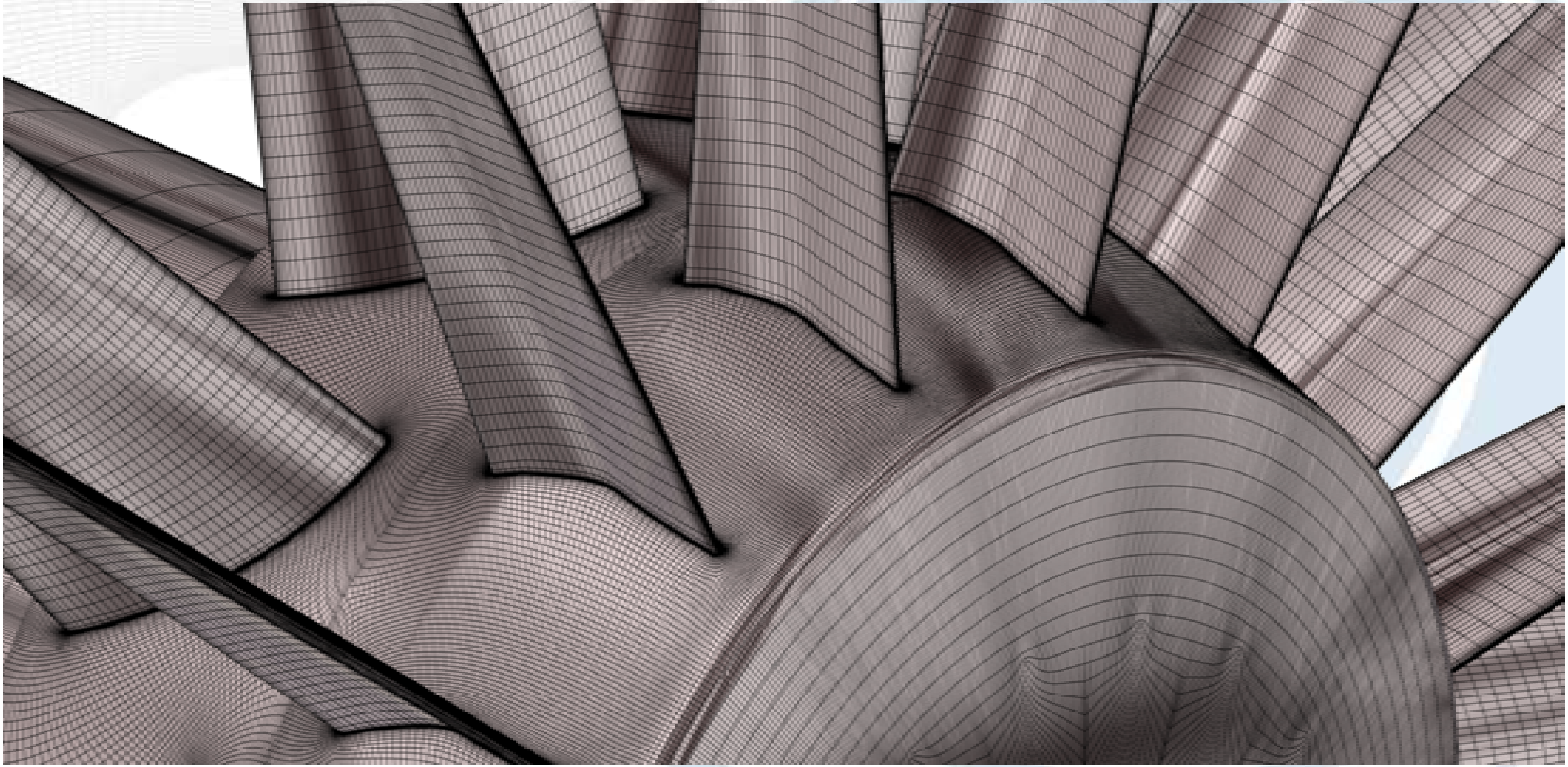
All the effort produced a grid with hiqh quality standards compliant with Numeca criteria. The resume of these requirement are defined in the report here below rapresented

Grid Quality Check

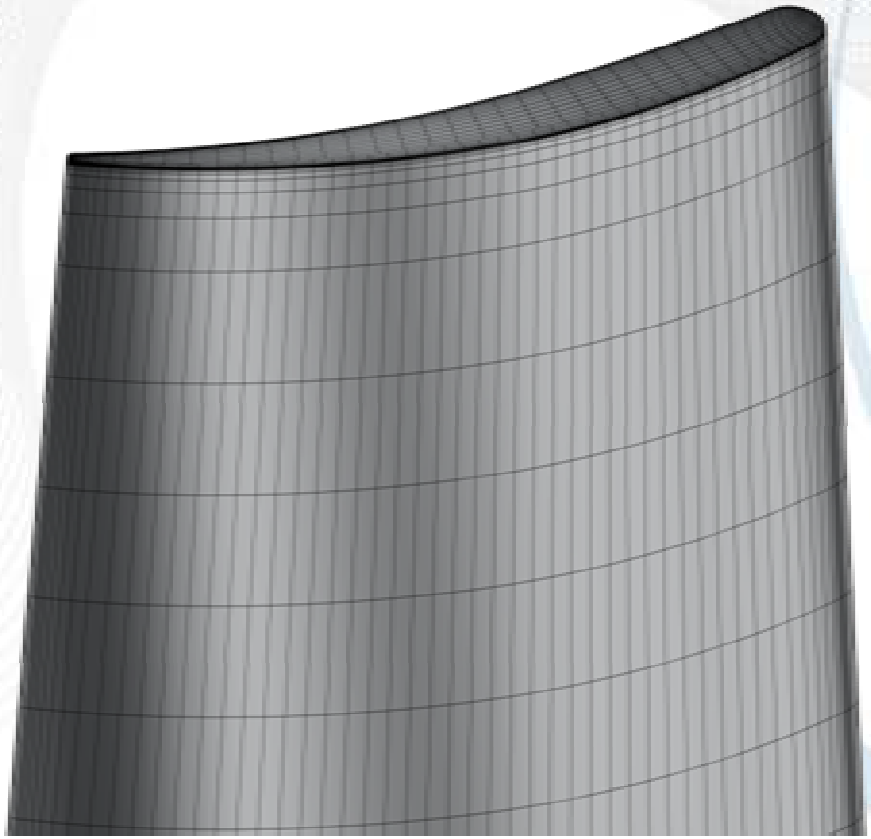
Quality Field	Nb of Pts	Neg. Cells	Nb levels	Min. Skewness	Max. Asp. Rati	Max. Exp. Rati	Span. Ang. Dev.	Span. ER	CPU
Entire Mesh	1394718	0	3	13.116	5363.2	4.3499	124.499	4.35	00:01:20
igv	570570	0	3	19.446	1947.4	2.4757	124.499	1.845	00:00:58
main_blade	590940	0	3	13.116	5363.2	4.3499	3.92	4.35	00:01:14
Inlet Bulb	103484	0	3	22.499	471.55	2.4178	14.67	2.418	00:00:00

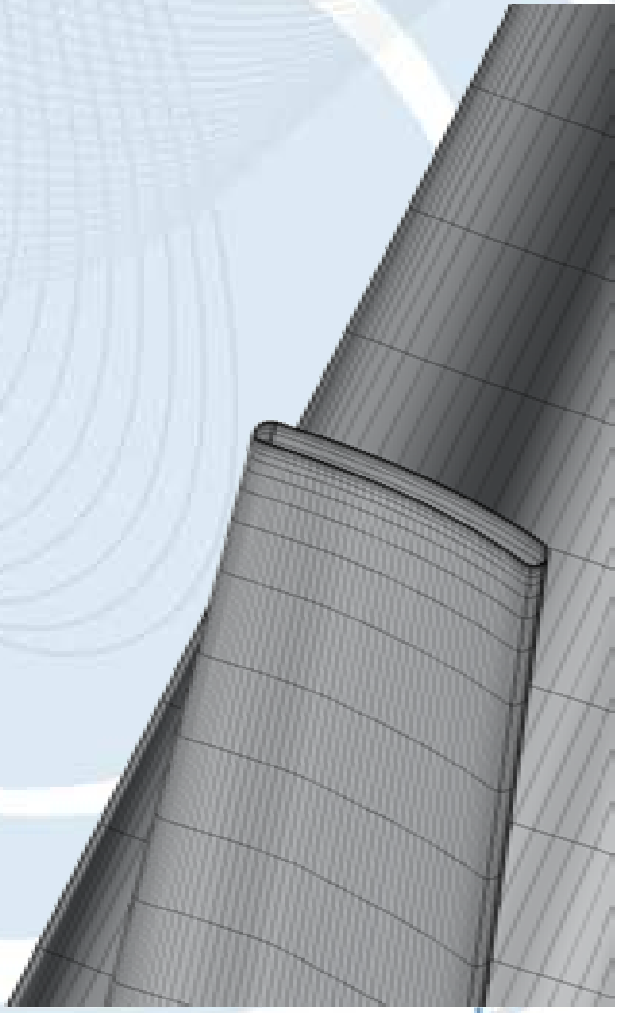


Mesh generation .#3



Mesh generation .#4





3

COMPUTATION

COMPUTATION SET UP

Computation here performed is:

a. Steady State Incompressible Navier Stokes
b. Fully turbulent kε extended wall function has been used due to the high Reynolds [4M], in order to capture boundary layer features
c. Fluid is incompressible Air, so precondintioning is applied
d. Total gauge of 0 Pa is imposed to inlet with velocity normal to inlet patch
e. Static gauge of 0 Pa is imposet at outlet, backflow probe is used.
f. Rotorblade spins at 750rpm

4 MAIN RESULTS

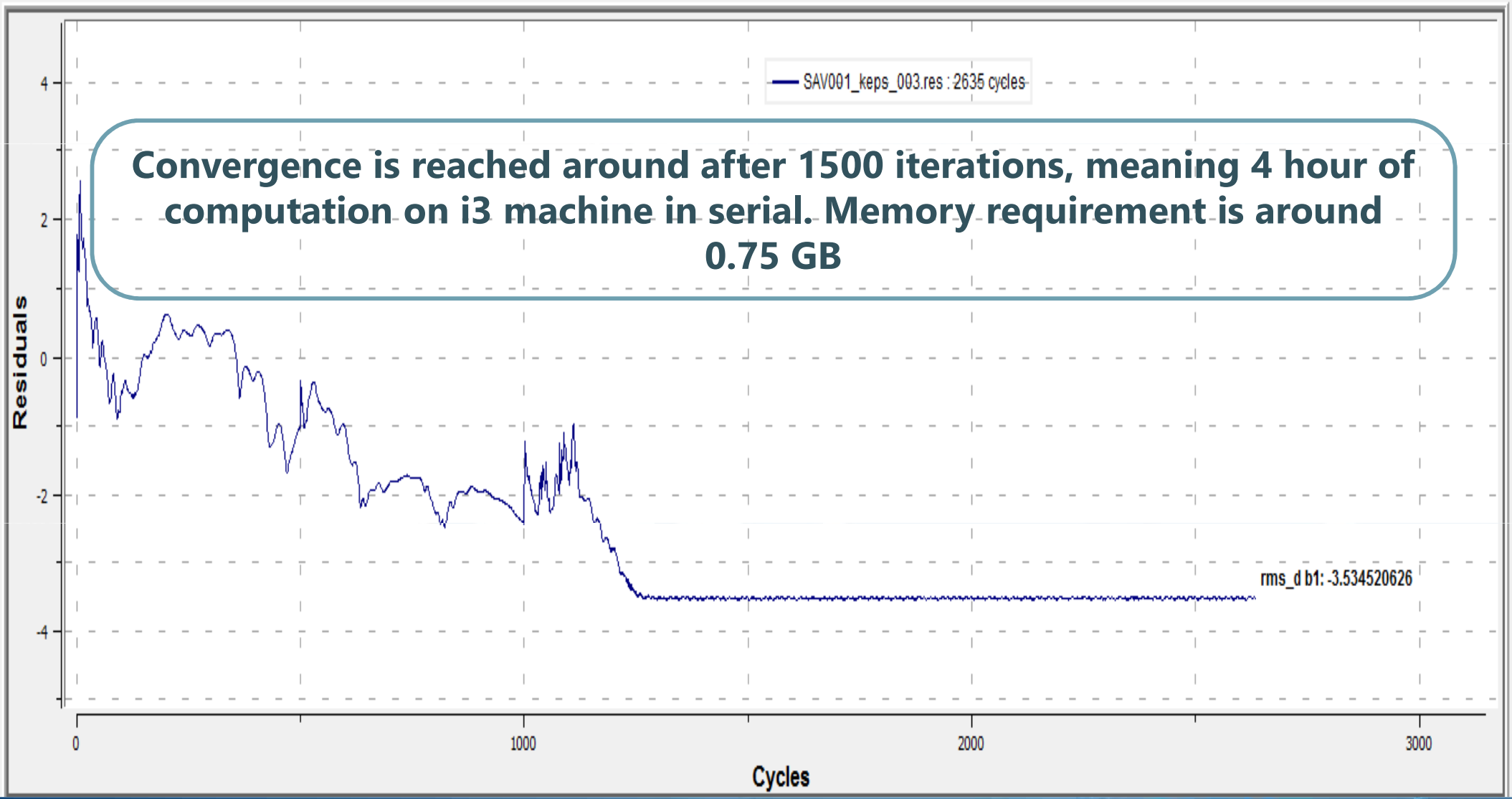
MAIN RESULTS

CONVERGENCE HISTORIES OF NONLINEARITIES HAS BEEN MONITORED.

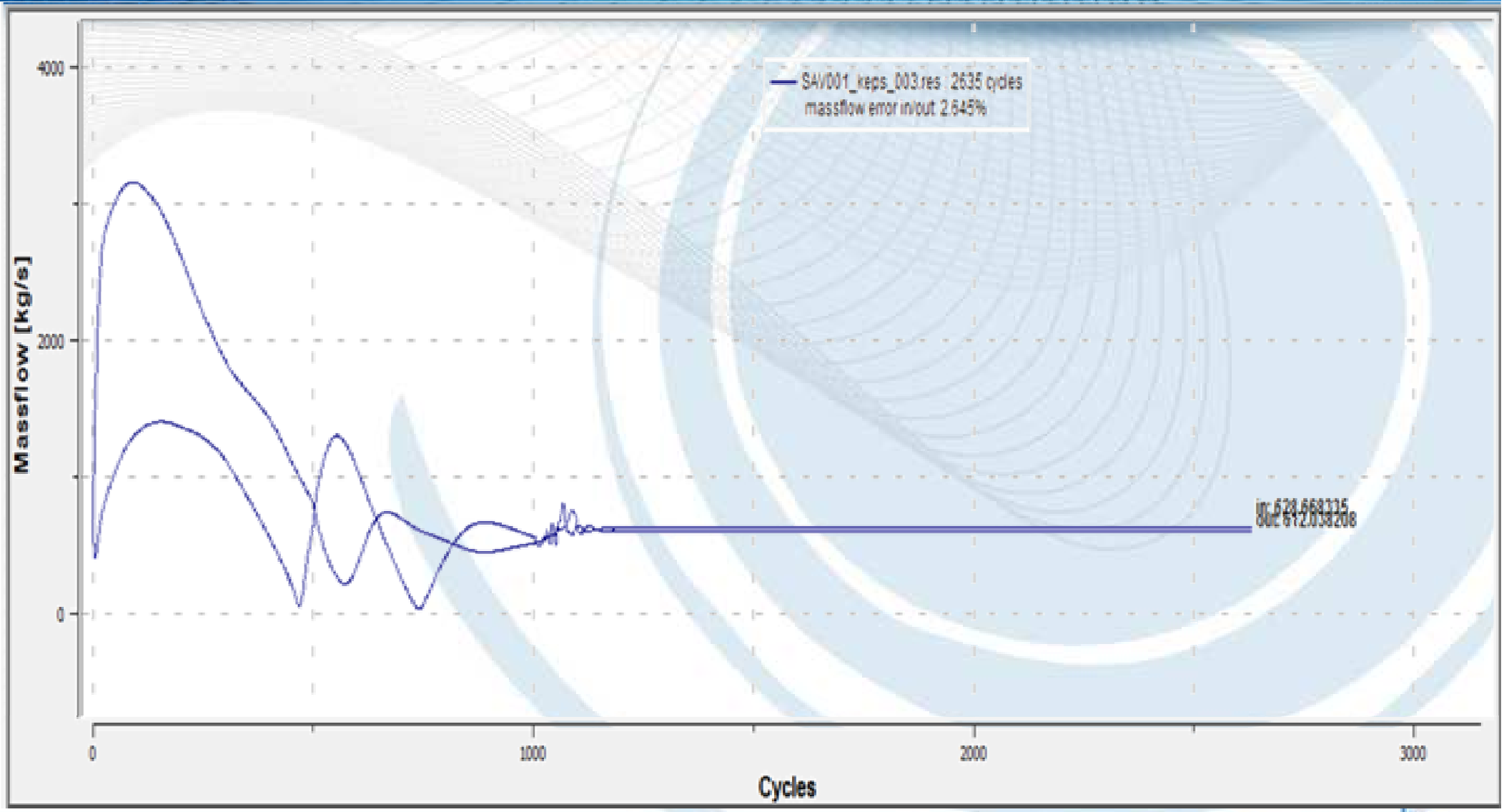
In order to judge whether if the convergence is reached, not just the residuals but massflow, forces efficiency has been monitored. The story of the iterations shows a slow convergence due to the need to match mass flow between inlet and oultet.

A lot of computation were performed using different stators. It's striking to note the importance of this component on the convergence. With other design no convergence was obtained... Optimization of this component is indeed mandatory to achieve better performances

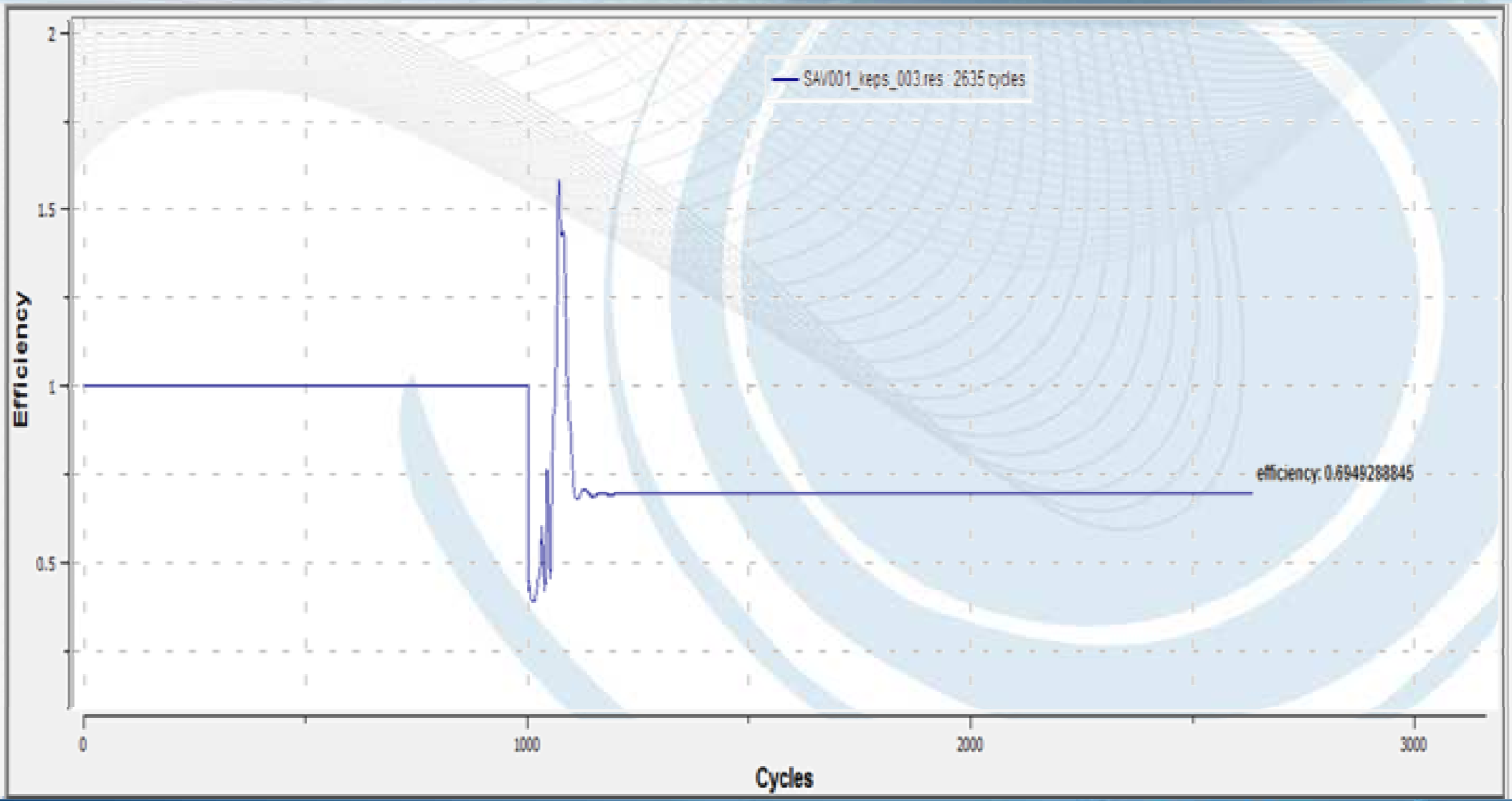
MAIN RESULTS, residual convergence



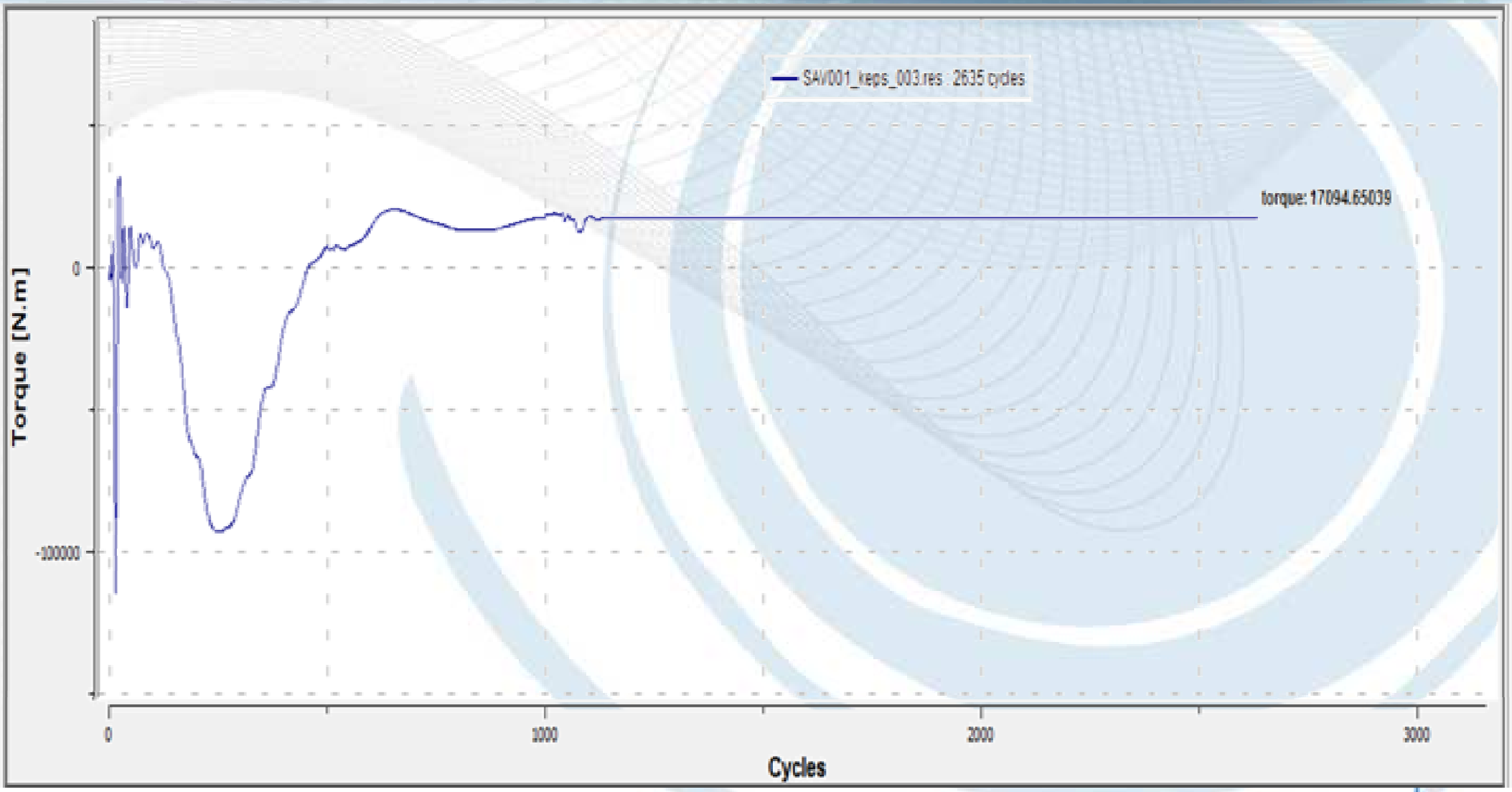
MAIN RESULTS, mass flow convergence



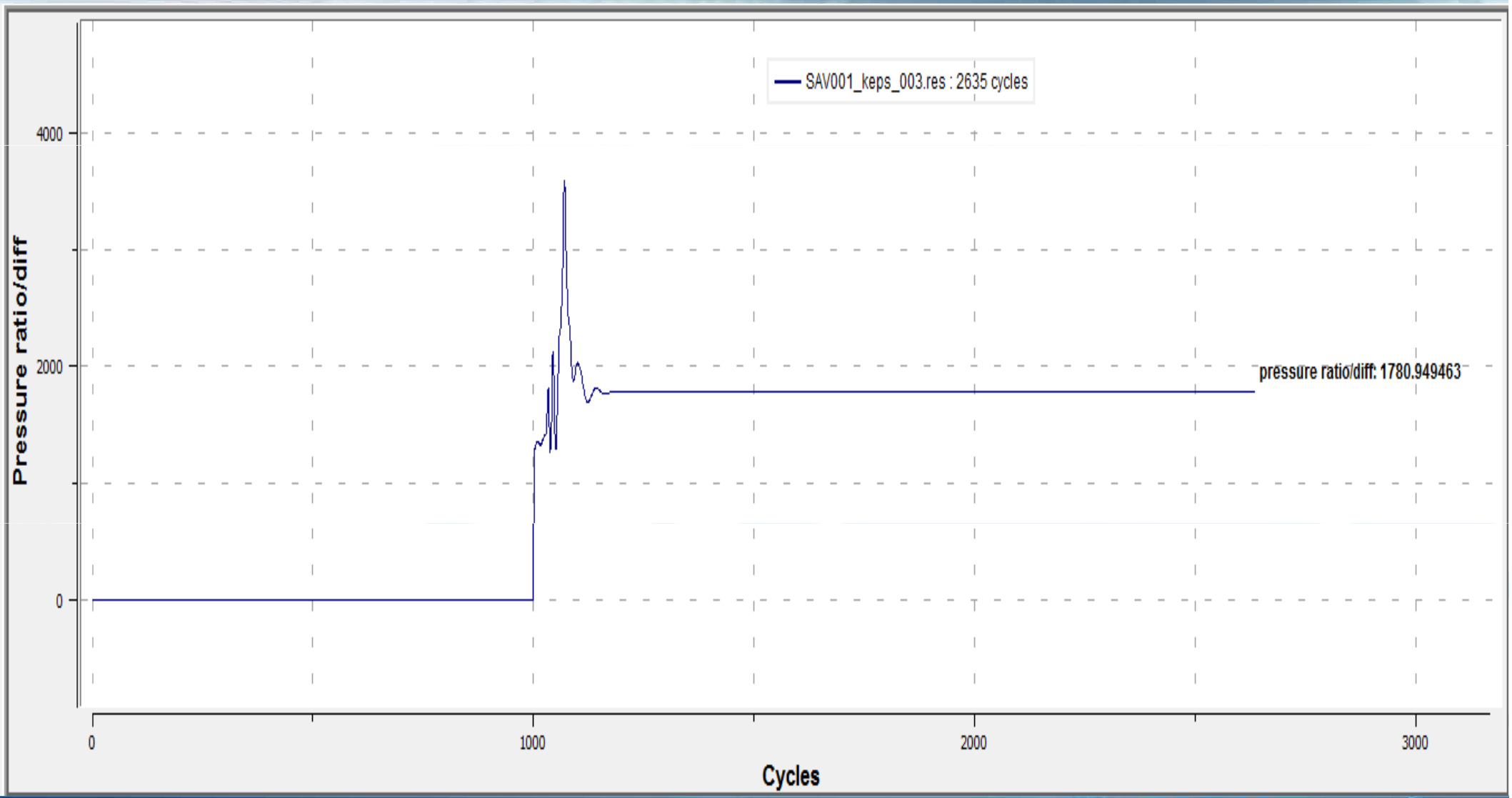
MAIN RESULTS, efficiency convergence



MAIN RESULTS, torque convergence

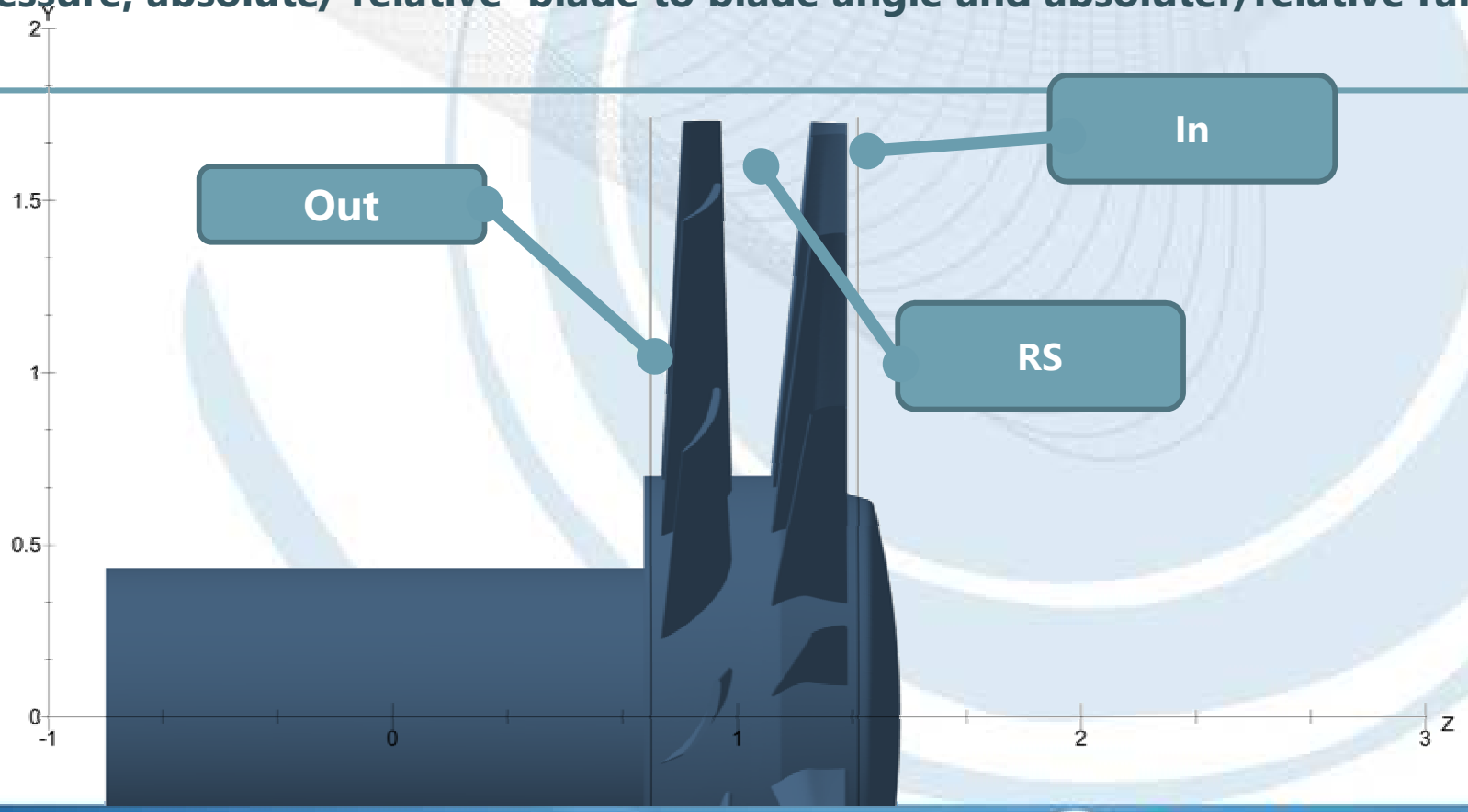


MAIN RESULTS, pressure difference convergence



MAIN RESULTS, scalar integral quantities

To better evaluate evolution streamwise of quantities, three cutting planes were defined as can be seen in the picture here below. On these three surfaces evaluation of main scalar important quantities are evaluated. These are inlet outlet massflow, static and total pressure, absolute/ relative blade to blade angle and absoluter/relative ramp angle



MAIN RESULTS, scalar integral quantities

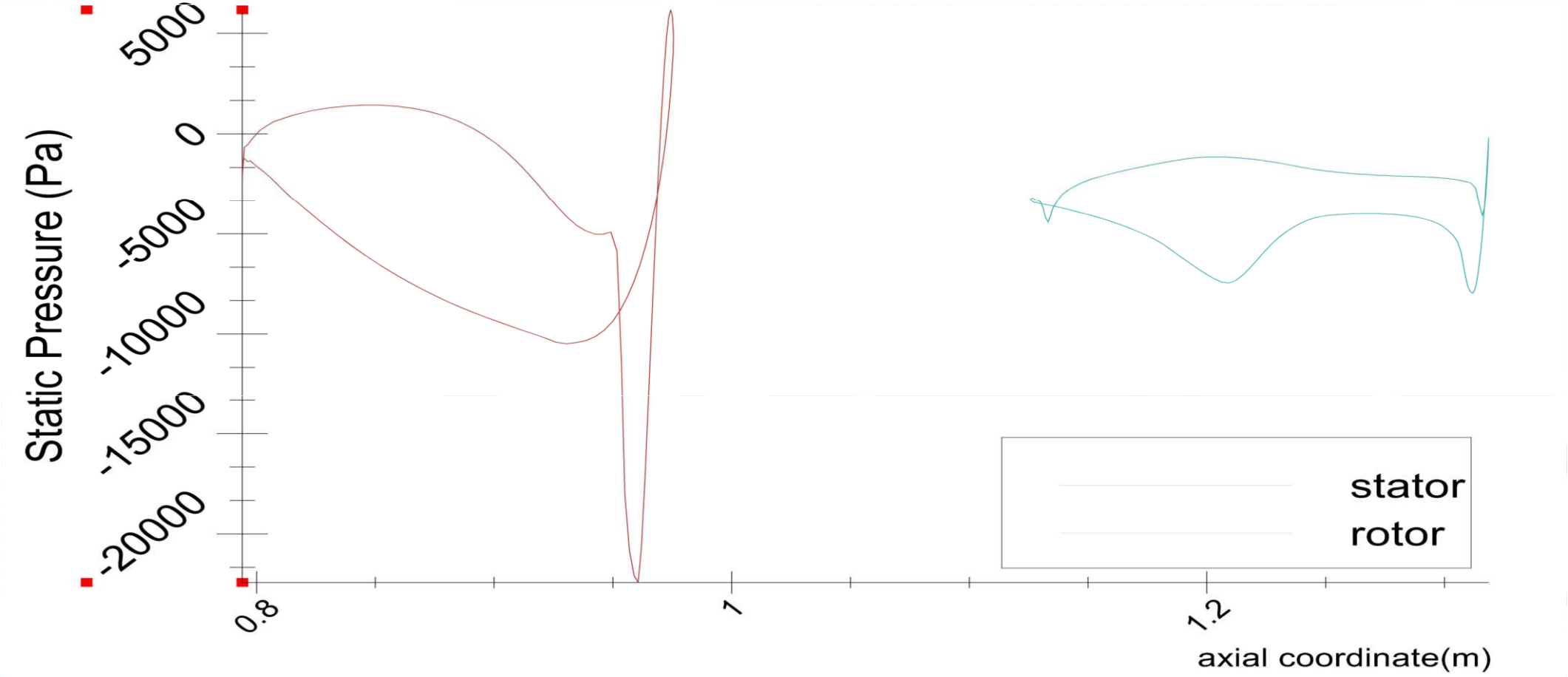
	in	rs	out
Mass flow [kg/s]	628.16	627.4	627.13
Static pressure [Pa]	-2630	-2932.6	-1005.6
Δstatic_pressure [Pa]		-302.6	**+1624.4**
Total Pressure [Pa]	-100.005	-158.093	2033.8
Δtotal_pressure [Pa]		-58.088	**+2133.8**
Absolute b2b angle [deg]	-0.003	11.6	-7.6
Relative b2b angle [deg]	-0.003	59.9	54.1
Absolute ramp angle [deg]	7.38	4.7	4.2
Relative ramp angle [deg]	7.38	2.6	2.6

MAIN RESULTS, scalar integral quantities

	in	rs	out
Mass flow [kg/s]	628.16	627.4	627.13
Static pressure [Pa]	-2630	-2932.6	-1005.6
Δstatic_pressure [Pa]		-302.6	**+1624.4**
Total Pressure [Pa]	-100.005	-158.093	2033.8
Δtotal_pressure [Pa]		-58.088	**+2133.8**
Stage Torque [N·m]	17095		
Revolution speed [rad/s]	78.5		
Shaft requred power [MW]	**1.342**		
Total Efficiency [stage]	**2133.8×627.1** / **1.2×17095×78.5**		**83.1%**
Static Efficiency [stage]	**1624.4×627.1** / **1.2×17095×78.5**		**63.26%**

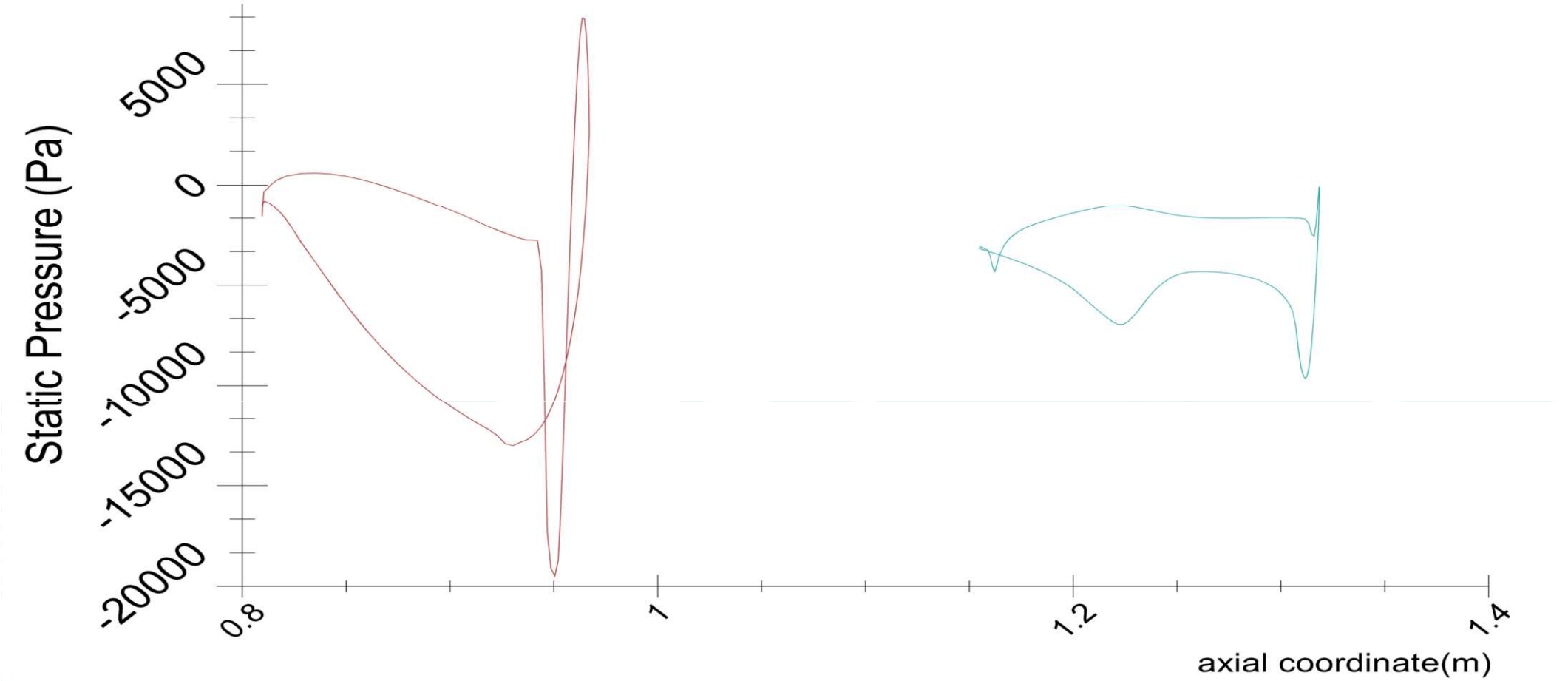
MAIN RESULTS, Contour Plots & Plots

Static pressure @ 25% span



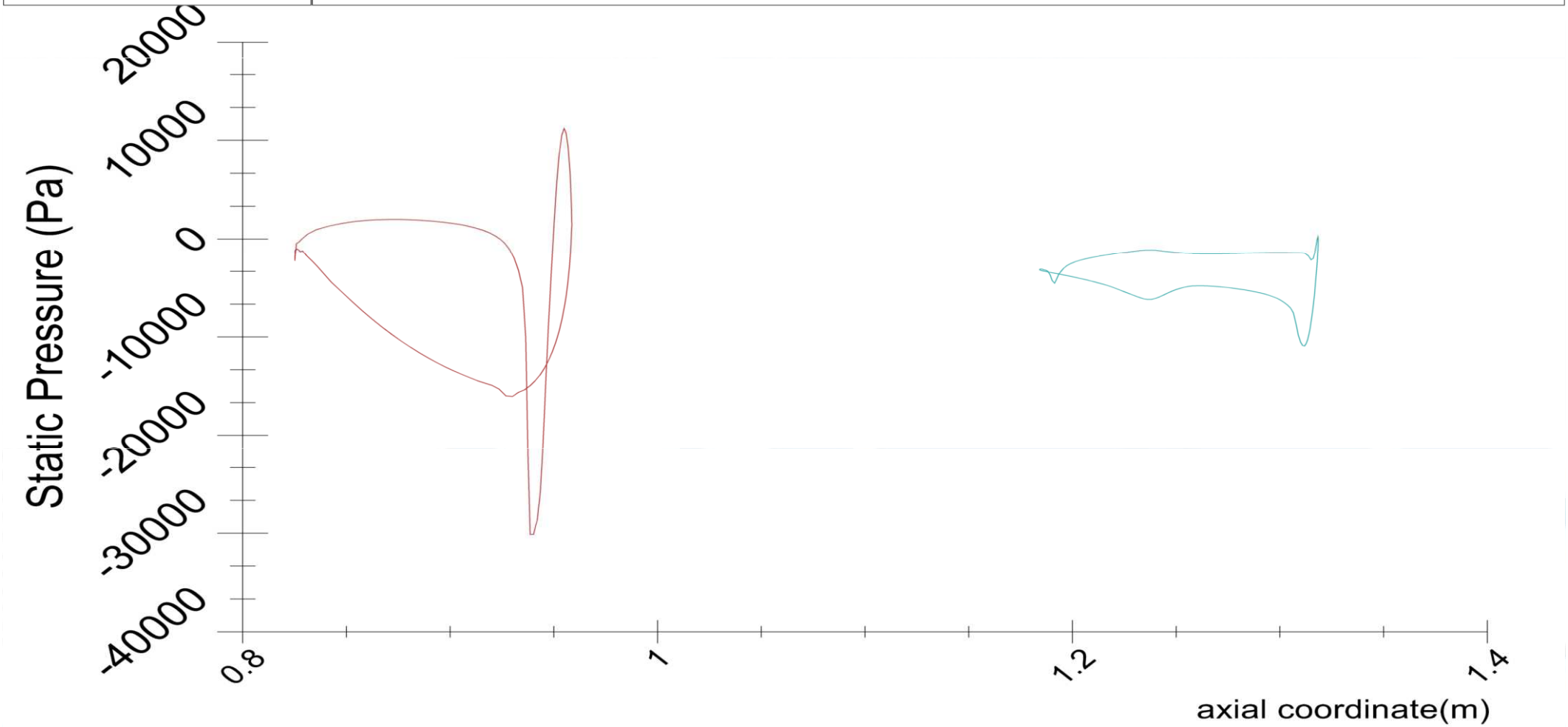
MAIN RESULTS, Contour Plots & Plots

Static pressure @ 50% span



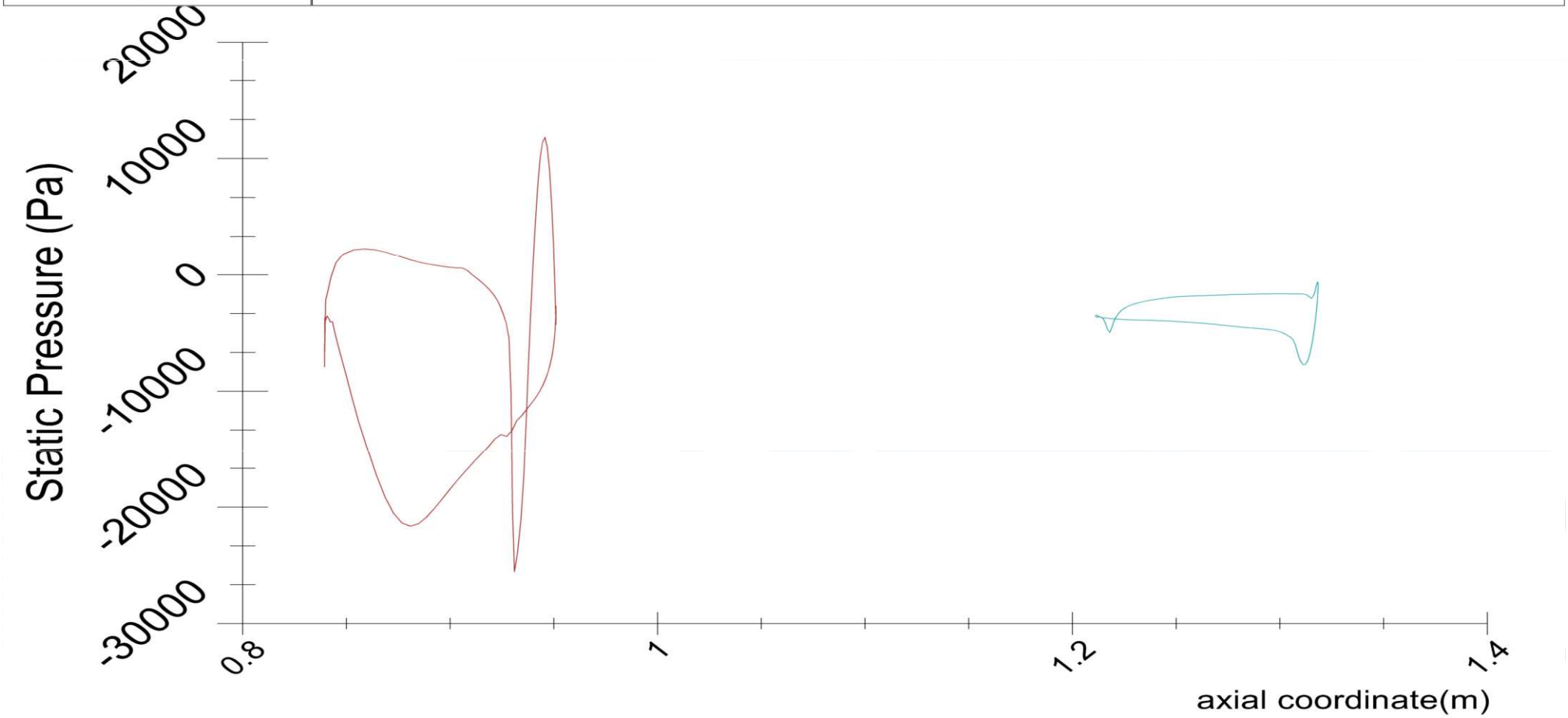
MAIN RESULTS, Contour Plots & Plots

Static pressure @ 75% span

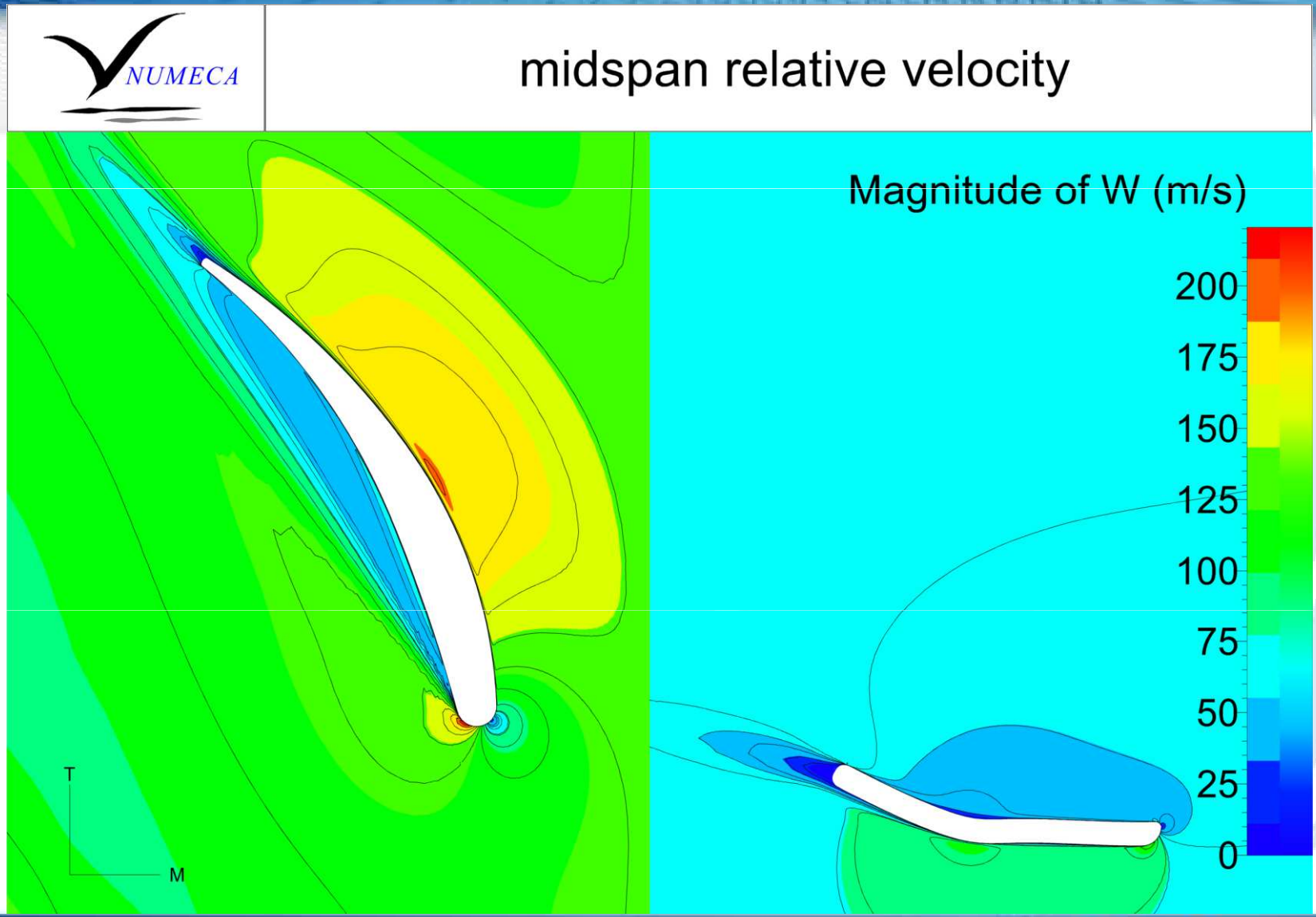


MAIN RESULTS, Contour Plots & Plots

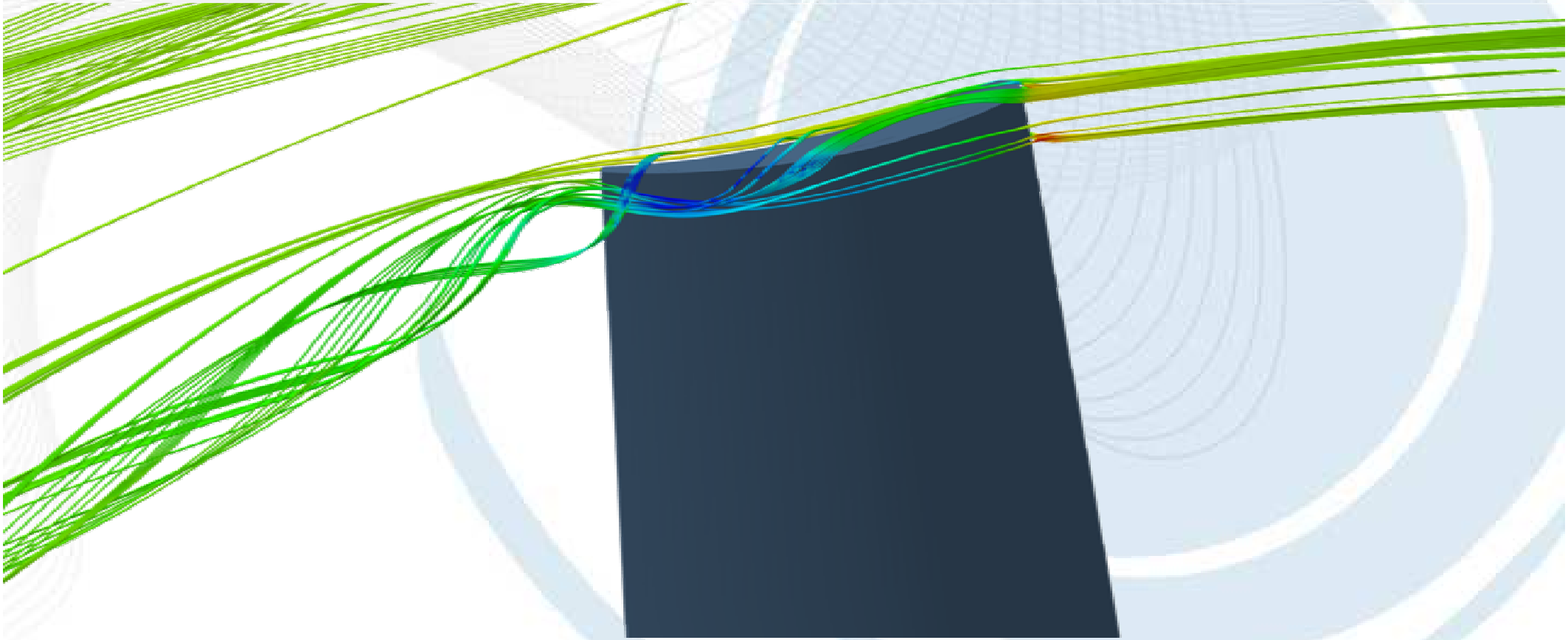
Static pressure @ 99% span



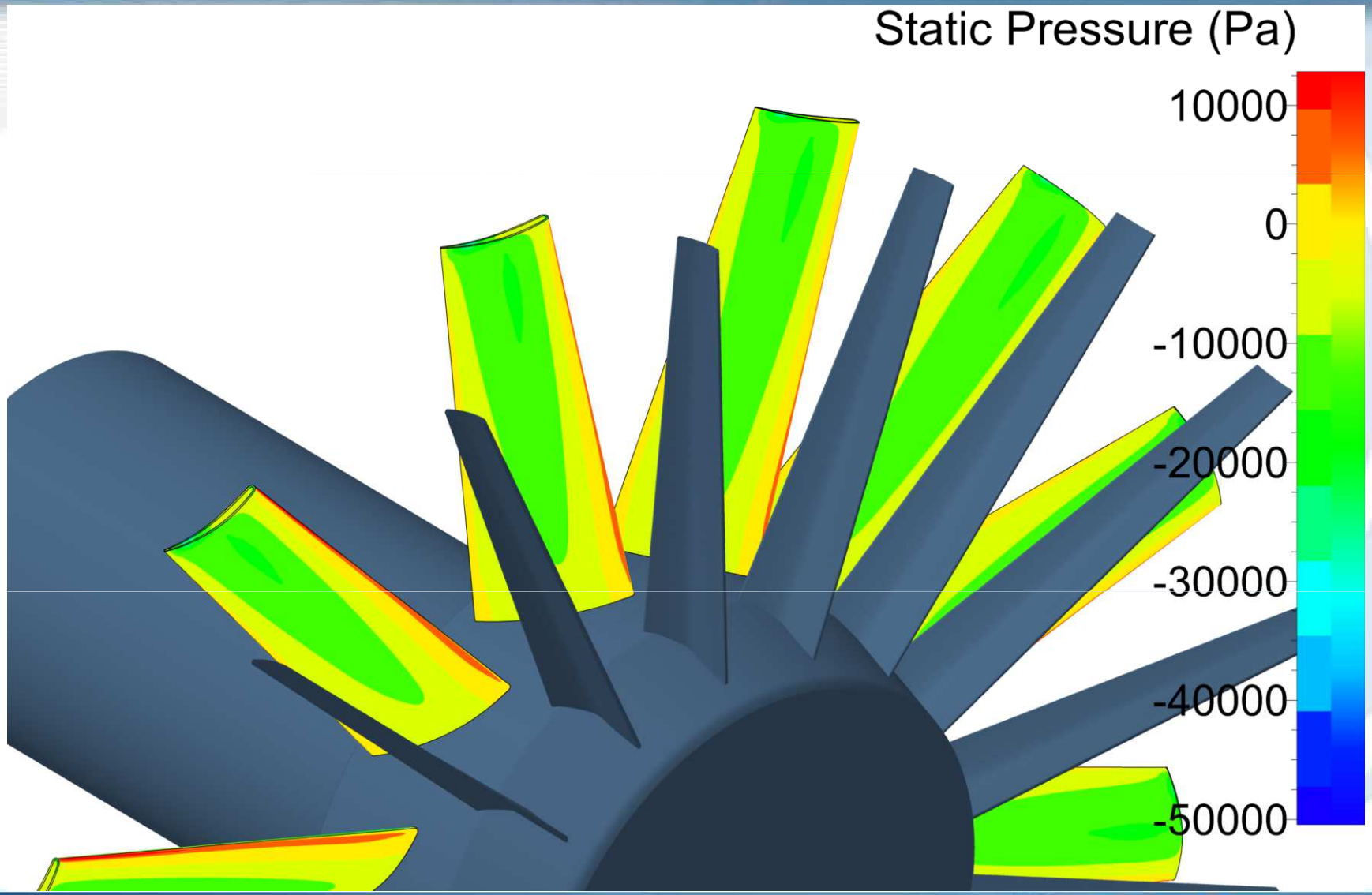
MAIN RESULTS, Contour Plots



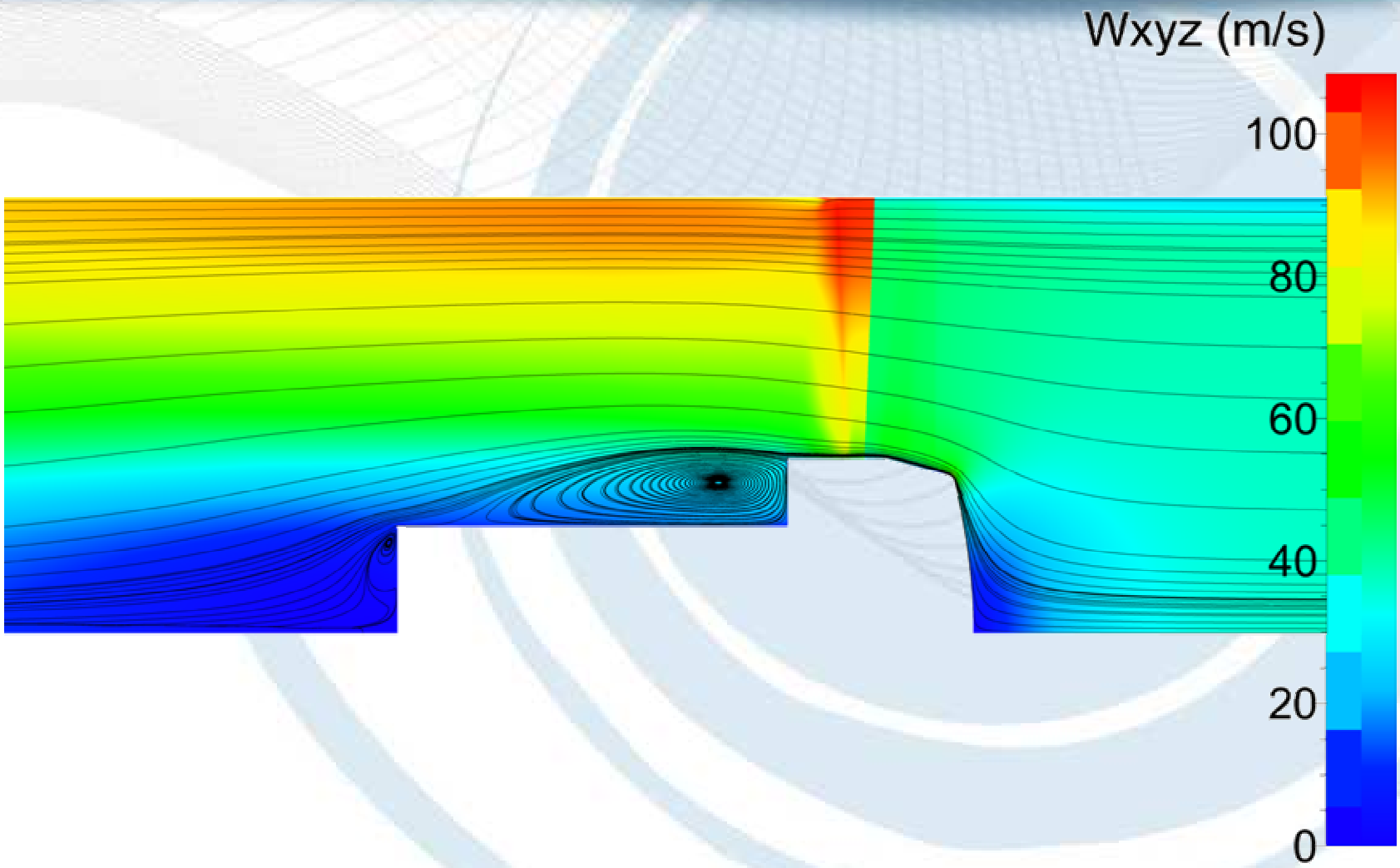
MAIN RESULTS, tip vortex @ rotor



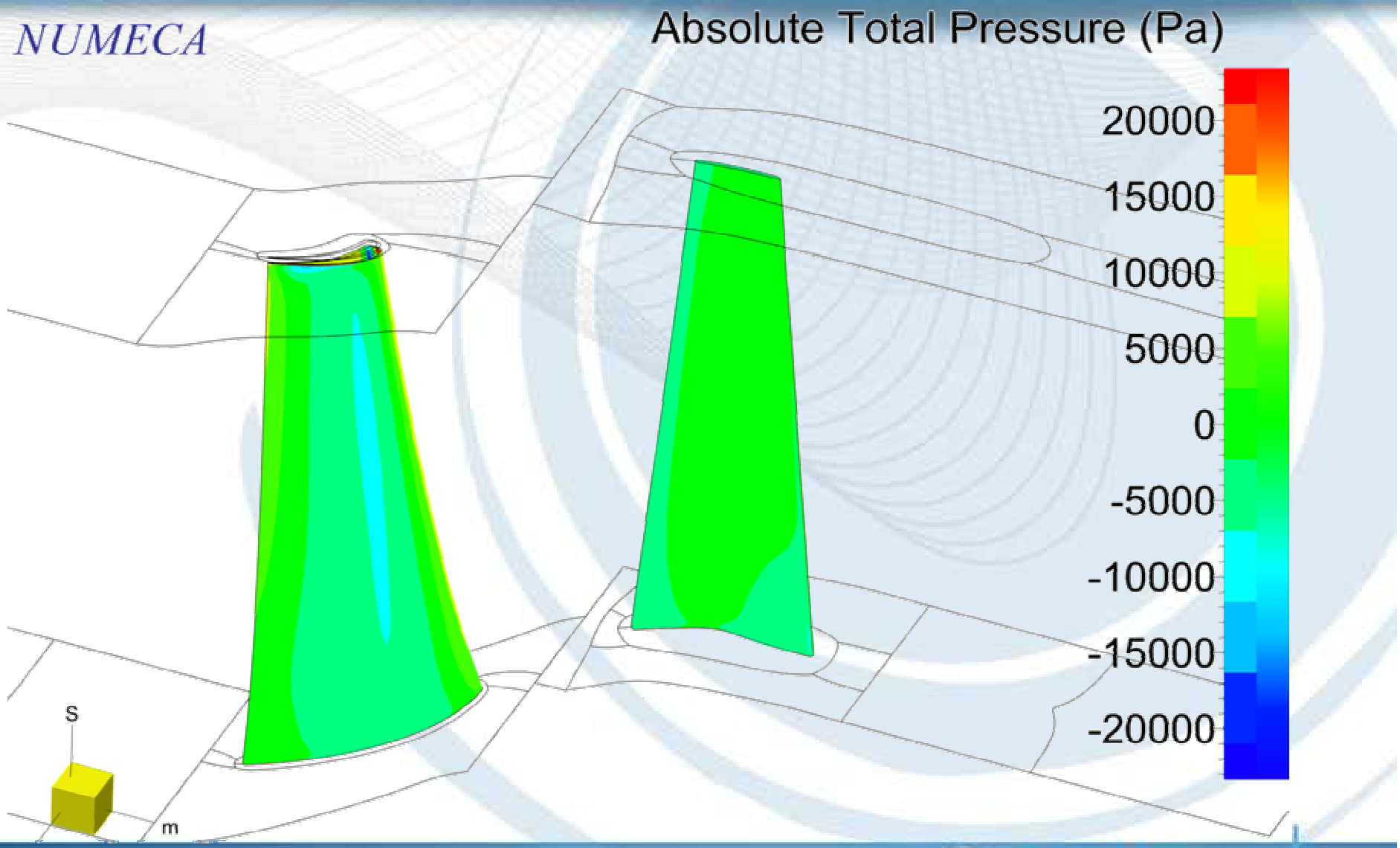
MAIN RESULTS, tip vortex @ rotor



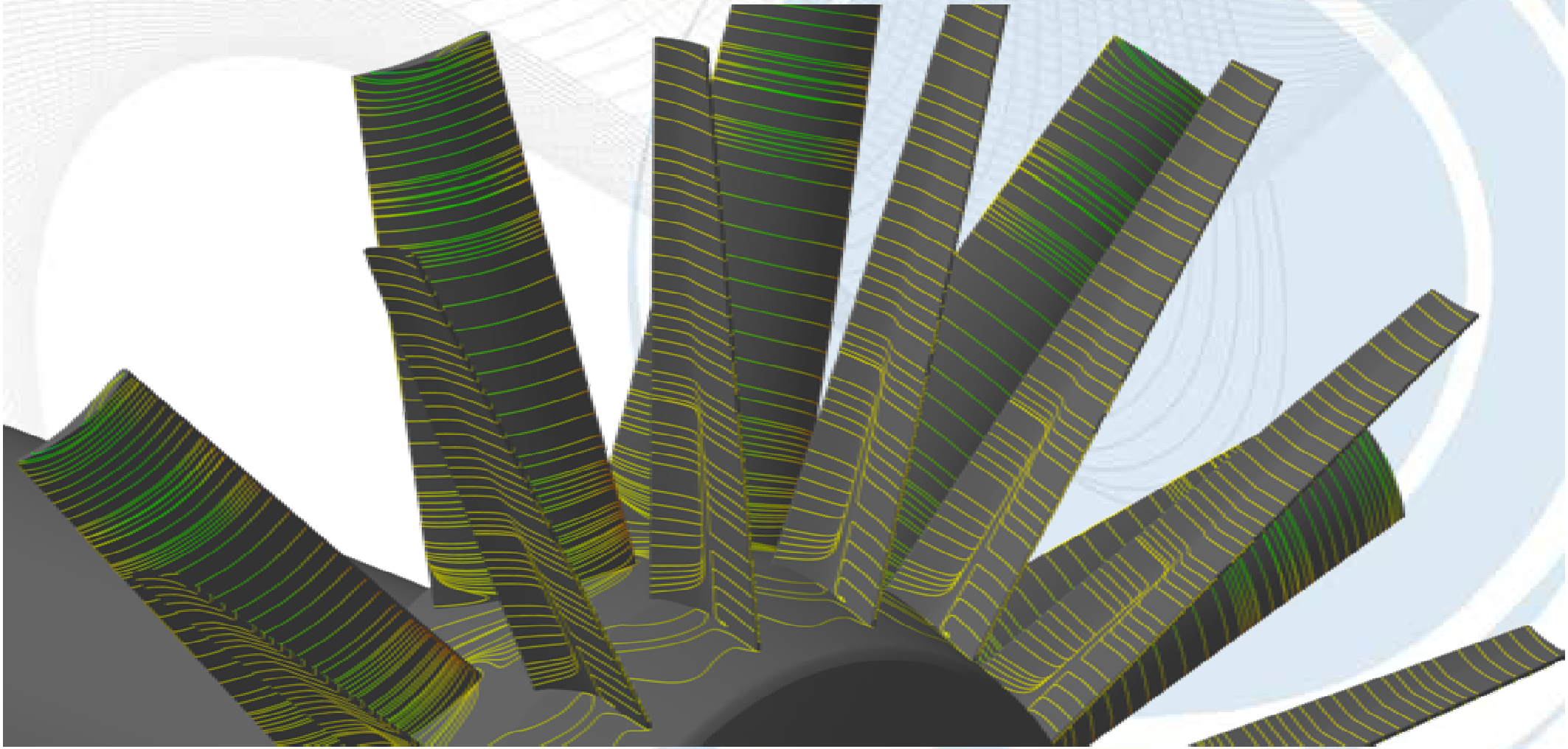
MAIN RESULTS, meridional plane streamlines



MAIN RESULTS, total pressure on blades



MAIN RESULTS, oilflow



5 CONCLUSIONS

CONCLUSIONS

Present report, consisted as a Benchmark trial done for Savio Srl as a starting point for further cooperations.
It serves as a test to verify the capabilities of Numitalia in simulating industral flow at hand in Savio srl.
The test here exposed showed the necessity to intervene in the design of the stator blade.
Furter development will be the optimization, the redesign the implementations of fillets and so on.