ASRM Multi-Port Igniter Flow Field Analysis

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Abstract

The Advanced Solid Rocket Motor (ASRM) program was initiated by NASA in response to the need for a new generation rocket motor capable of providing increased thrust levels over the existing Redesigned Solid Rocket Motor (RSRM) and thus augment the lifting capacity of the space shuttle orbiter. To achieve these higher thrust levels and improve motor reliability, advanced motor design concepts were employed. In the head end of the motor, for instance, the propellent cast has been changed from the conventional annular configuration to a "multi-slot" configuration in order to increase the burn surface area and guarantee rapid motor ignition. In addition, the igniter itself has been redesigned and currently features 12 exhaust ports in order to channel hot igniter combustion gases into the circumferential propellent slots. Due to the close proximity of the igniter ports to the propellent surfaces, new concerns over possible propellent deformation and erosive burning have arisen. The following documents the effort undertaken using computational fluid dynamics to perform a flow field analysis in the top end of the ASRM motor to determine flow field properties necessary to permit a subsequent propellent fin deformation analysis due to pressure loading and an assessment of the extent of erosive burning.

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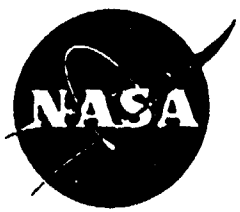
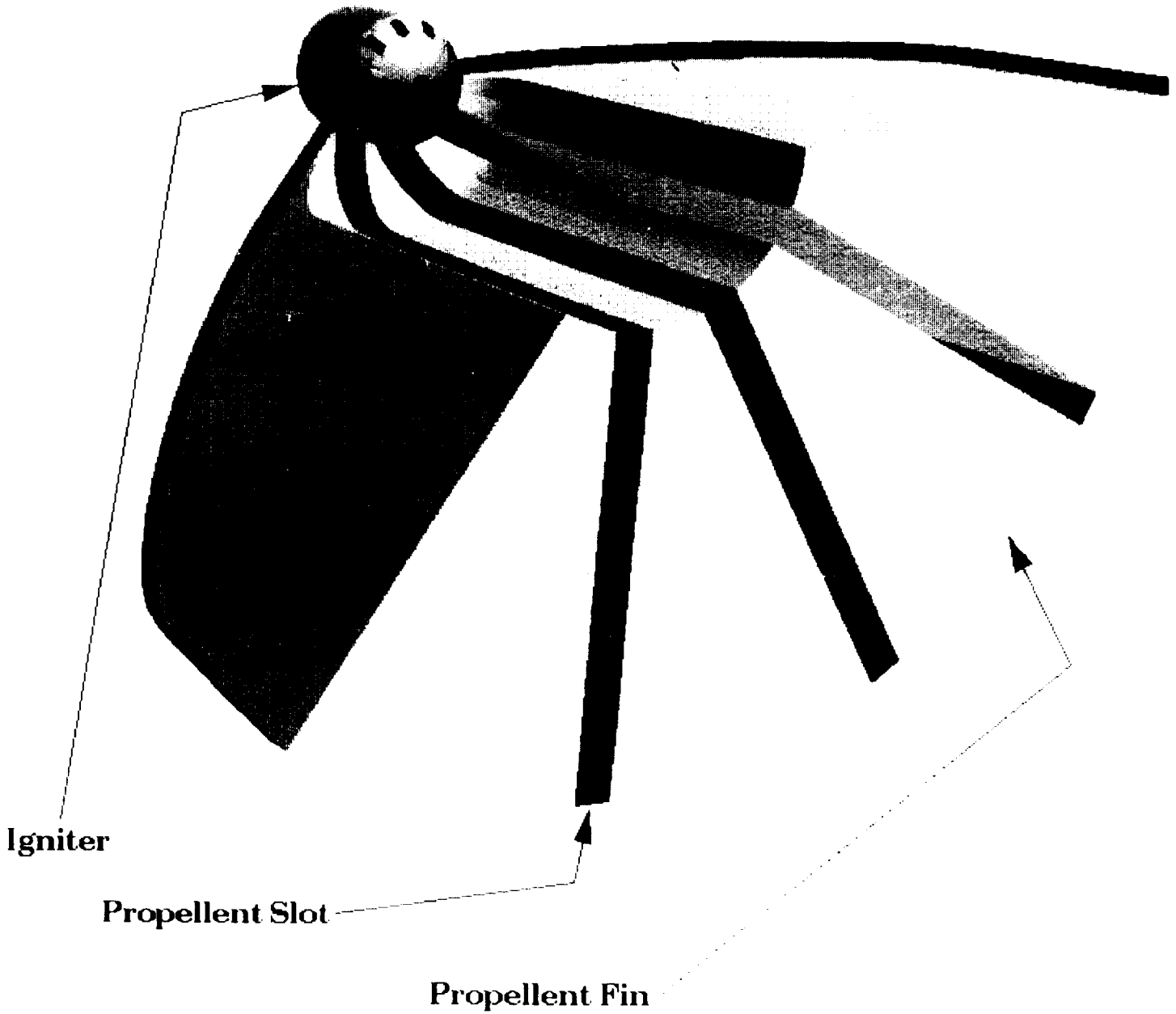
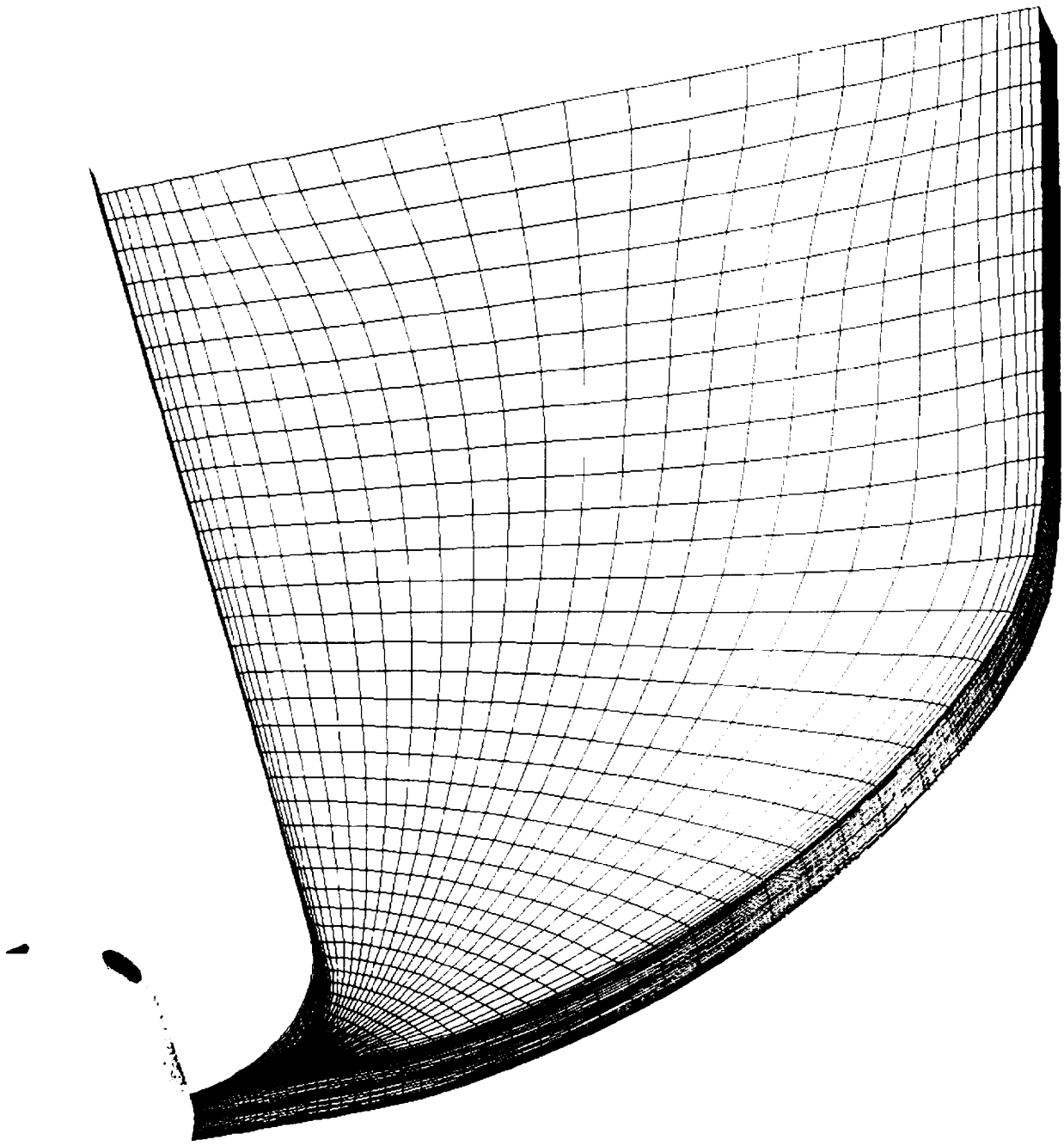


Sverdrup

ASRM Head End



- Objective
  - Characterize ASRM Head End Flow Field
- Purpose
  - Estimate propellent surface pressures for deformation analysis
  - Quantify nature of impingement to assess erosive burning
- Approach
  - Three-dimensional CFD analysis
    * Utilize REFLEQS3D and FDNS
    * Physical discretization to include region from mid-slot to mid-fin
    * grid contains 169K points



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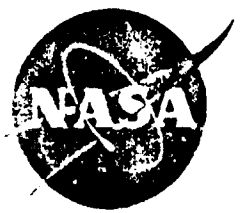
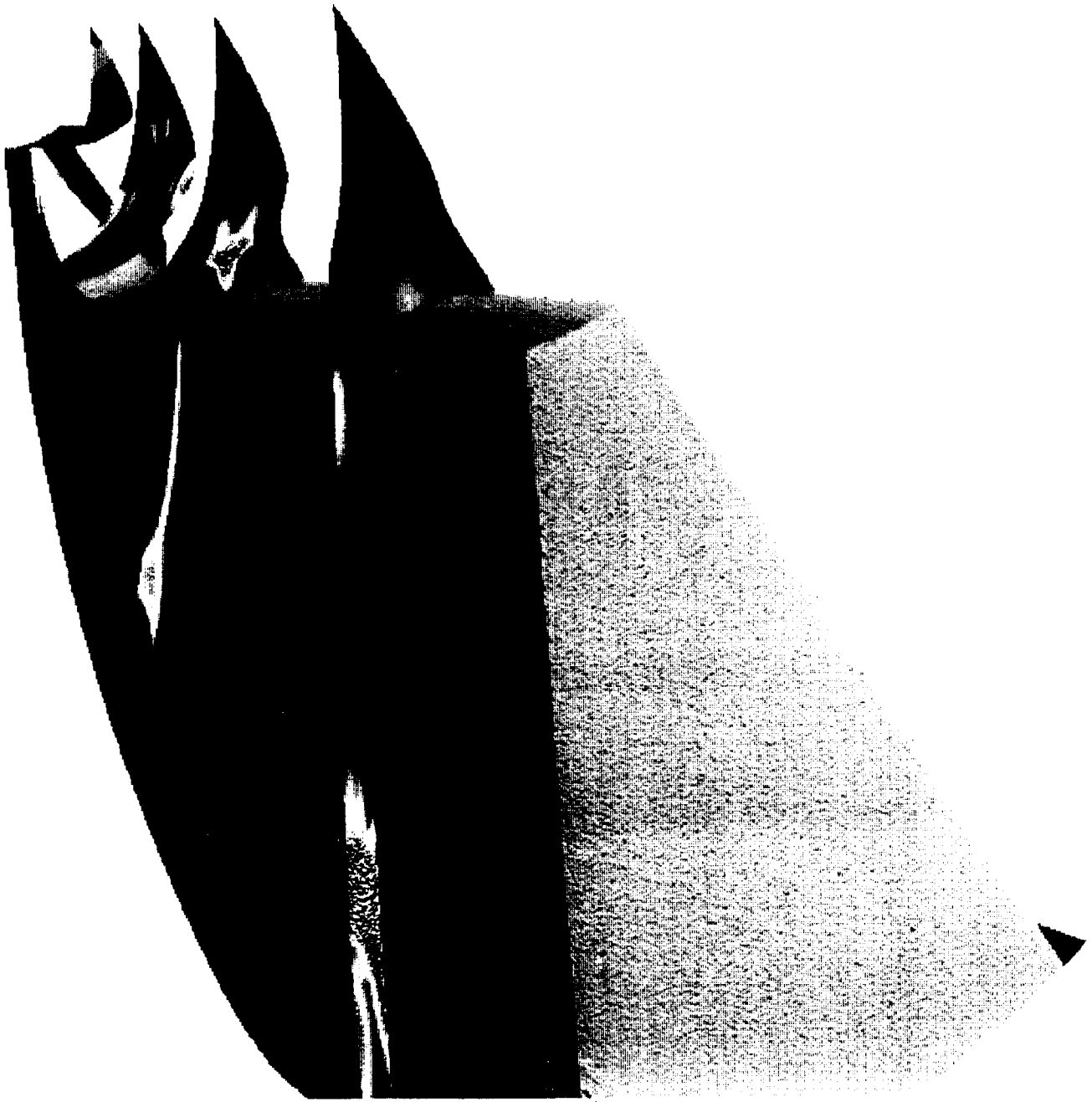
- Physical Models
  - Assume steady flow of a perfect gas
    * $\gamma = 1.166,\ R_{gas} = 1717.03$
  - $K - \epsilon$ turbulence model with wall functions



- Igniter Port Flow Conditions
  - P = 145,000 psf
  - T = 5861 R
  - M = 1.0

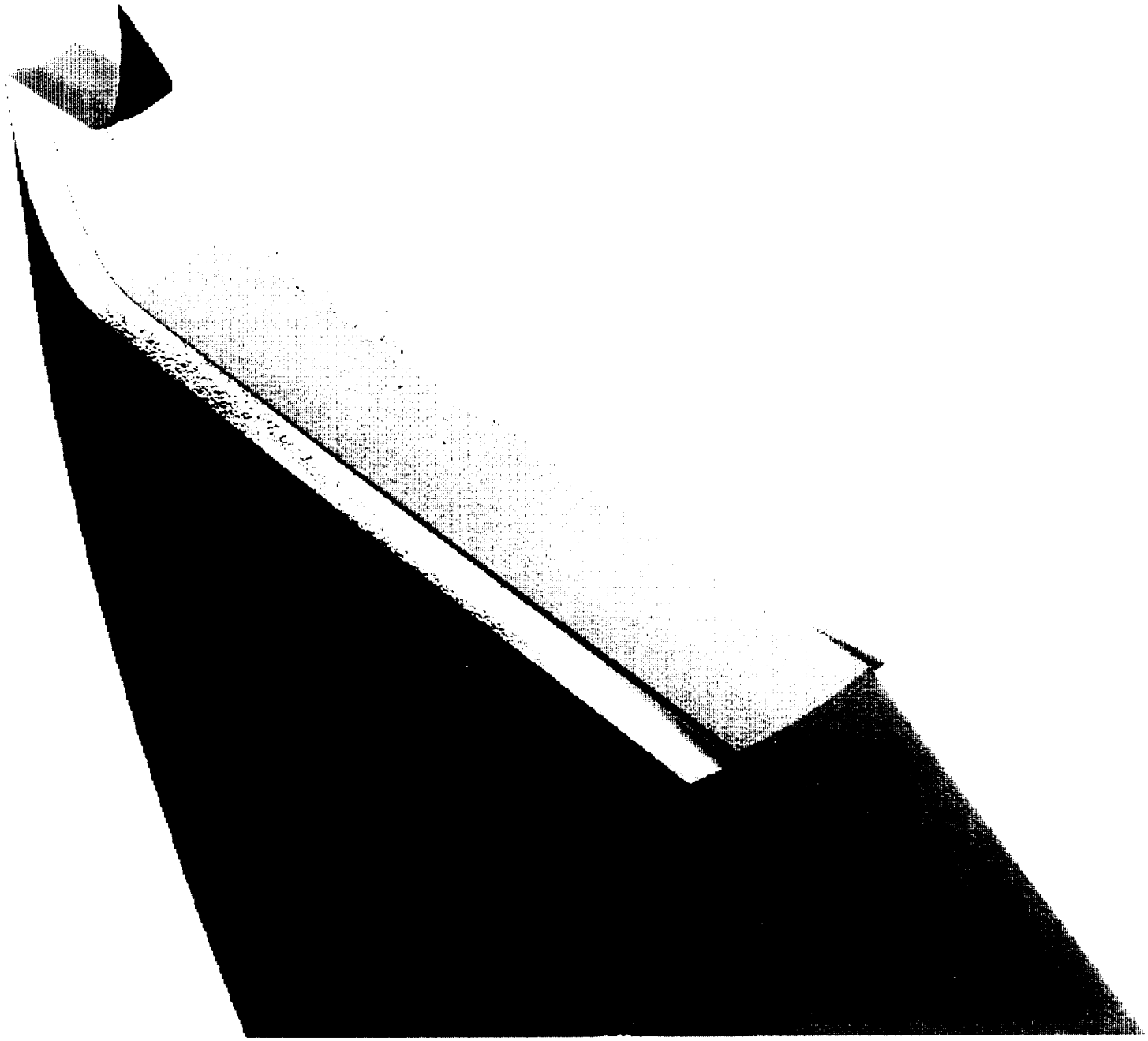
Pressure Contours - Fin Surface (psf)

Streamwise Mass Flux Contours

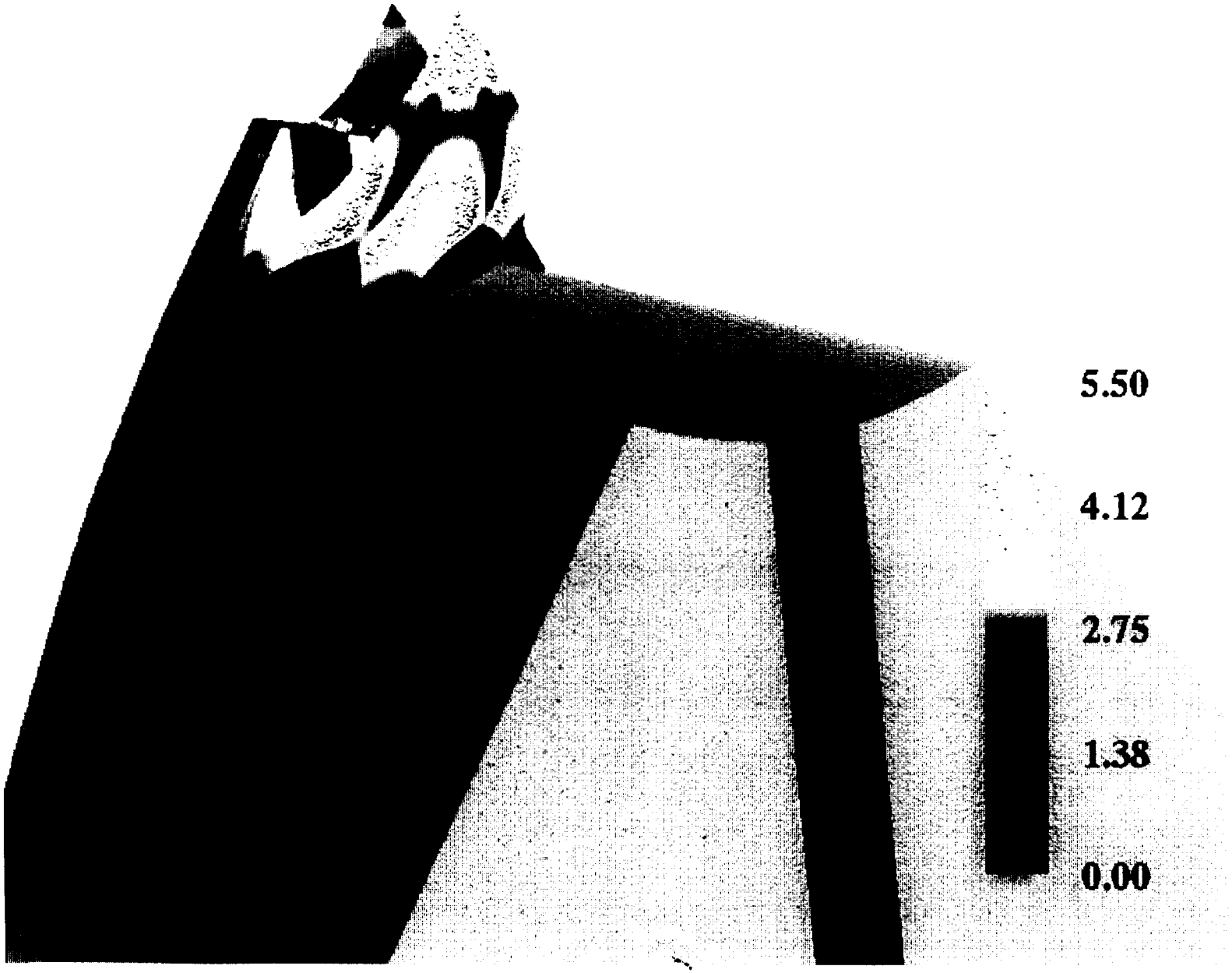


Transverse Mass Flux Contours

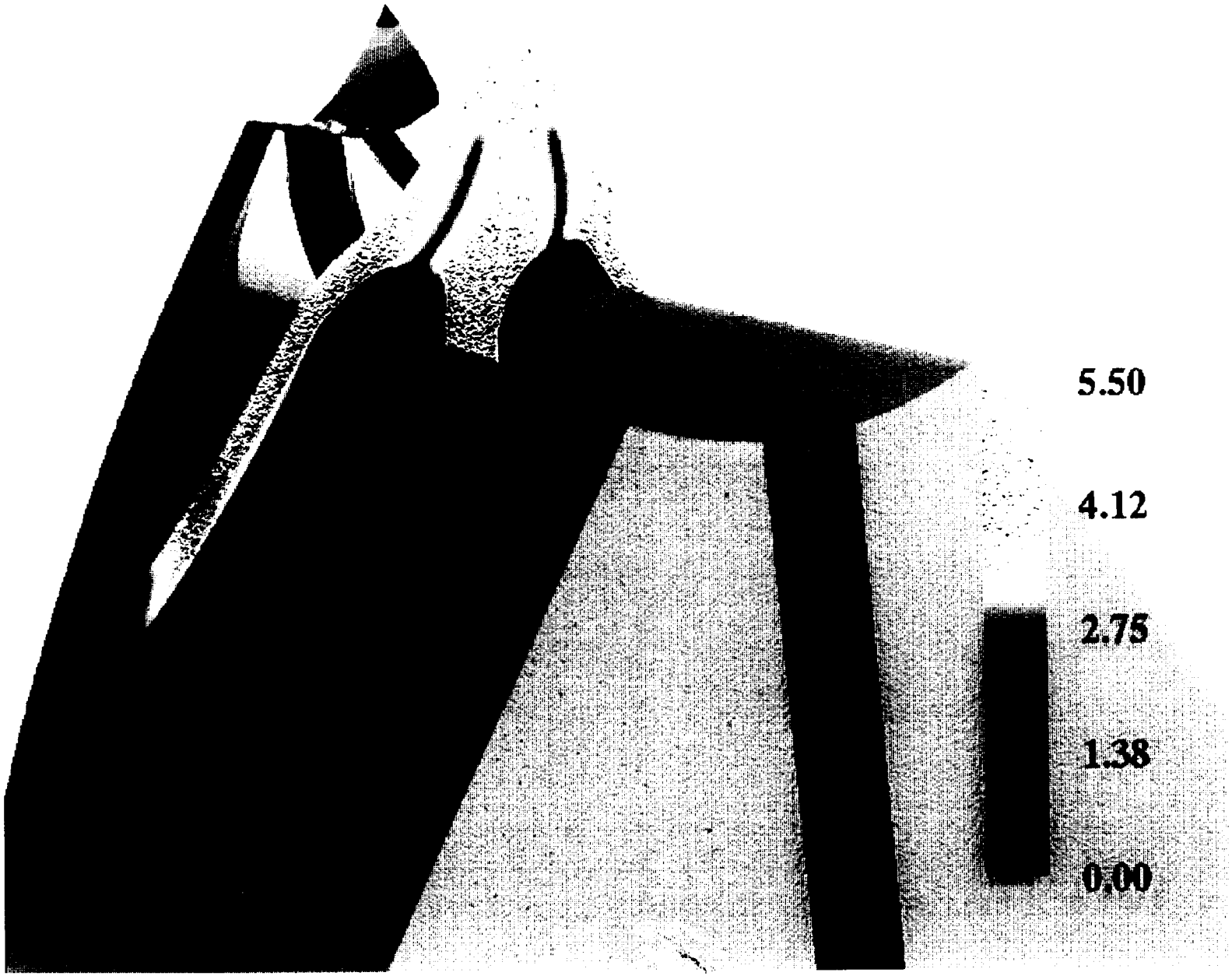
Transverse Mass Flux Contours



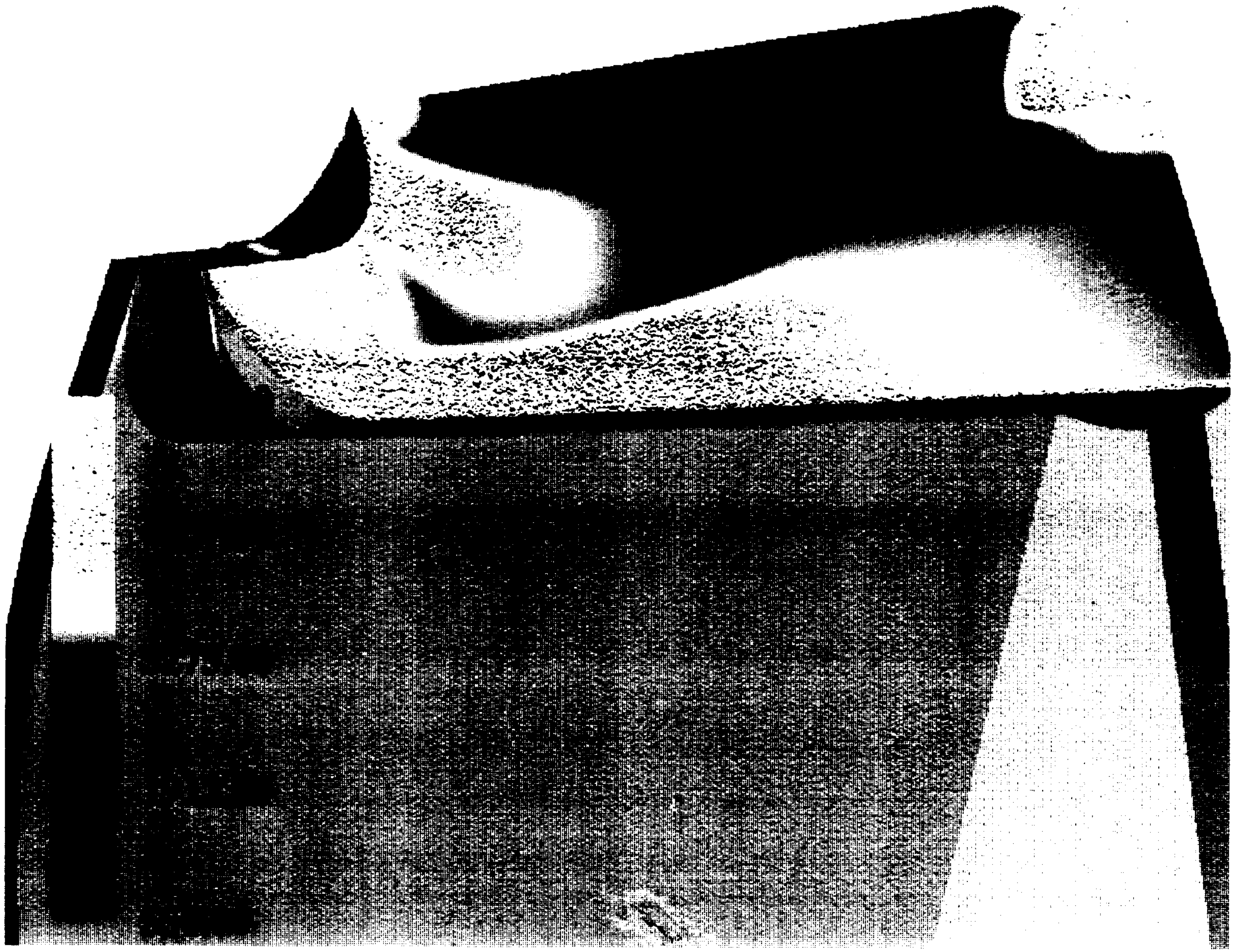
Mach Number Contours



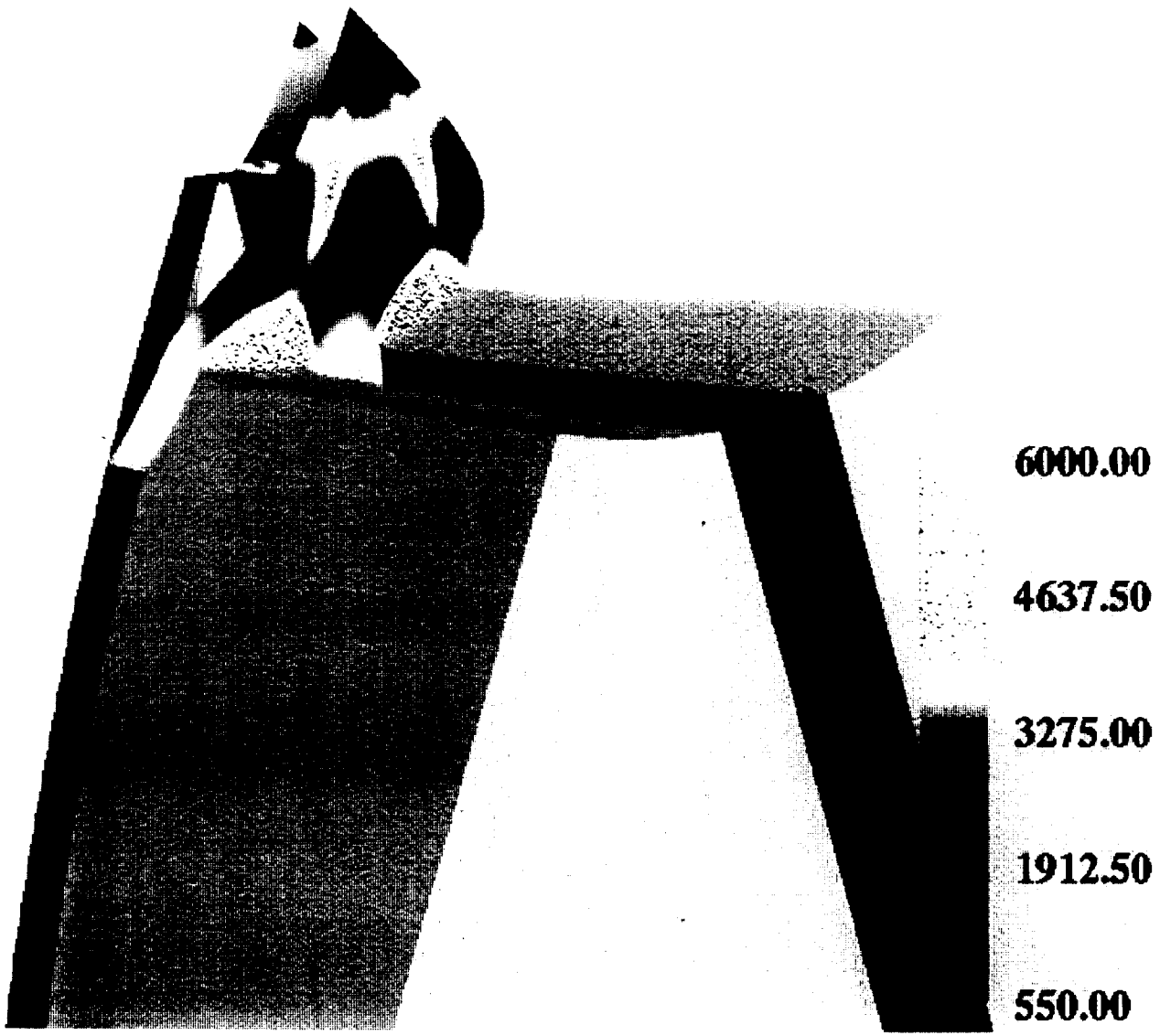
Mach Number Contours

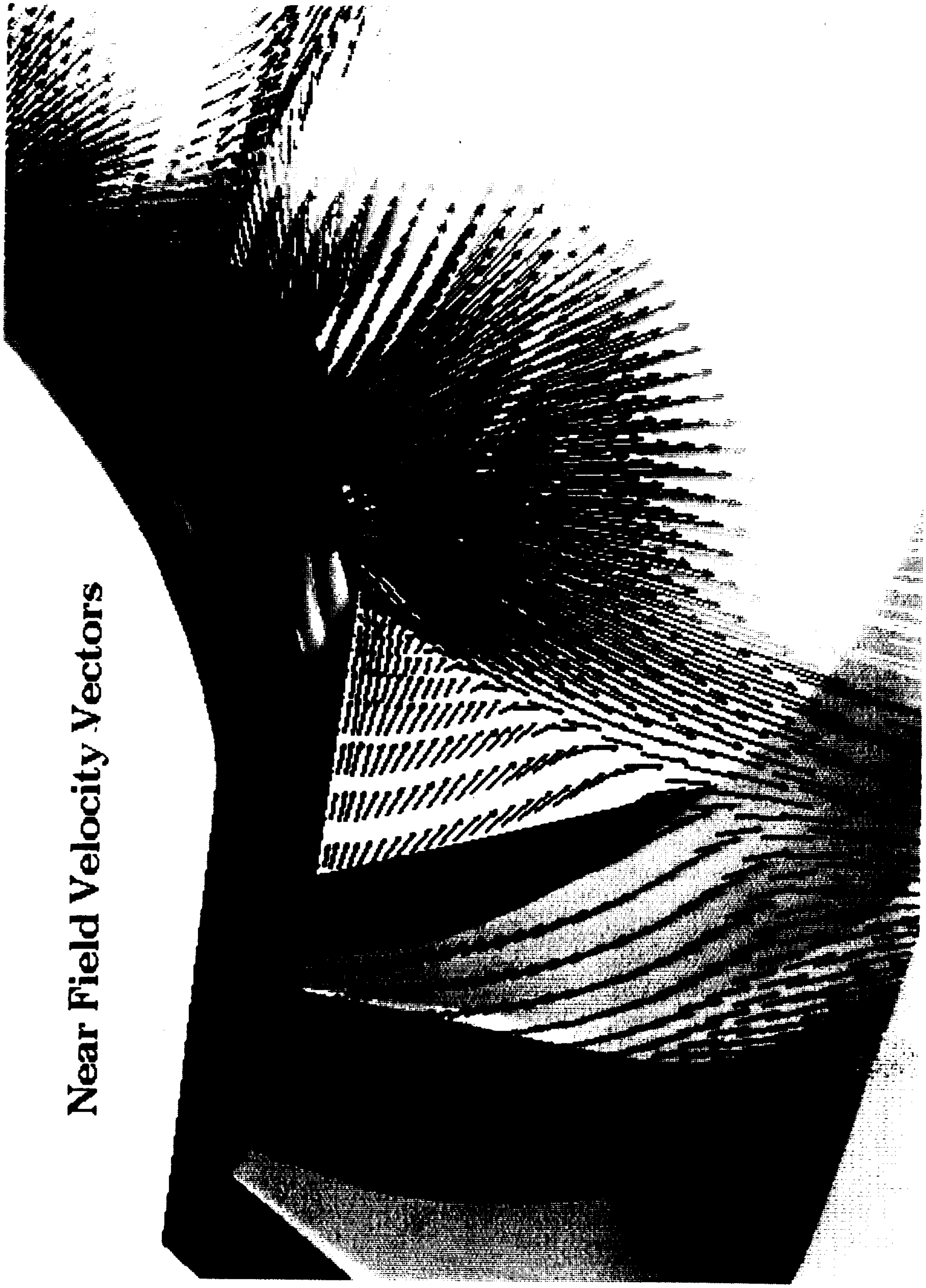


Temperature Contours



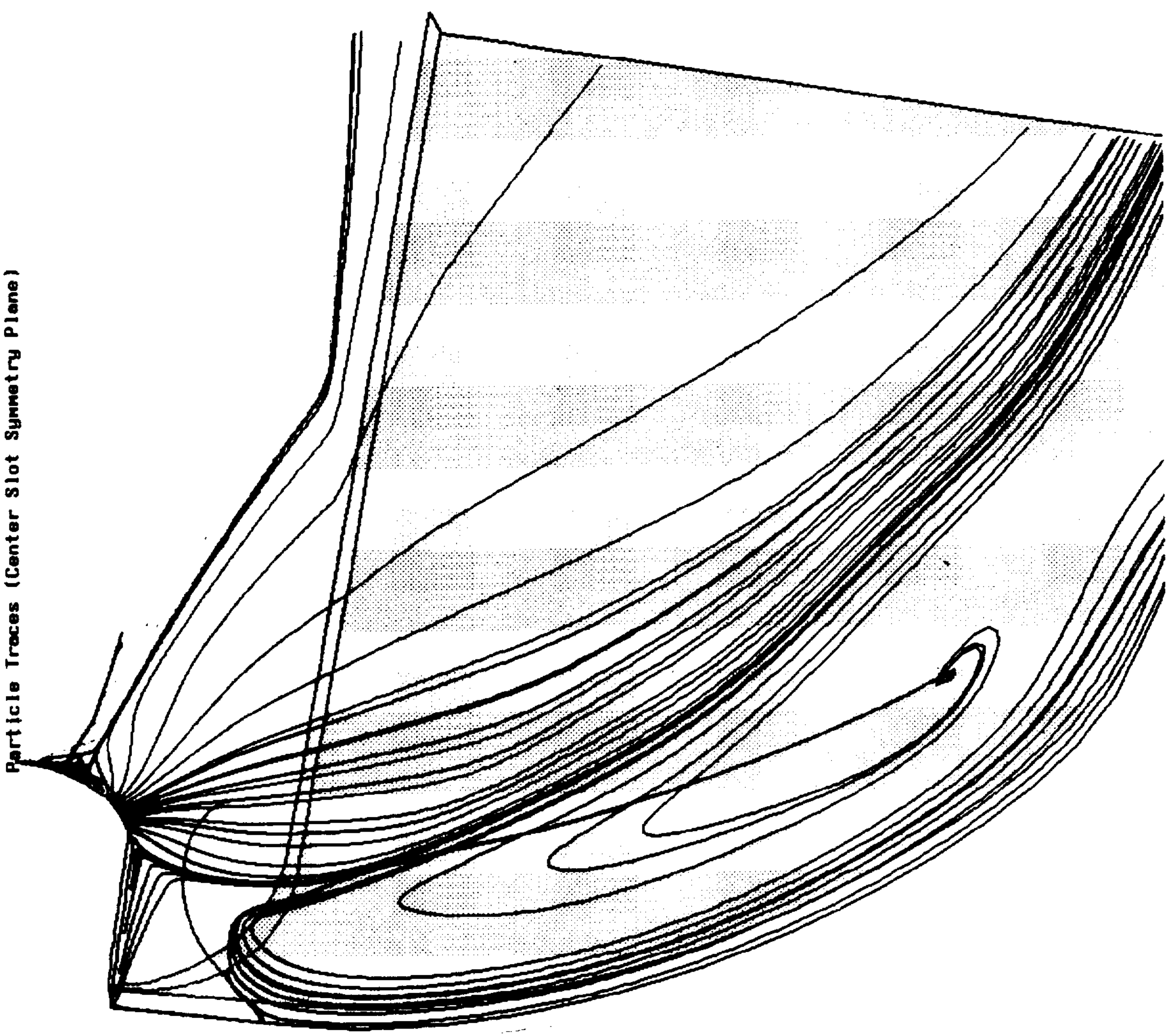
Temperature Contours





Near Field Velocity Vectors

Particle Traces (Center Slot Symmetry Plane)



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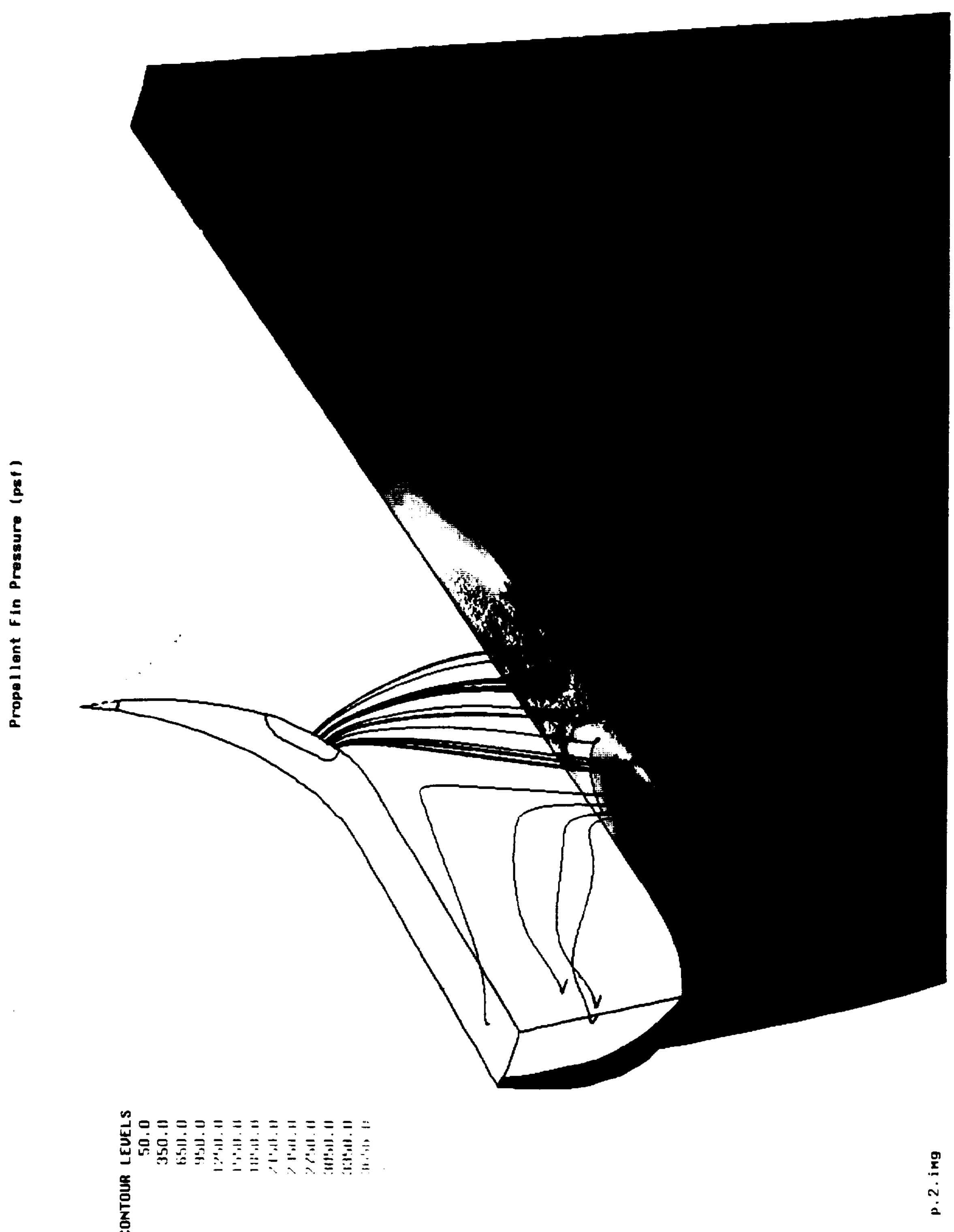

- Conclusions
  - Rapid expansion of port flow plume causes pressure "hot" spots on fin surfaces
  - Subsequent propellent deformation and erosive burning analyses now required