Turbine Casing – CFD & FEM Combined Analysis

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Software used: Siemens NX Simcenter | Ansys 2025 R1

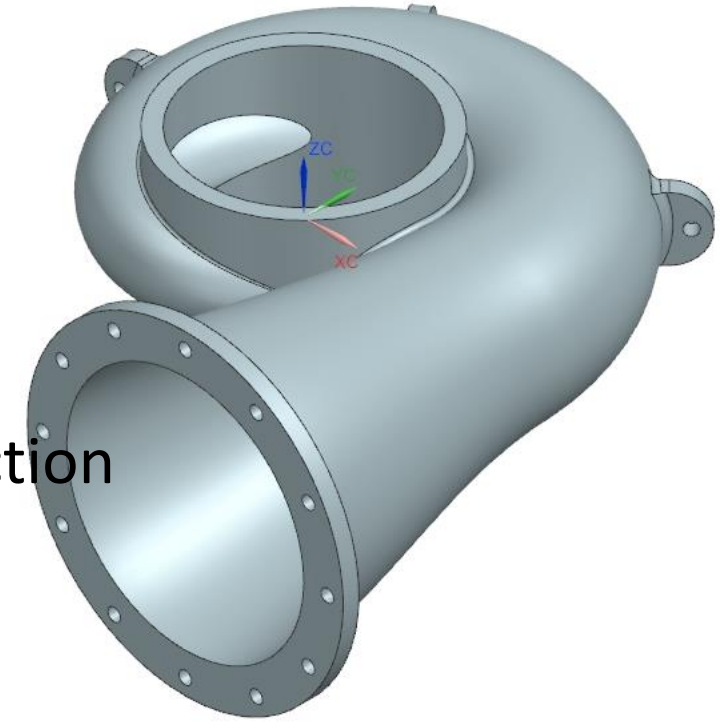
The turbine casing should be considered as a scale model

Objective

- Evaluate the aerodynamic and structural performance of a turbine casing.
- Perform a CFD simulation to analyze the internal air velocity field.
- Carry out a FEM (static structural) analysis to assess stress distribution under loading conditions.
- Identify possible design optimizations for improved efficiency and reliability.

Geometry and Model Description

- The component analyzed represents the volute casing of a small turbine stage.
- CAD geometry modeled in Siemens NX and imported into Ansys 2025 R1 for structural validation.
- Casing material: Steel
- The casing features:
  - Tangential inlet
  - Gradual cross-section reduction
  - Outlet flange for turbine connection



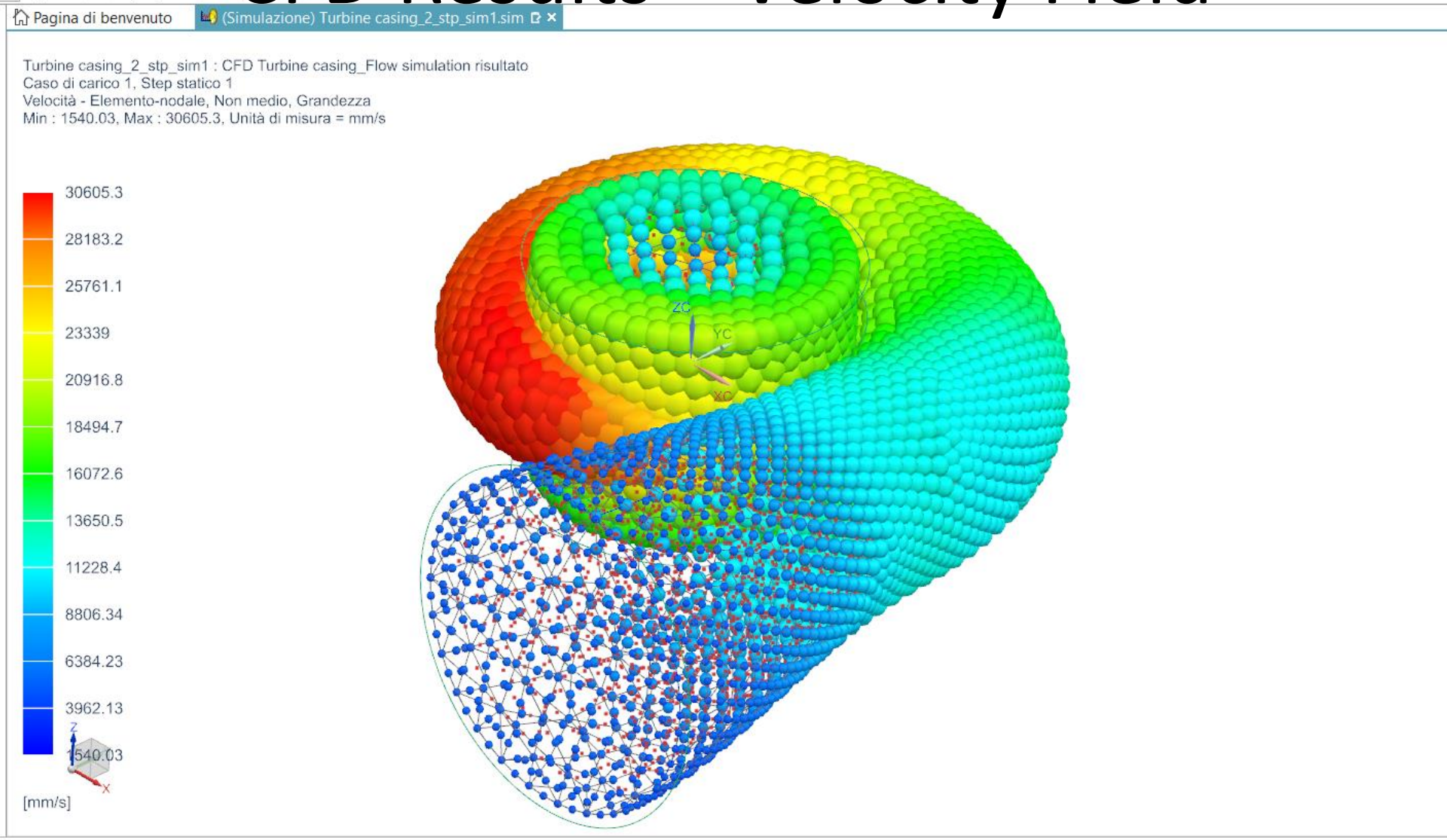
CFD Setup

- Fluid: Air (ideal gas)
- Flow type: Steady-state, incompressible
- Boundary conditions:
  - Inlet: Velocity 30 m/s (approx.)
  - Outlet: Static pressure = 0 Pa
- Turbulence model: Standard k–ε
- Mesh: Hybrid tetrahedral with boundary layer refinement

CFD Results – Velocity Field

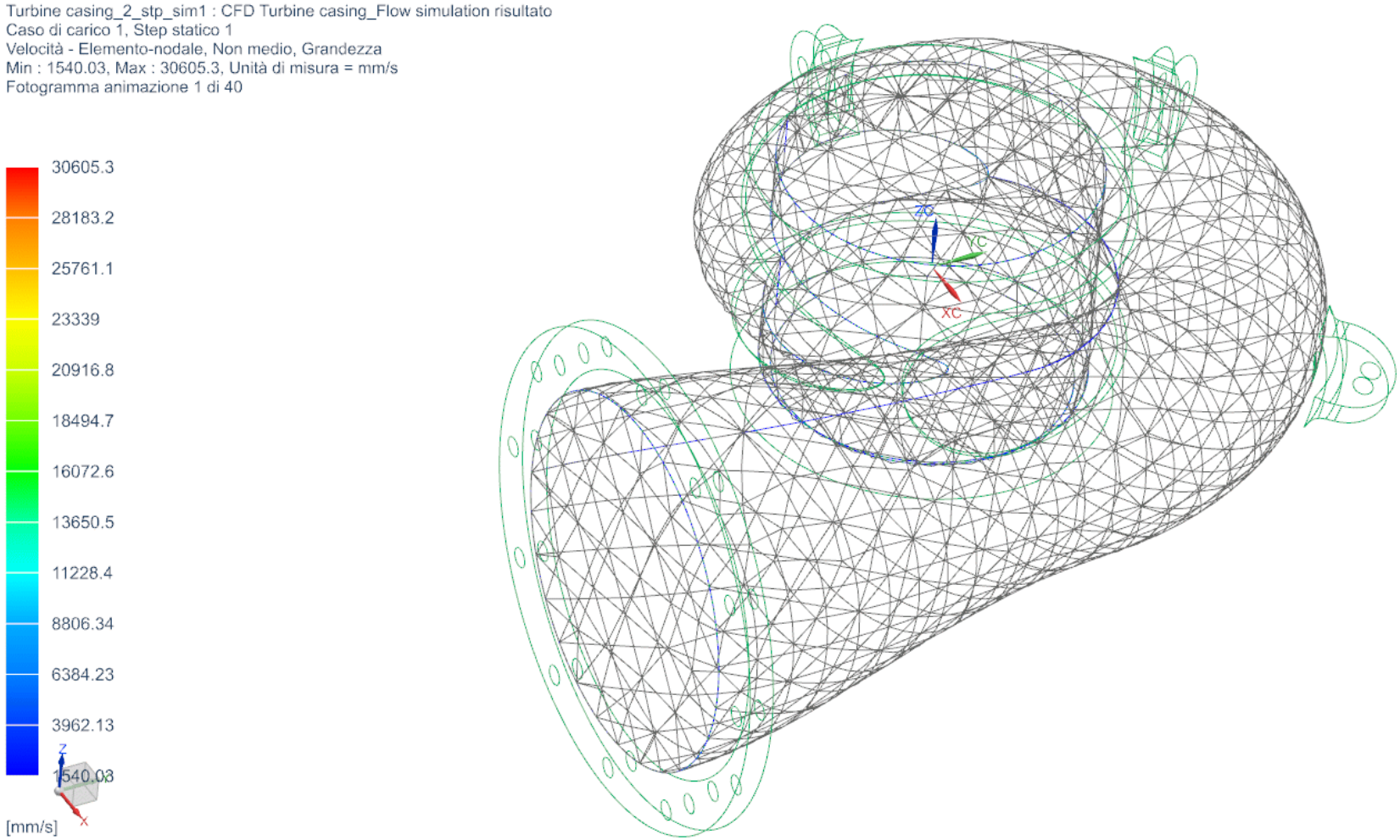
- Velocity range: 1.5 – 30 m/s.
- Flow acceleration observed along the curved volute.
- High-velocity region near outlet → good flow guidance.
- Low-velocity recirculation zones visible near the inlet curvature.
- CFD confirms the casing ensures smooth air delivery toward the turbine inlet.

CFD Results – Velocity Field



CFD analysis shows the air velocity distribution within the turbine casing.
The flow enters tangentially, accelerating along the spiral path, with a peak velocity of 30.6 m/s.

CFD Results – Velocity Field



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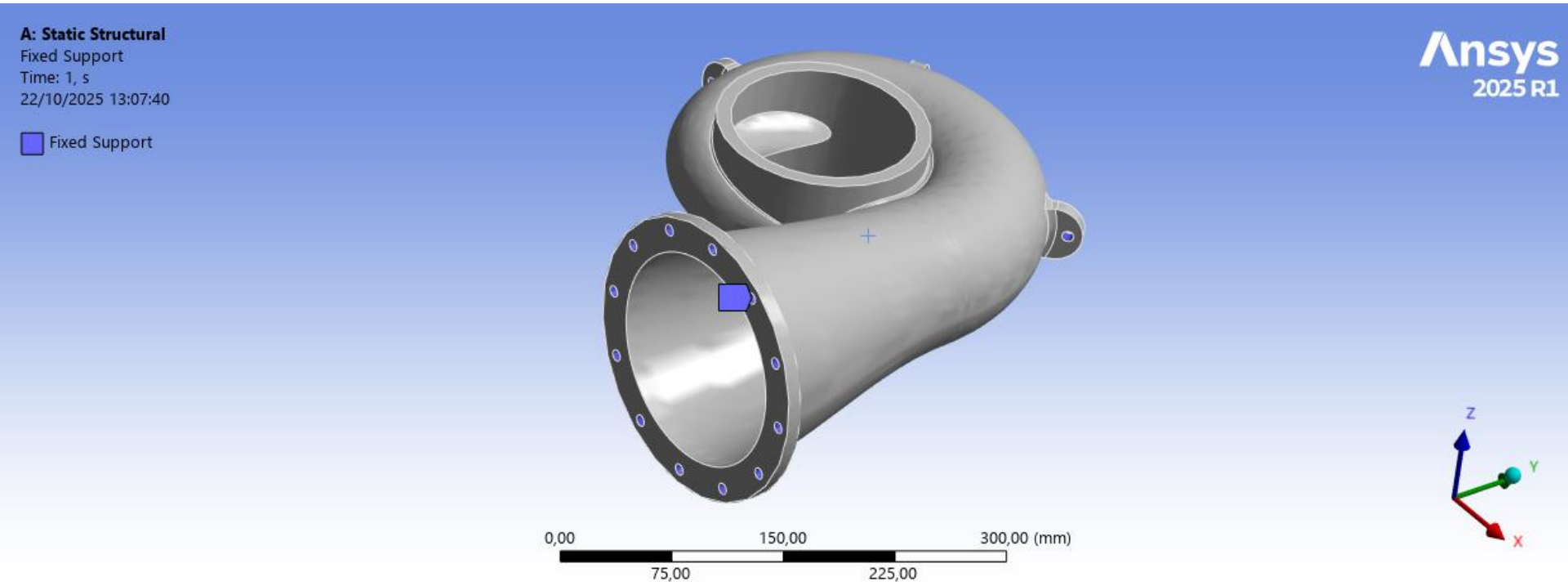
FEM Setup

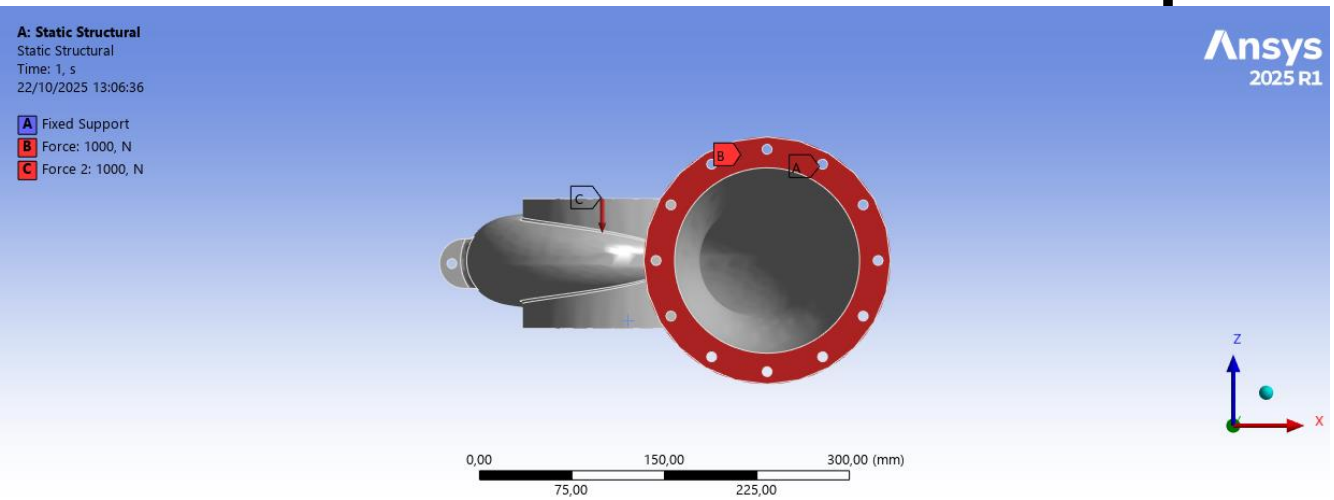
- Material: Steel (E = 207 GPa, ν = 0.33)
- Boundary conditions:
  - Fixed support at mounting flange.
  - Two 1000 N forces applied at casing outer surface to simulate pressure load.
- Mesh: Tetrahedral solid elements with local refinement in high-stress regions.

FEM Setup

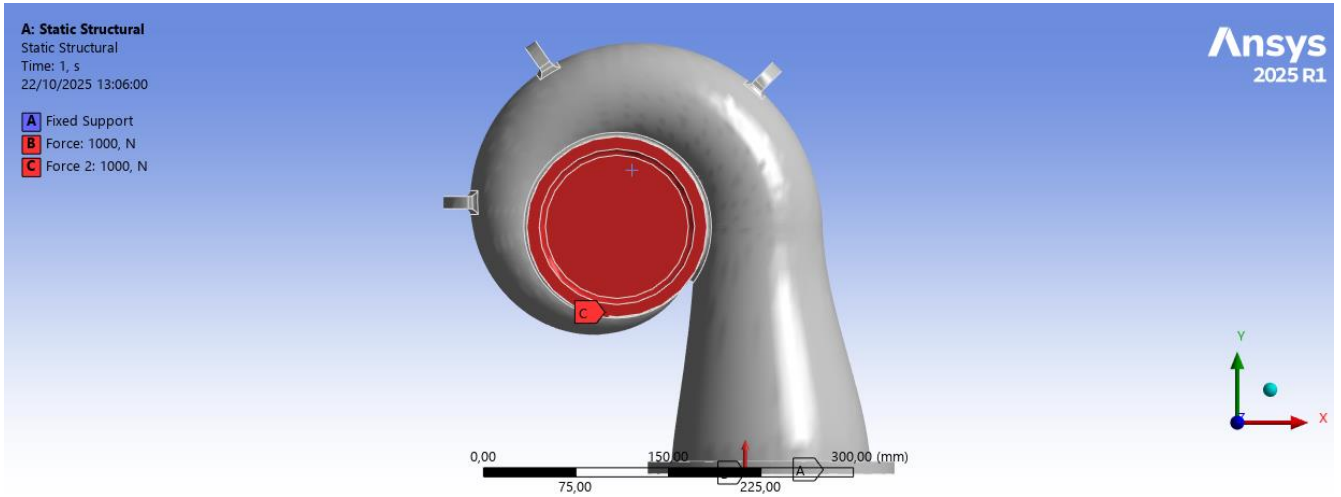


Fixed support at mounting flange

FEM Setup



1000 N forces applied at casing outer surface – Front view

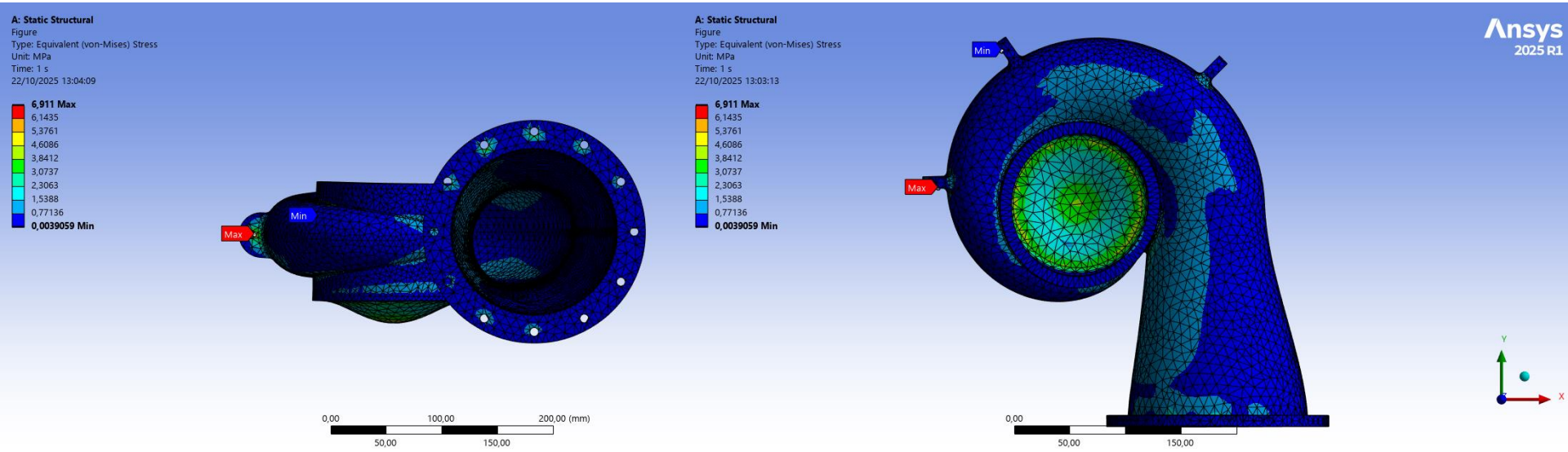


1000 N forces applied at casing outer surface – Top view

FEM Results – Equivalent Stress (von Mises)

- Maximum equivalent stress: 6.91 MPa
- Stress concentration observed near the fixed flange and load application points.
- Structural integrity verified with high safety margin.
- Deformation negligible under the applied load (quasi-rigid behavior).

FEM Results – Equivalent Stress (von Mises)



The FEM analysis simulated a 1000 N load applied at both inlet and outlet flanges.
Maximum stress: 6.9 MPa (at the flange connection).
The structure remains well below typical material yield limits, confirming design robustness.

Discussion

- CFD and FEM analyses confirm the robustness and flow efficiency of the casing design.
- Airflow is well-distributed, with minimal recirculation effects.
- Structural stresses remain well within allowable limits.
- Combined simulation approach demonstrates design feasibility and readiness for prototyping.

Conclusions

- The turbine casing geometry shows good aerodynamic and structural behavior.
- CFD analysis confirms proper flow acceleration and guidance.
- FEM results demonstrate low stress levels and excellent mechanical reliability.
- Further improvements could focus on optimizing the curvature for smoother flow transitions.

The turbine casing should be considered as a scale model