Three-Dimensional Viscous Flow Analysis Inside a Turbine Volute

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A three-dimensional numerical method has been developed to analyze the complex flow field inside a turbine volute. Comparisons are made between solutions with different boundary conditions.

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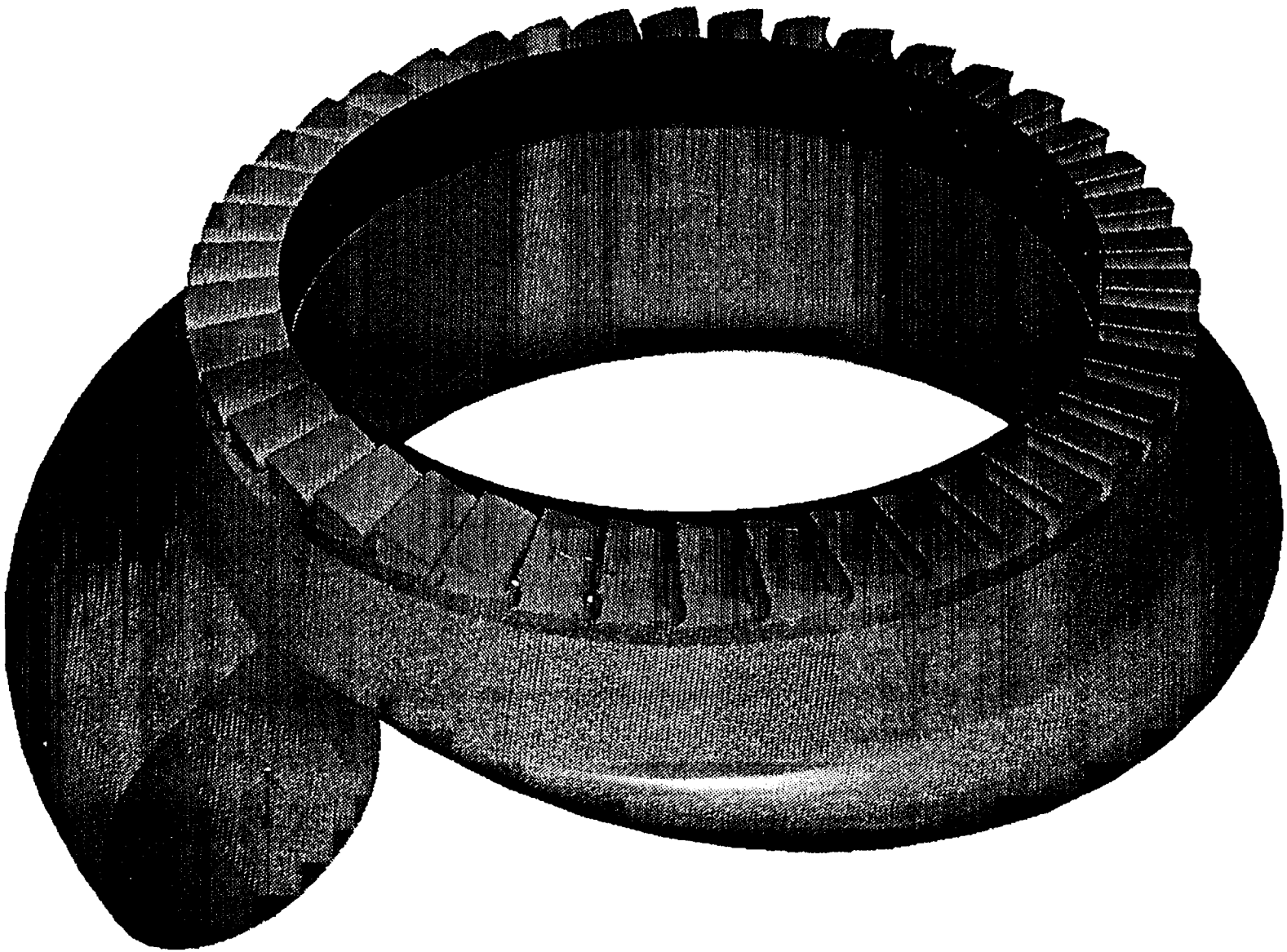
Consortium Turbine and Exit Volute



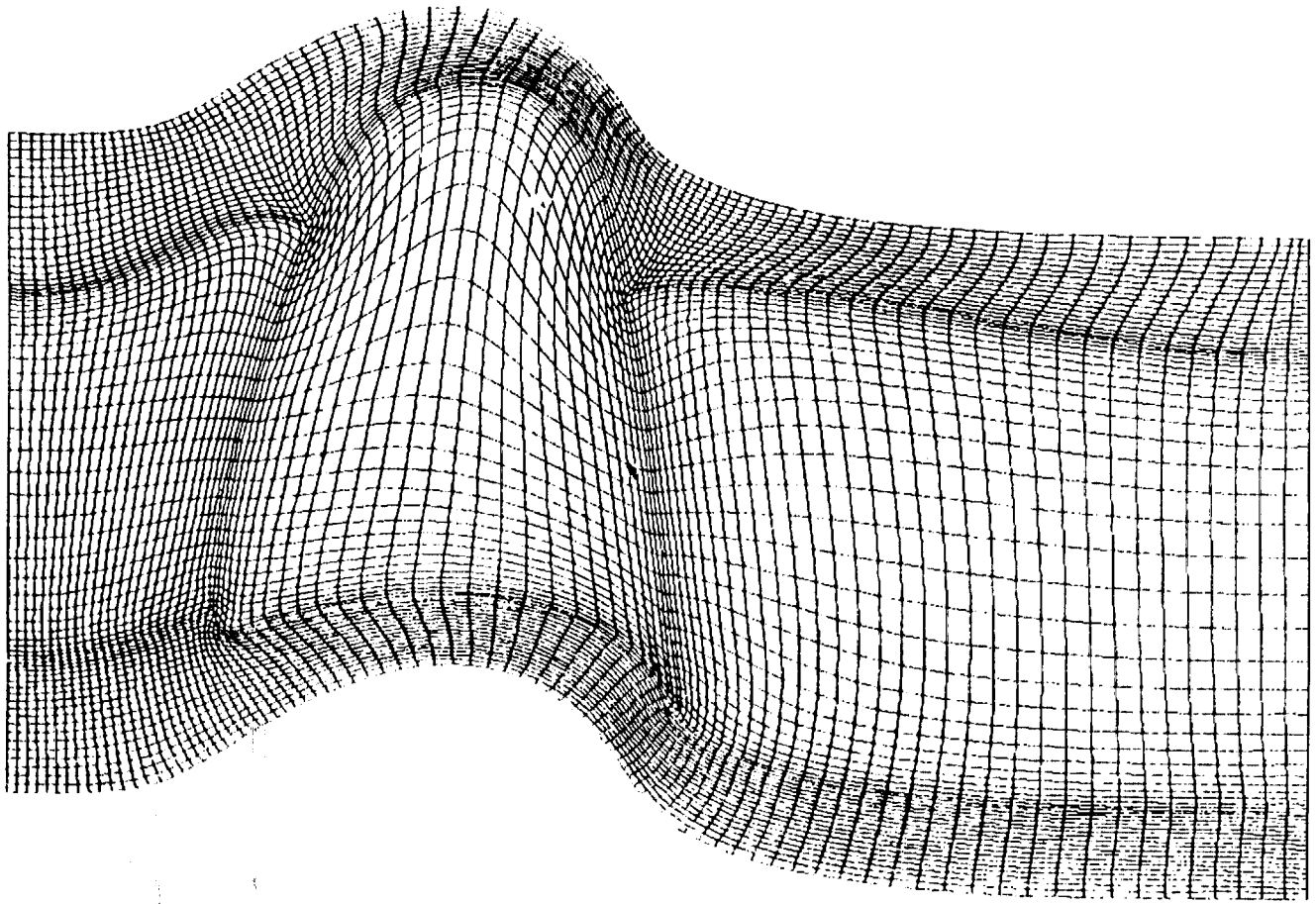
Objective

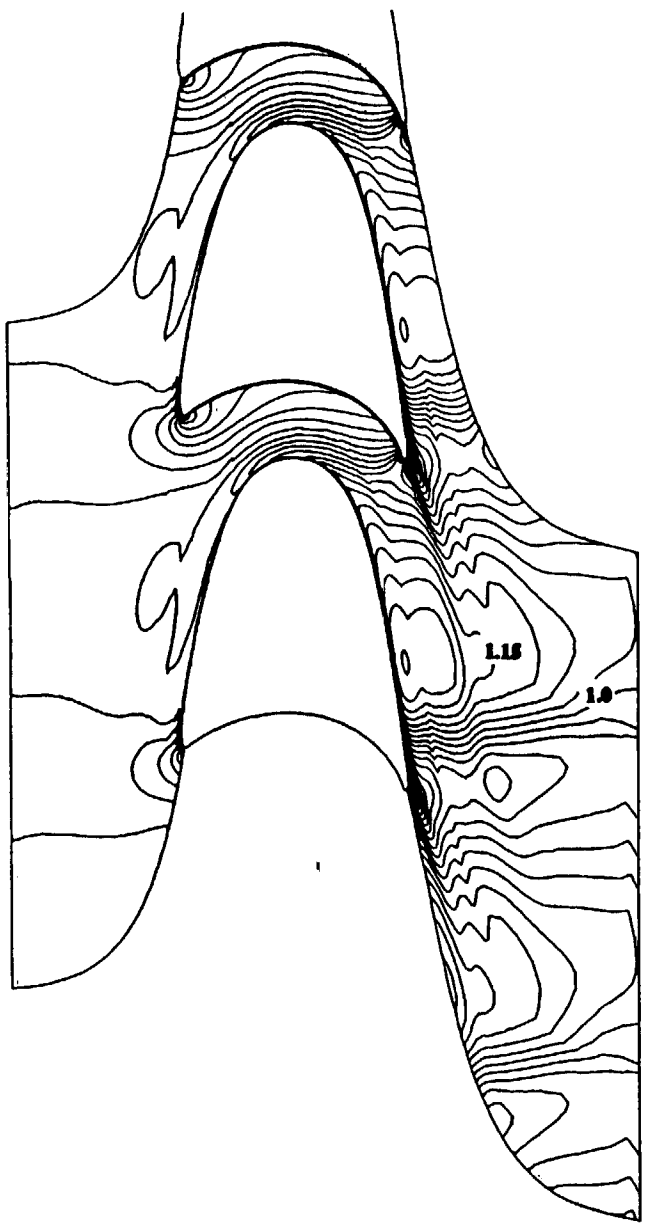
- o 3-D Turbulent Flow inside Volute
- o Integrated Analysis of Turbine Stage and Inlet & Exit Volutes

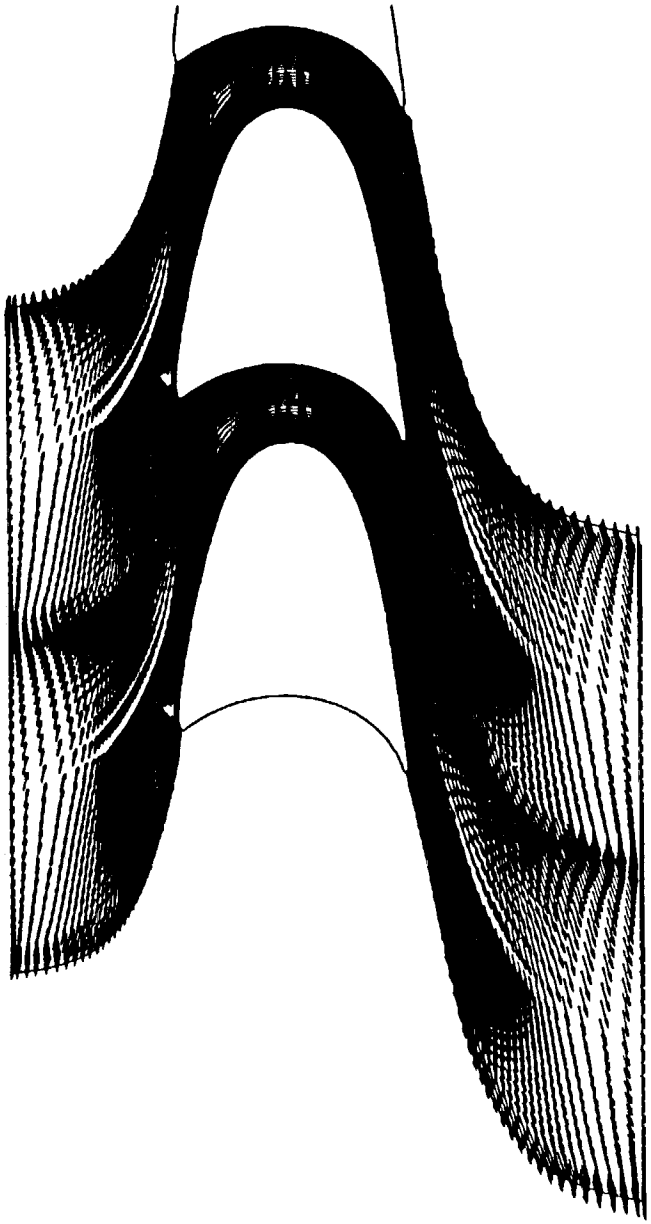
Approach

- o 3-D Navier-Stokes Code (Structured Grid)
- o 3-D Euler Code (Unstructured Grid)

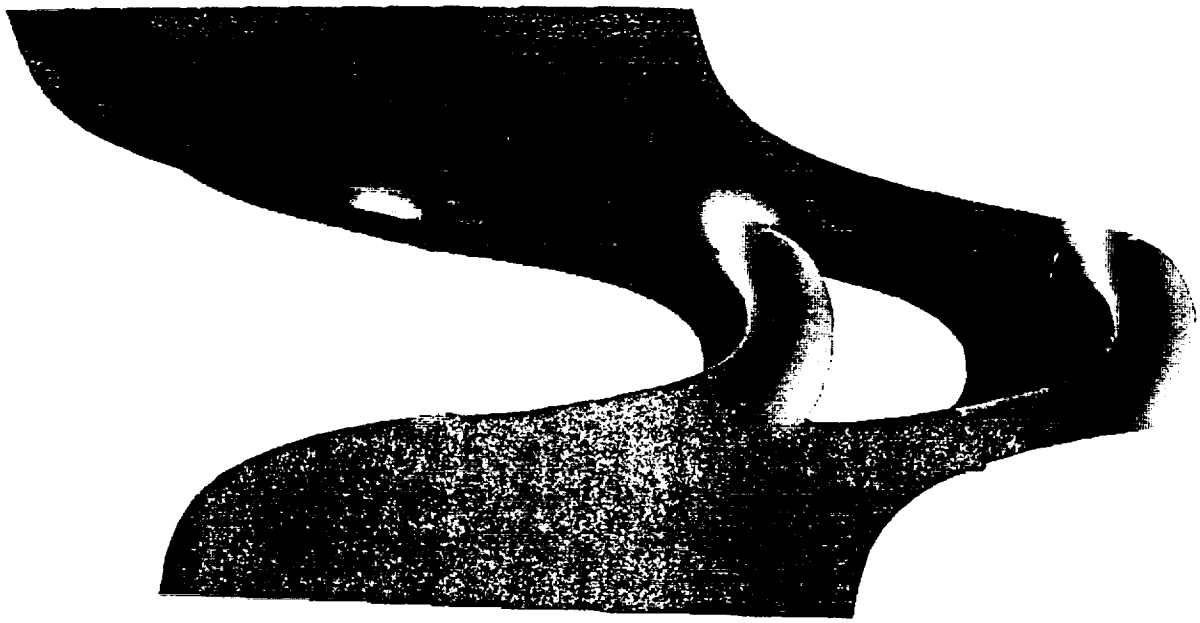
TIP GRID

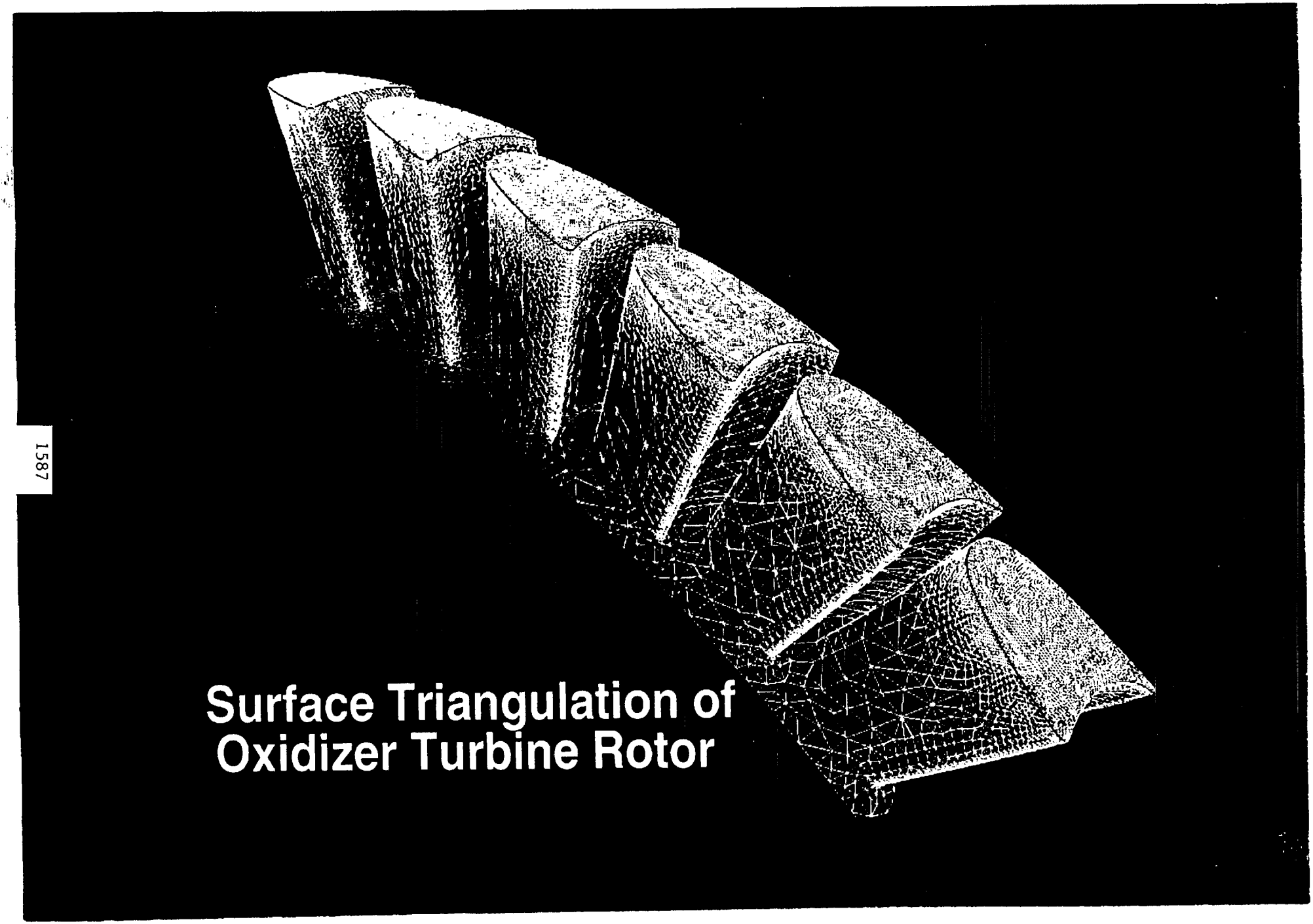




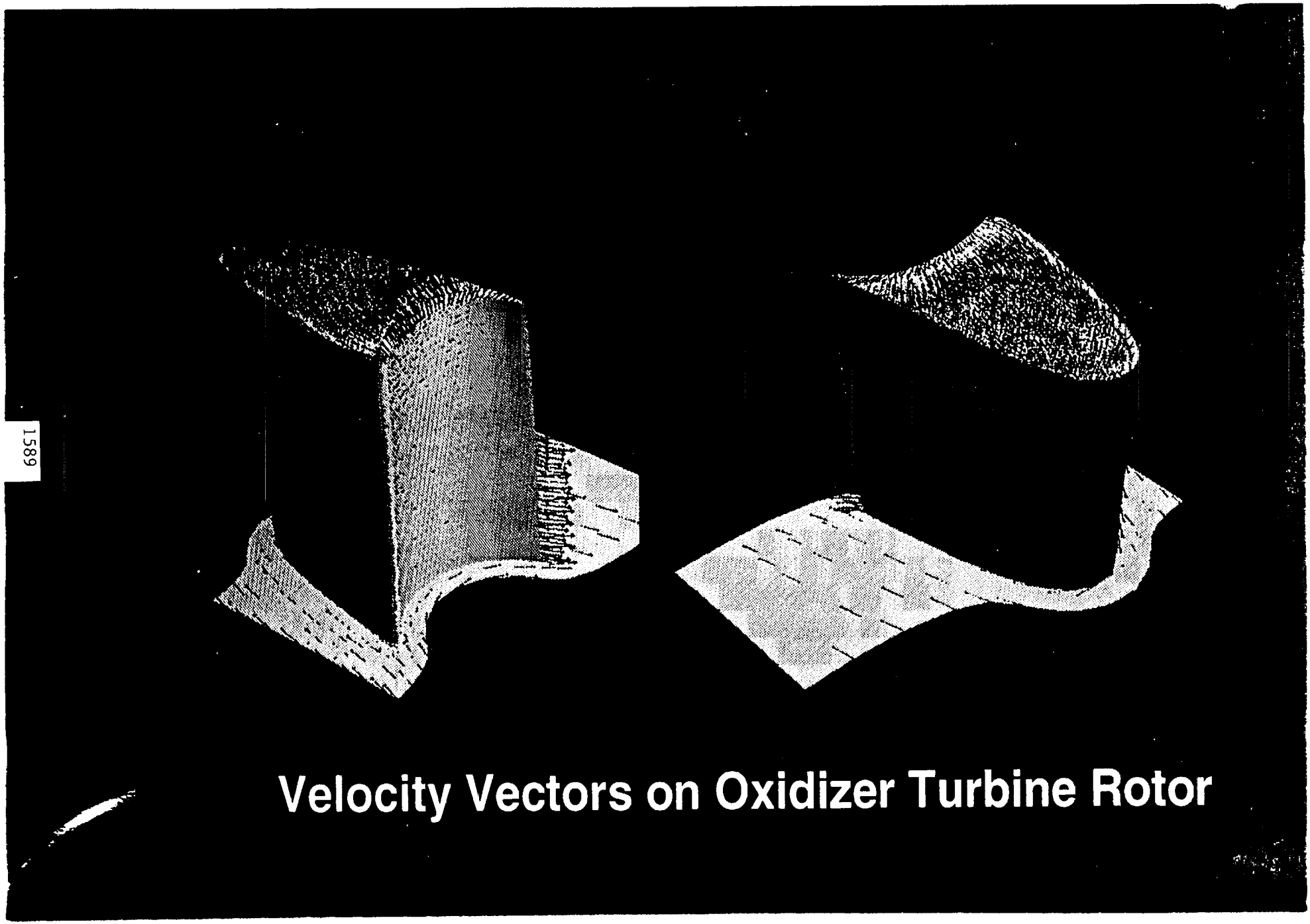


MACH-NUMBER AND VELOCITY VECTORS (MID-SPAN)





Surface Triangulation of
Oxidizer Turbine Rotor

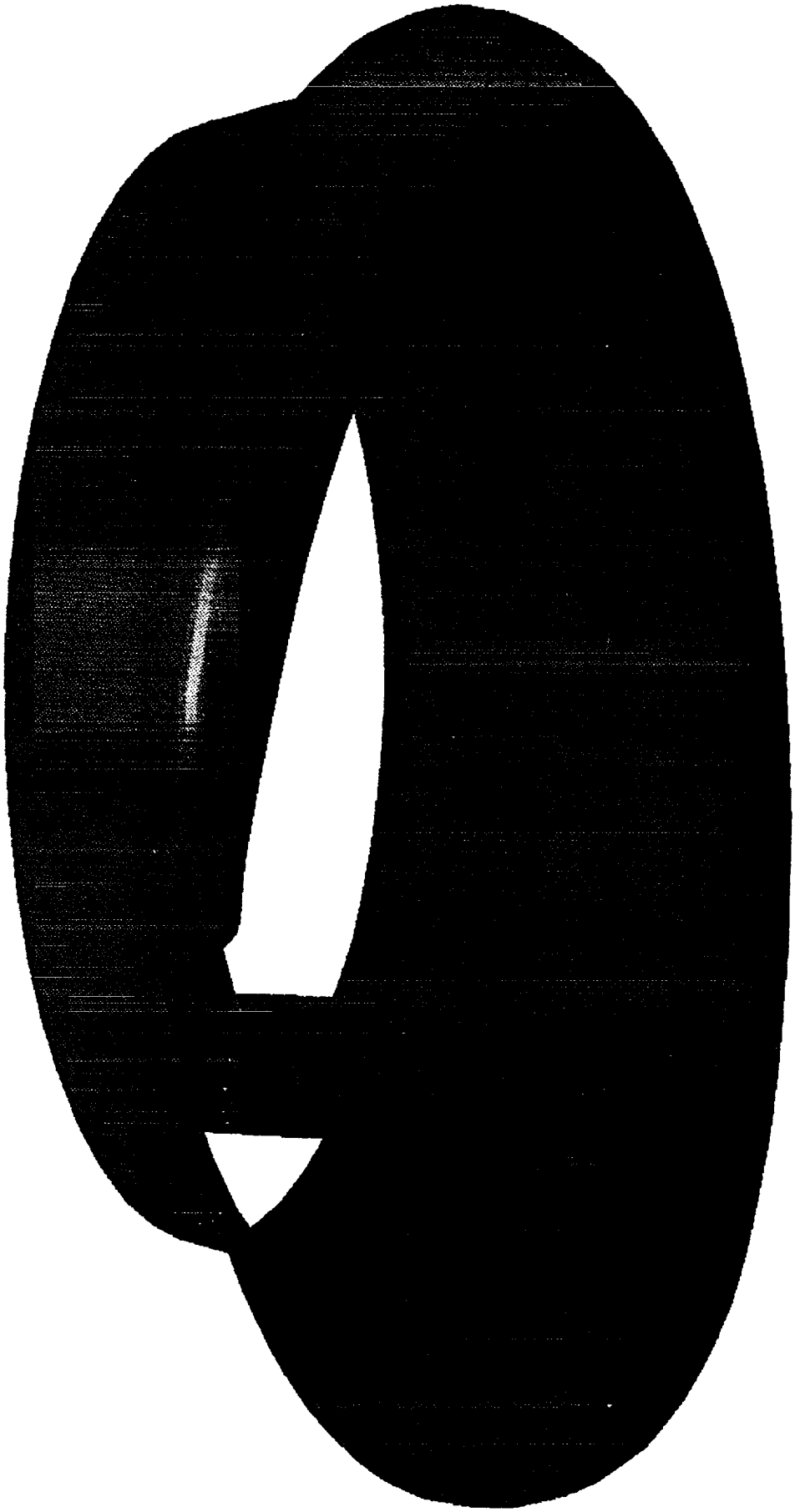


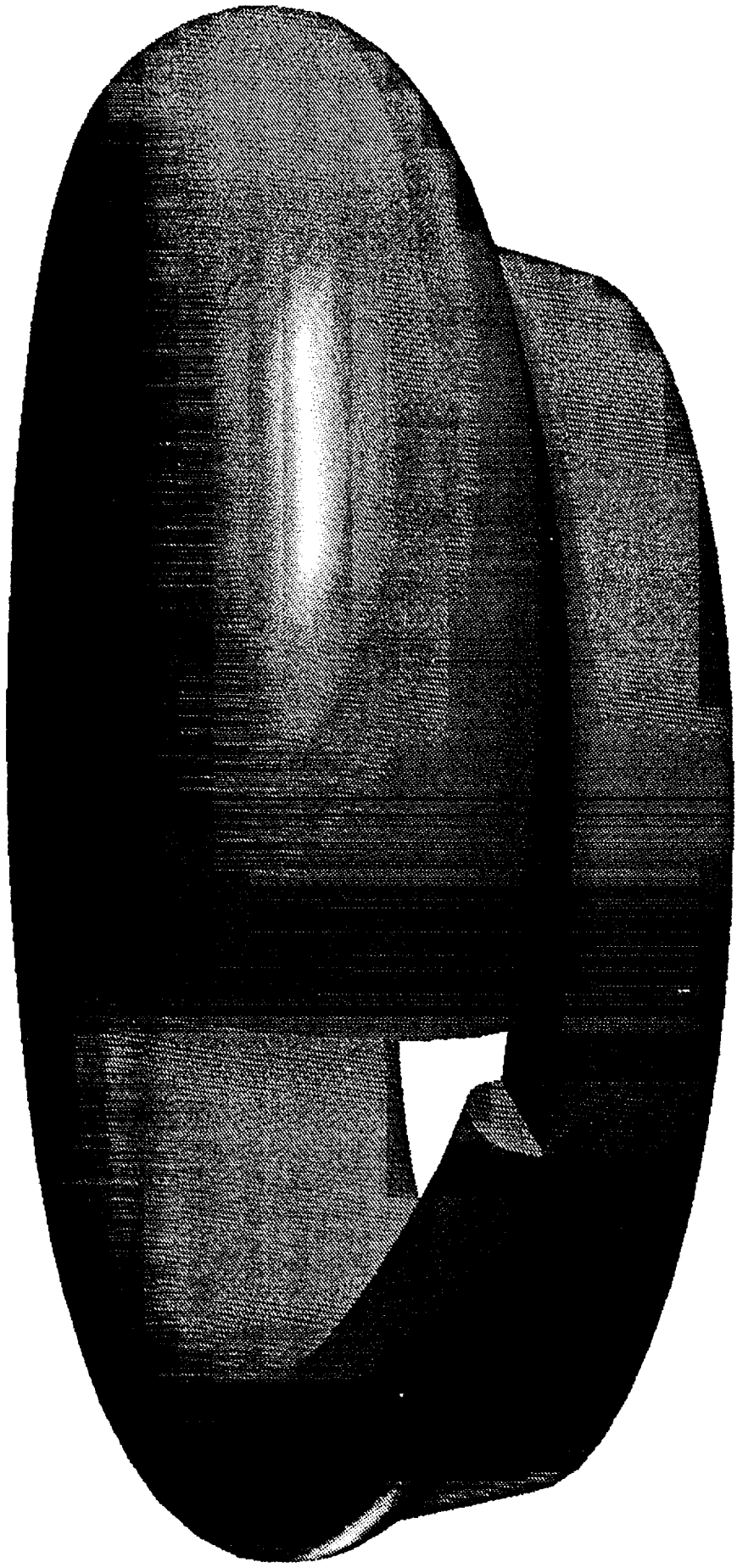
Velocity Vectors on Oxidizer Turbine Rotor

Consortium Turbine and Exit Volute

Computational grid

- o Structured Grid (I-Grid) : 51x32x46
- o Unstructured Grid : 90,000 Nodes





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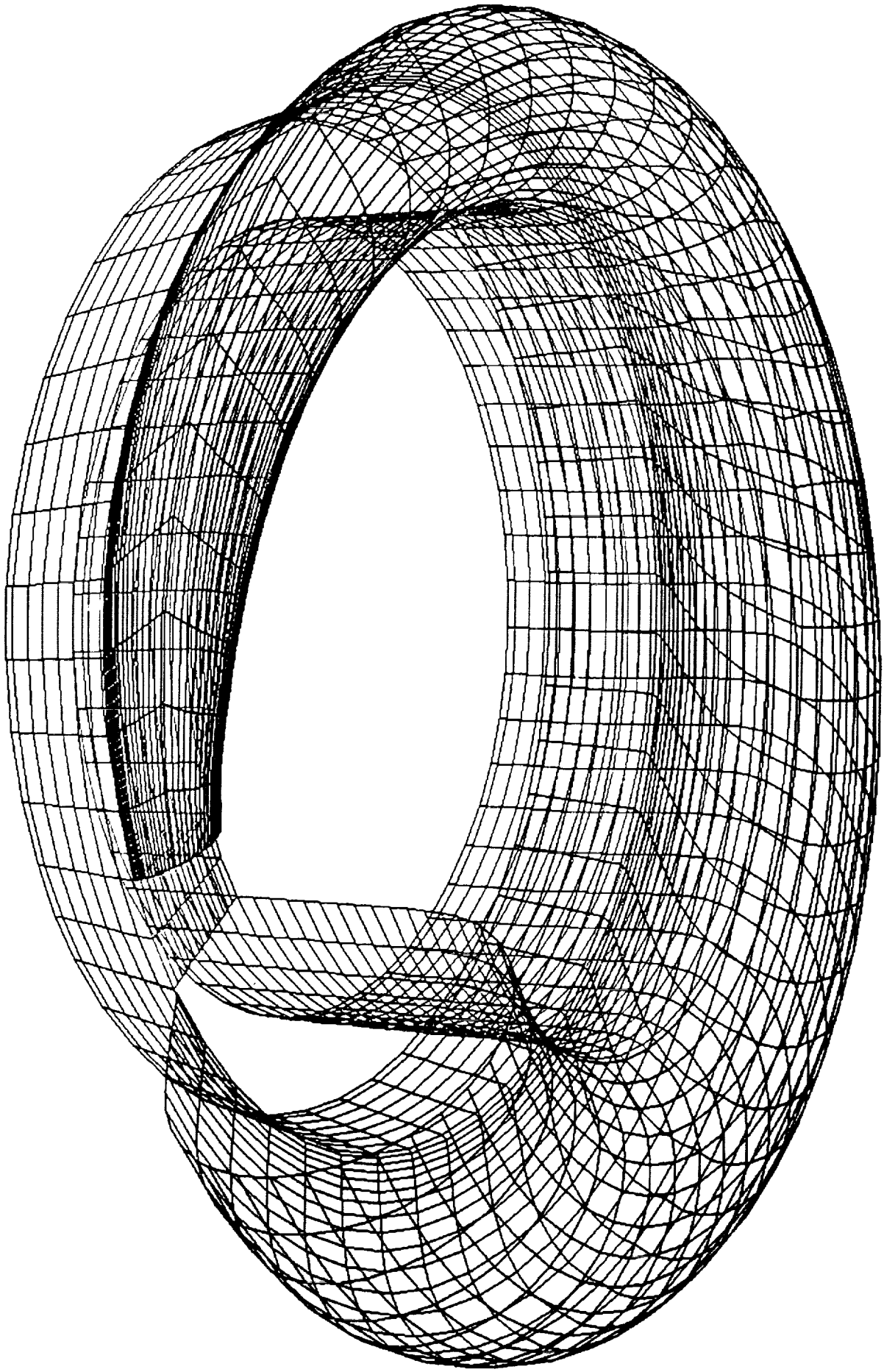
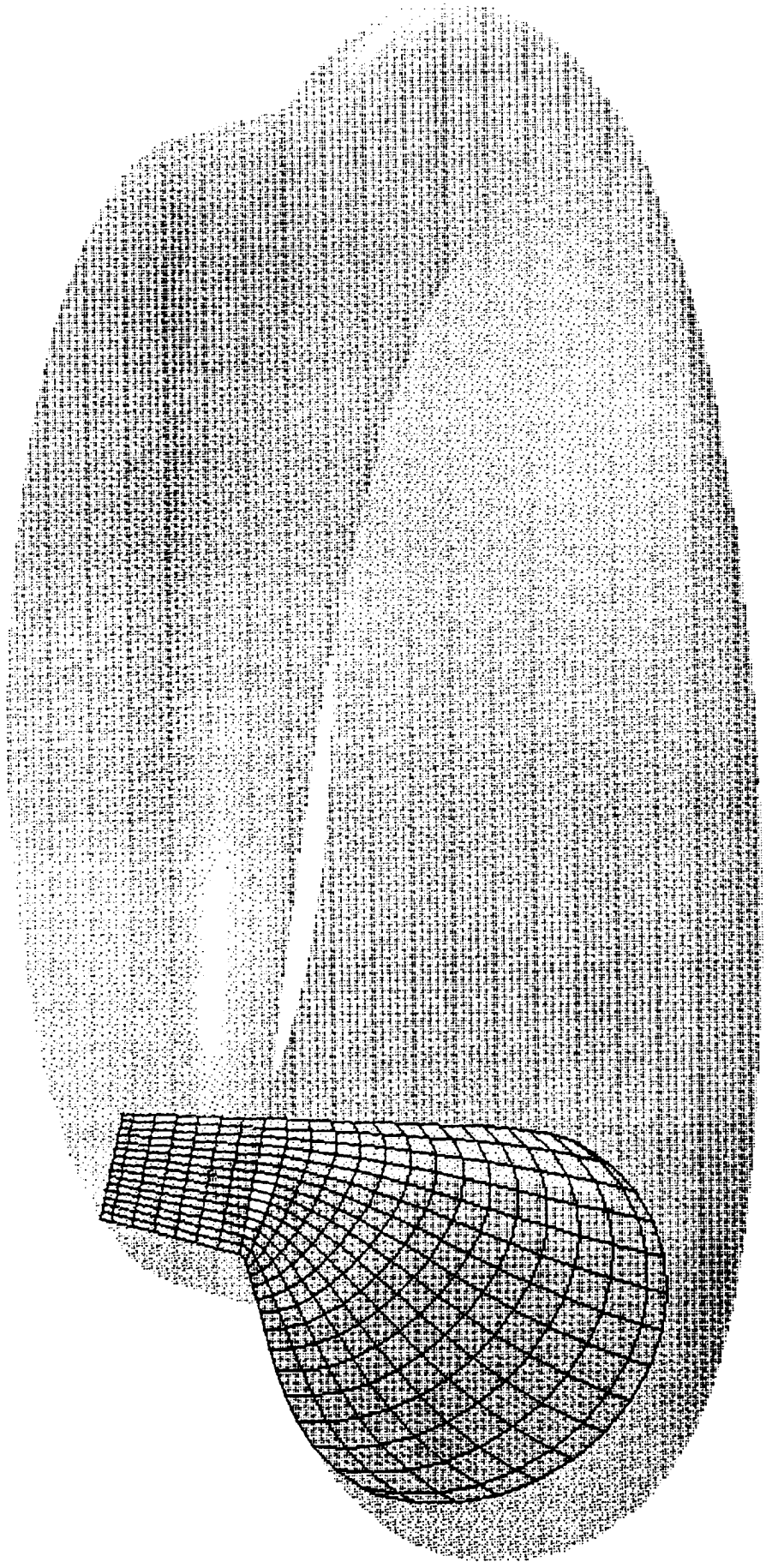
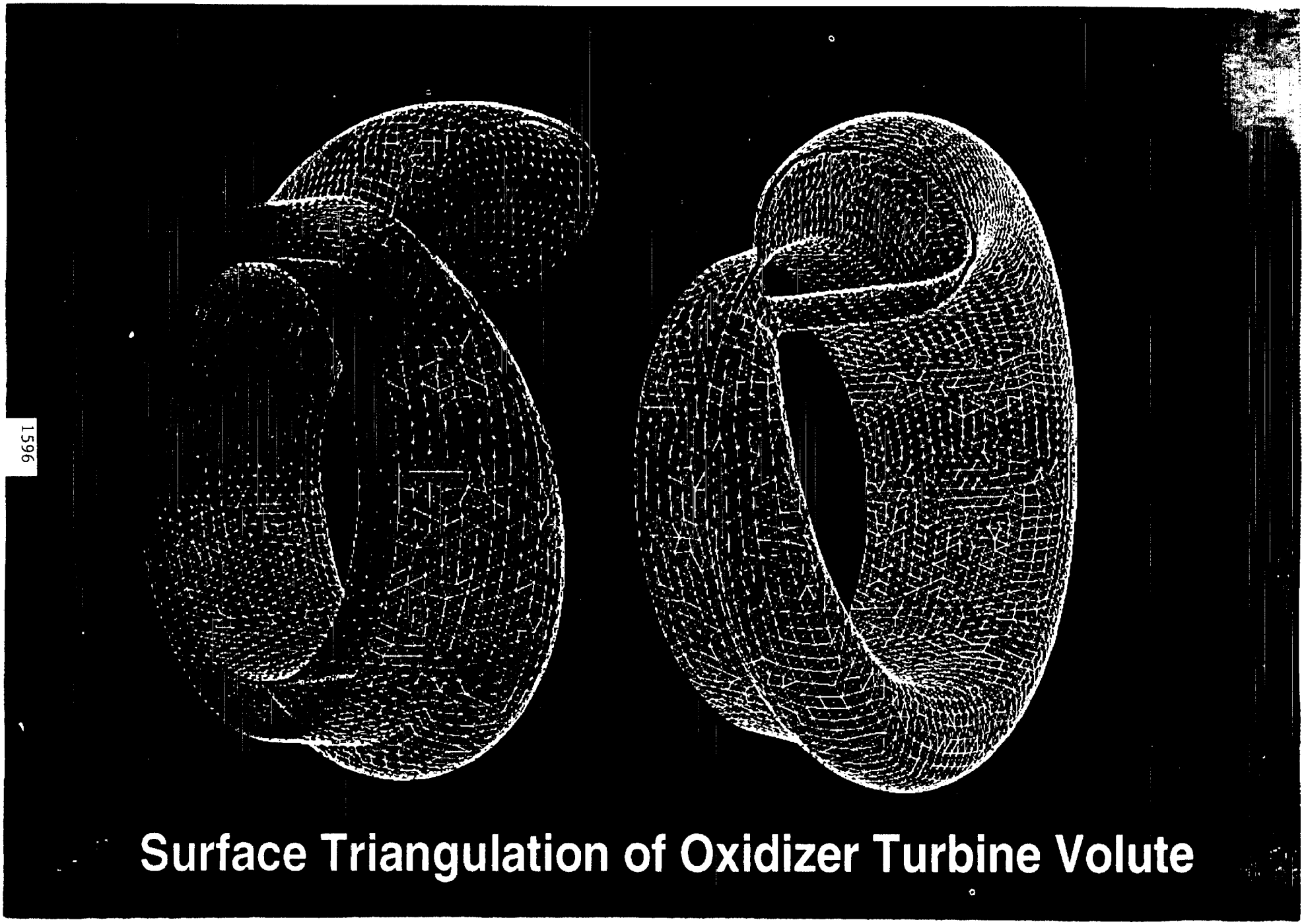






Surface Triangulation of Oxidizer Turbine Volute

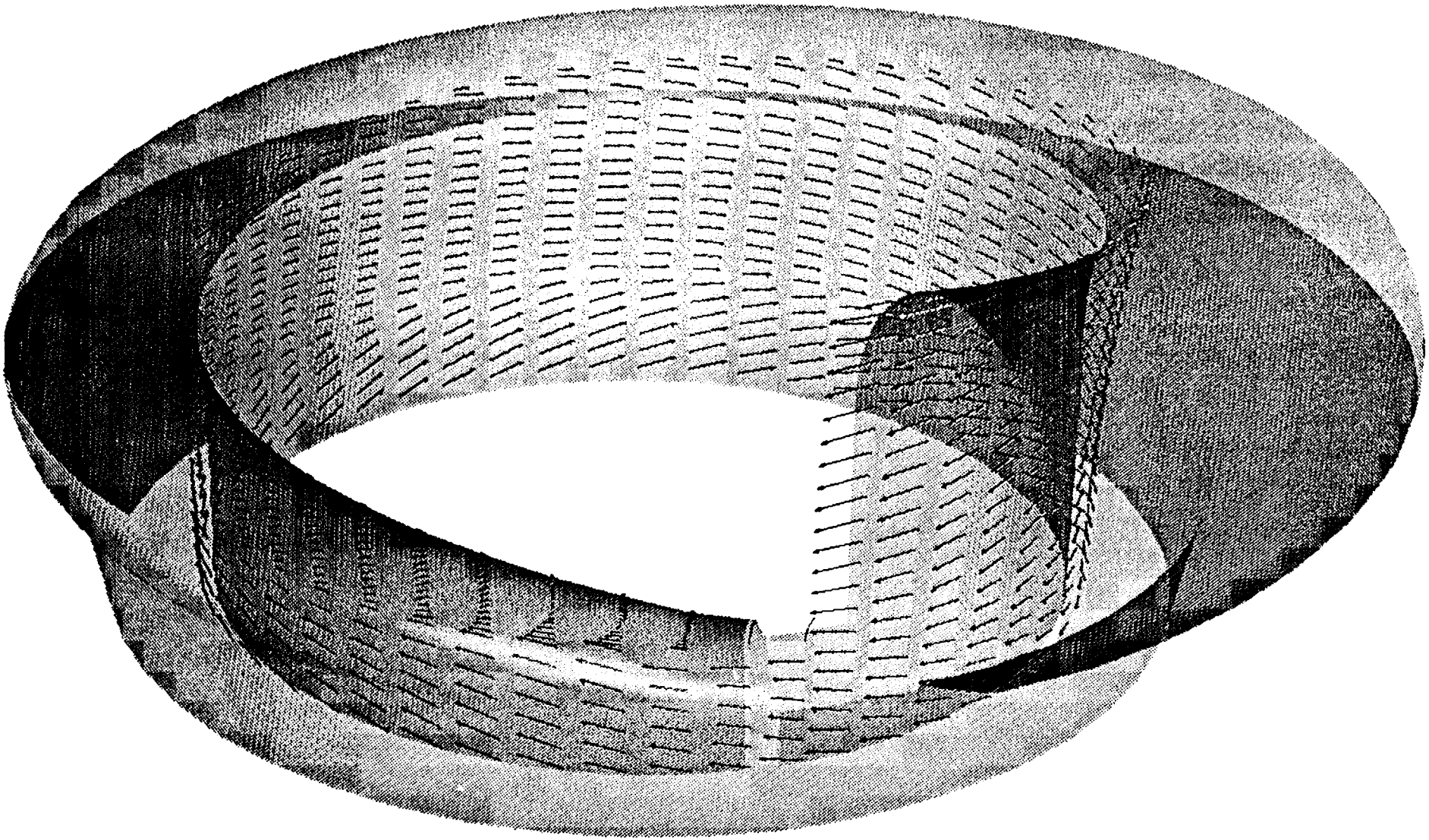
BOUNDARY CONDITIONS

- Inlet
  - Total Pressure
  - Total Temperature
  - Two Velocity Components
- Exit
  - Static Pressure

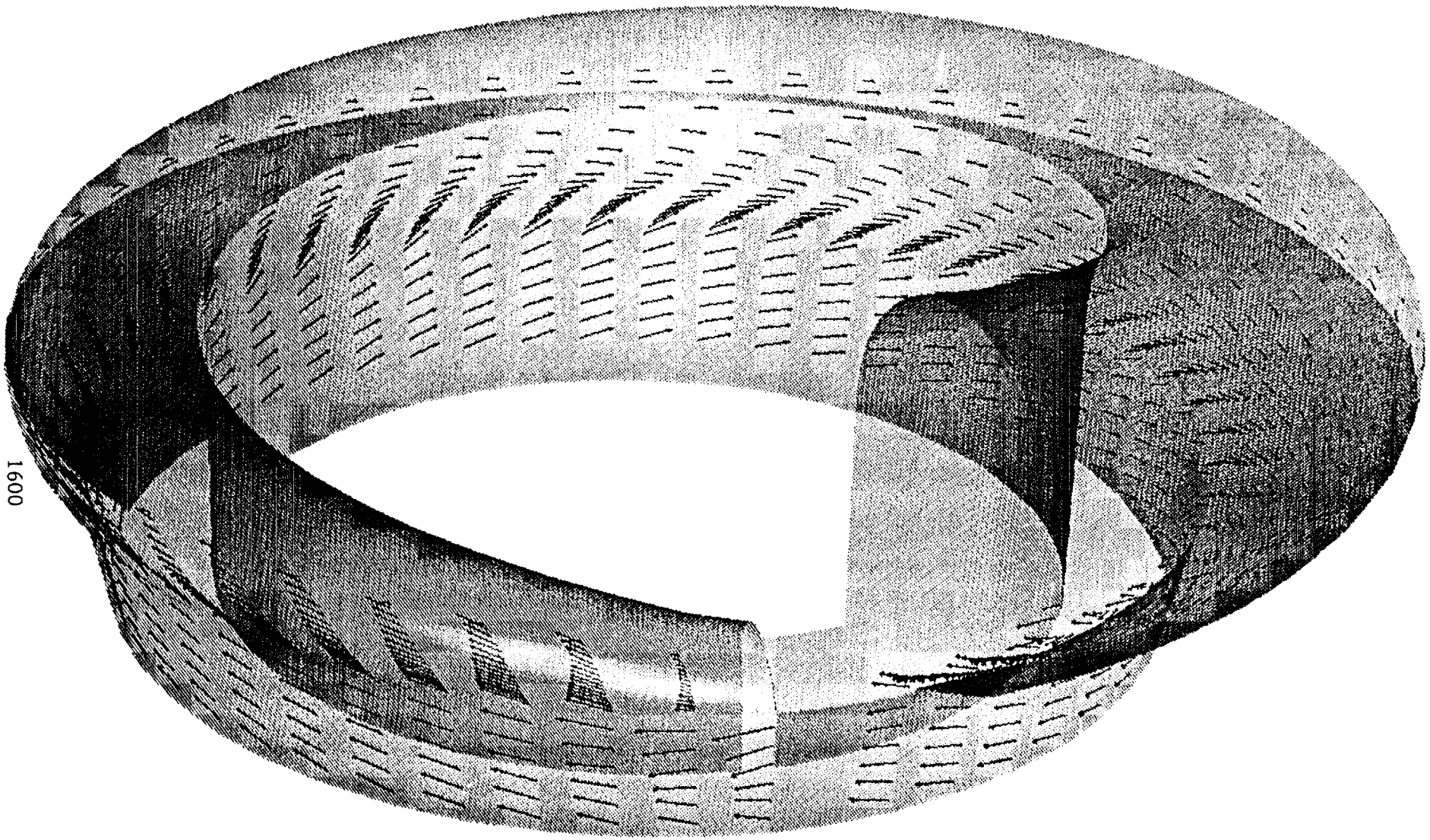
HAH3D Viscous Flow Code

- o Three-Dimensional Navier-Stokes
- o Pressure-Based Control Volume
- o Two-Equation Turbulence Model with Low-Reynolds Number Extension
- o Incompressible, Transonic, Supersonic Flows
- o Tested for Wide Range of Flows

Velocity Vectors Near Inner Wall



Velocity Vectors Near Outer Wall



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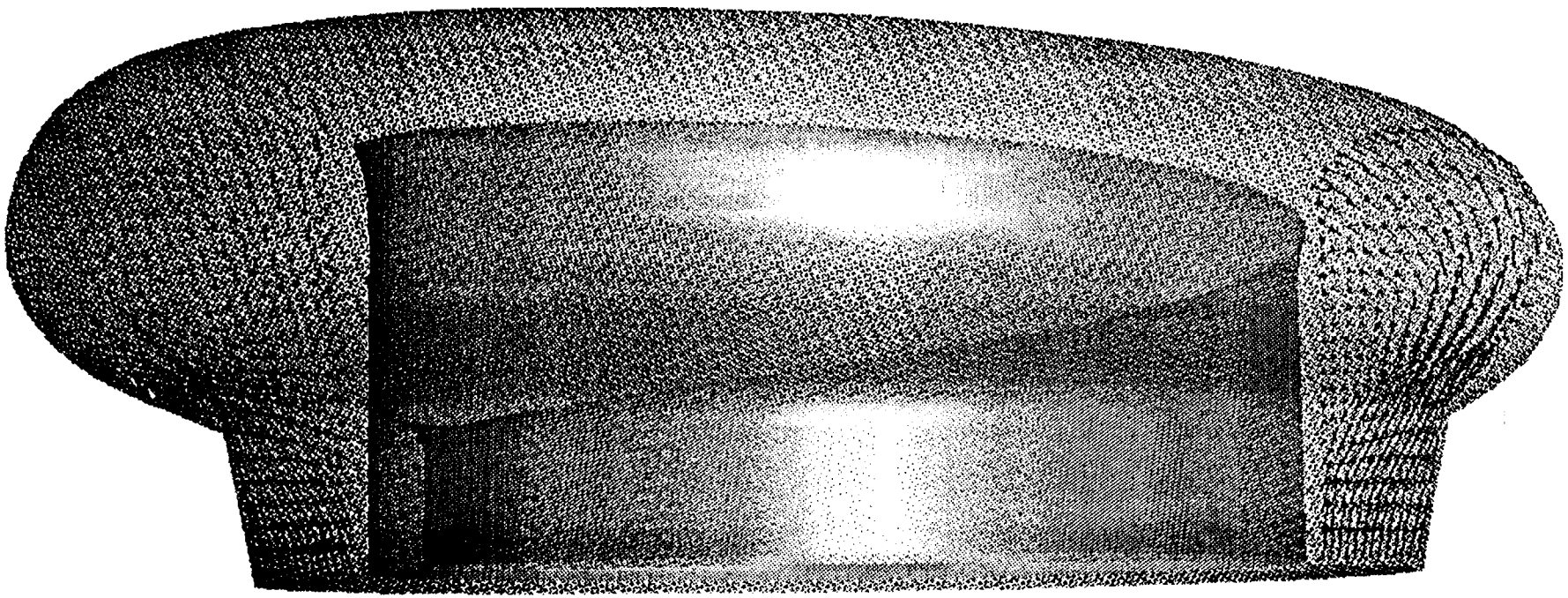
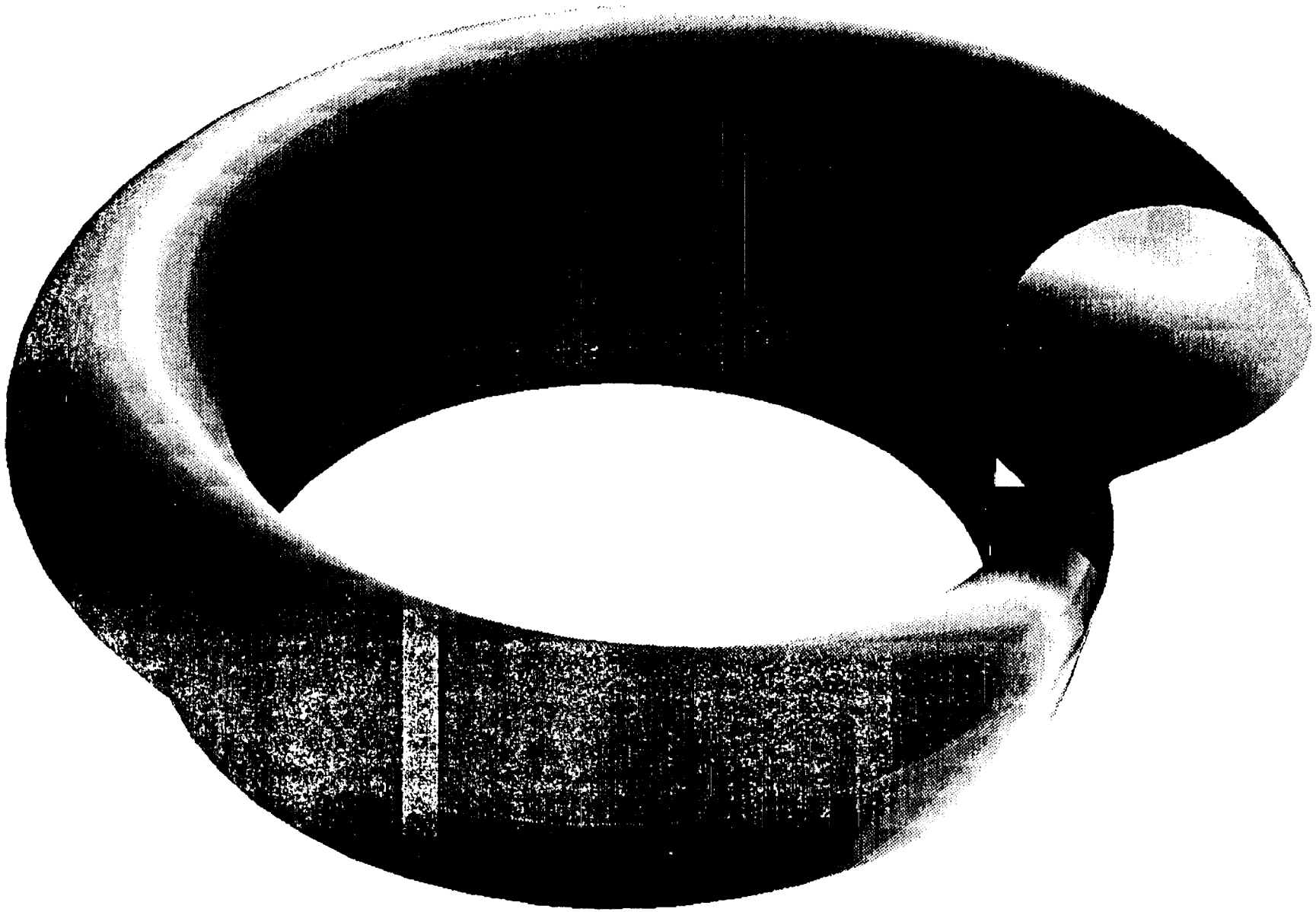
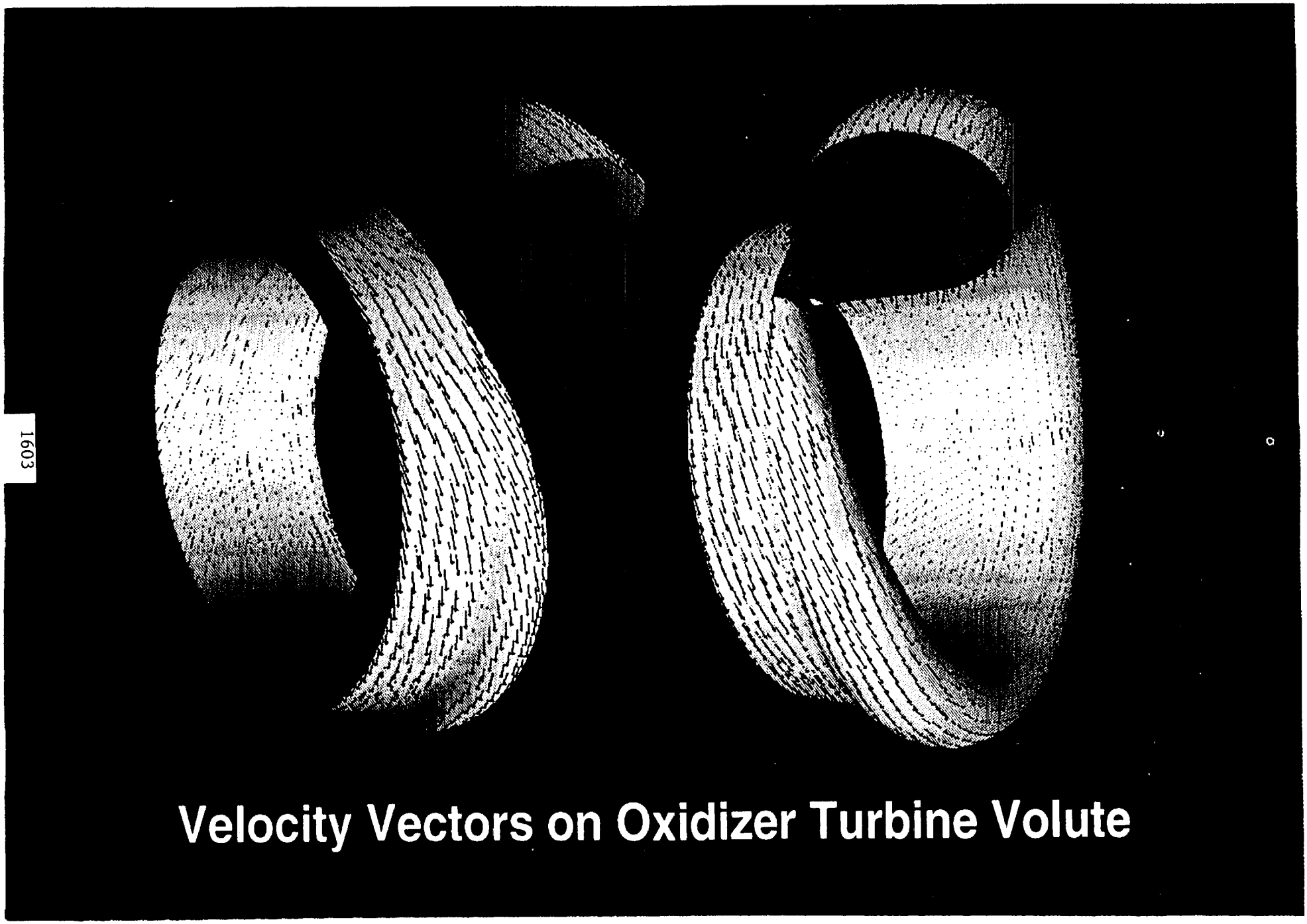
Crossflow Velocity Vectors

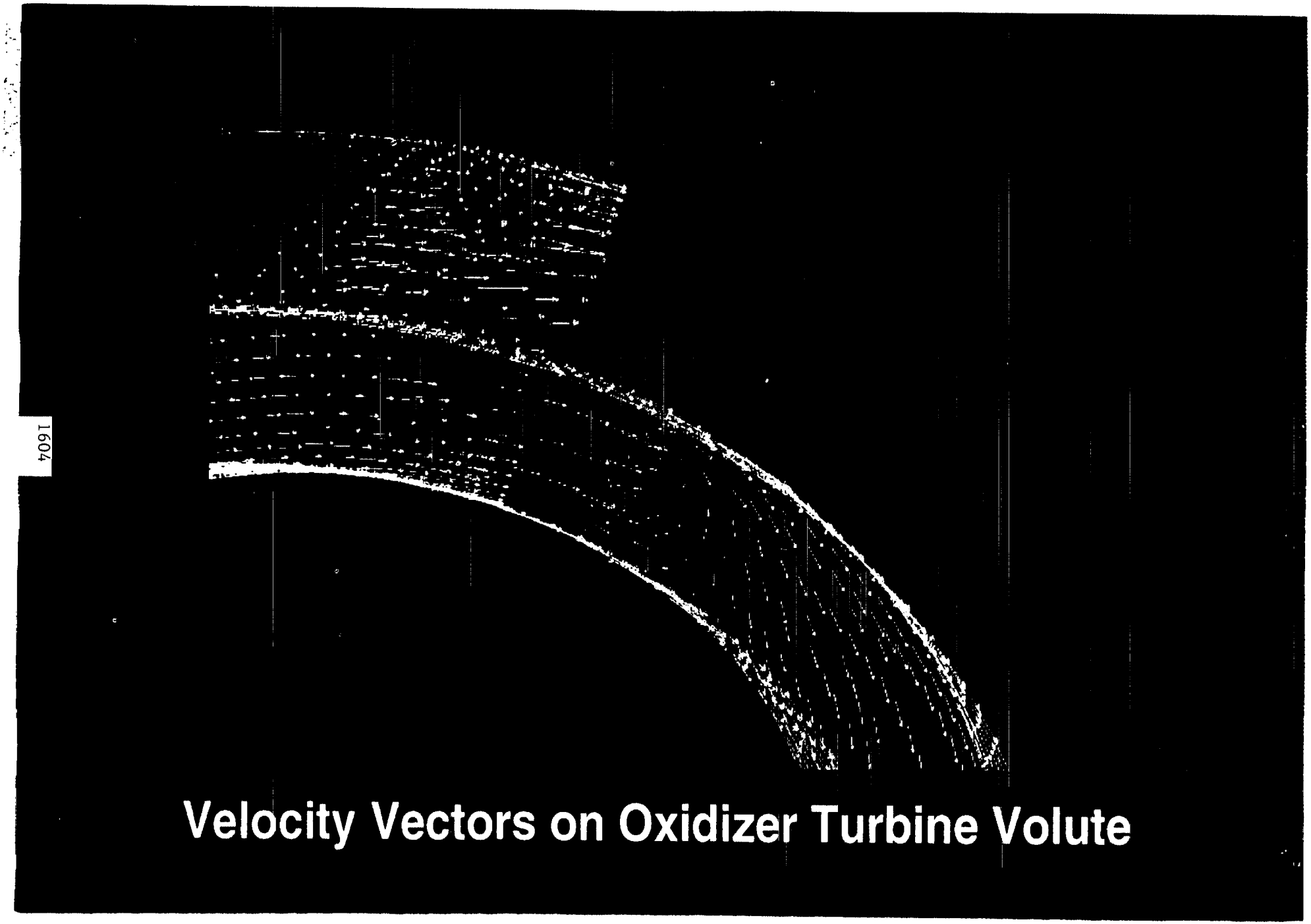


Surface Static Pressure





Velocity Vectors on Oxidizer Turbine Volute



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Velocity Vectors on Oxidizer Turbine Volute

Surface Pressure Contour on Oxidizer Turbine Volute

Observation and Future Study

- o Successful 3-D, N-S & Euler Flow Study for Volute Design
- o N-S & Euler Predict Different Flow features
- o Comparative Study between Structured and Unstructured Grid Methods
- o Further Verification Necessary