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THREE-DIMENSIONAL FLOW CALCULATIONS INSIDE SSME GGGT FIRST STAGE BLADE ROWS

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A numerical analysis of the first stage of the SSME GGGT was conducted using a 3-D Reynolds-averaged Navier-Stokes flow solver. This turbine stage was designed to improve both aerodynamic efficiency and durability. The blade has an unconventional shape; with a large blade thickness, and no experimental data is available to verify the computational results. The objective of the current study is to analyze this turbine blade stage with a well established Navier-Stokes computational method in order to determine if the turbine is operating in the subsonic flow regime and also if there are any significant separated flow regions. The stage was analyzed in a steady state flow condition. The inlet vane was analyzed with the flow conditions from the axisymmetric entire stage solution. The viscous flow solution of the first vane is used as the inlet flow condition for the rotor.

A structured I-grid included a tip grid inside the clearance region across the blade surface so as to accommodate the need for analysis in this important region of the flow. The relative velocity vectors for the guide vane shows no regions of separation, and the solution also showed that all of the flow is subsonic in the blade passage. The results for the first stage rotor reveals the stronger radial velocities at the hub and tip regions near the suction surface. Relative velocity vectors near the suction surface show that a vortex near the blade tip produces strong radial velocities a considerable distance in the

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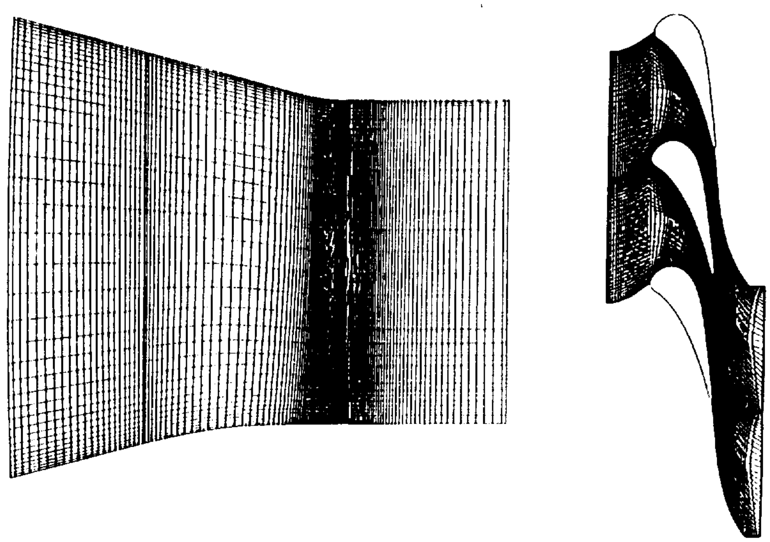
spanwise direction from the tip. On the pressure side, the tip vortex has an expectedly less anomalous effect on the overall flow, but is still fairly well resolved in the numerical solution.

Overall analysis of the velocity vectors for the first stage rotor reveal no regions of separation. A spanwise comparison of the velocity vectors shows that indeed the tip region influences the flow measurably as far away as 10% span from the tip. Inside the tip clearance region, the solution resolved the tip vortex fairly well. Pressure contours in this region indicate the telltale signs of vortex effects. Further corroborating evidence that the tip region harbors the anomalous contributions to the flow is shown in the study of the total temperature distribution in the spanwise direction. There is no perceptible difference in total temperature until up to the 98% span distance.

Computational Grid for the Nozzle



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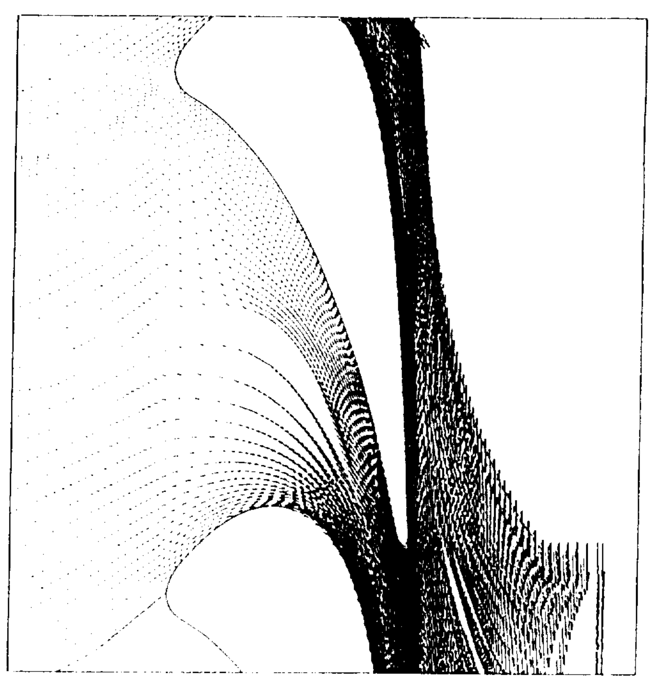
Calculated Velocity Vectors at Midspan



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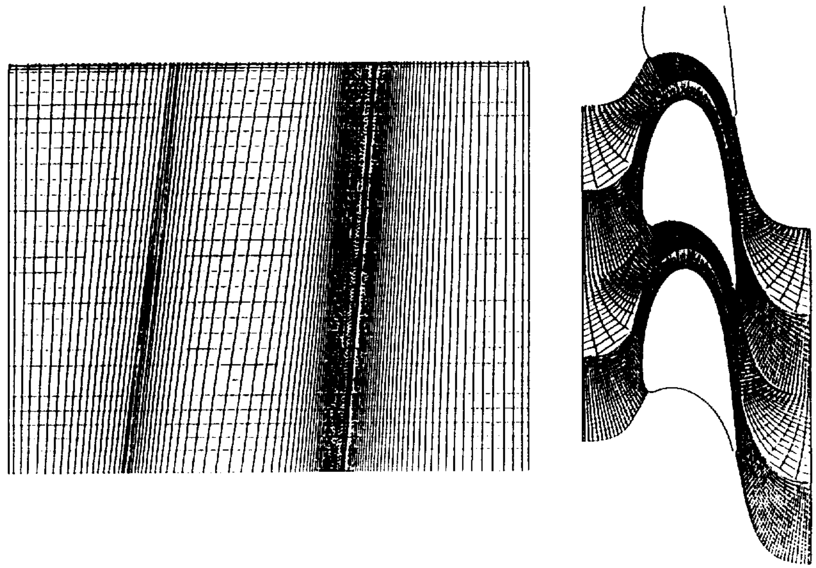
Computational Grid for the Rotor



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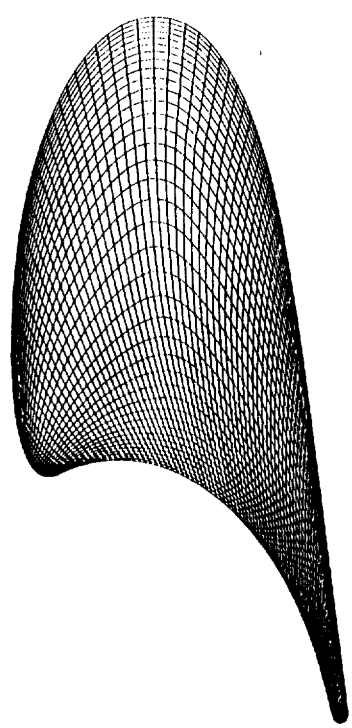
Tip Grid



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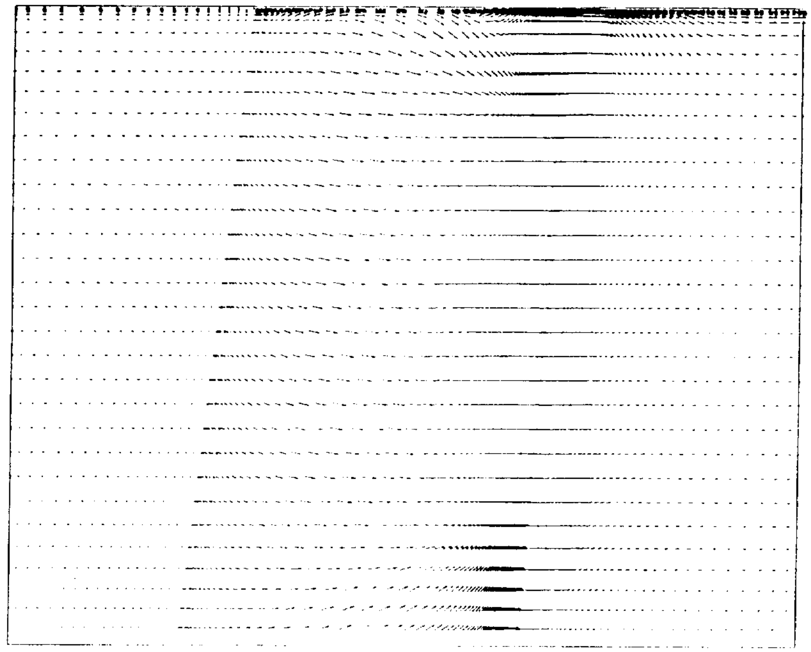
Relative Velocity Vectors Near Suction Surface



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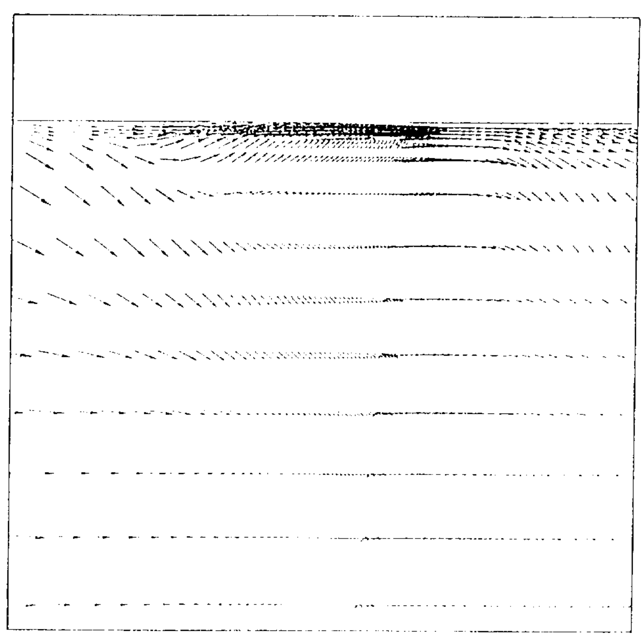
Velocity Vectors Near Tip
(Suction Side)



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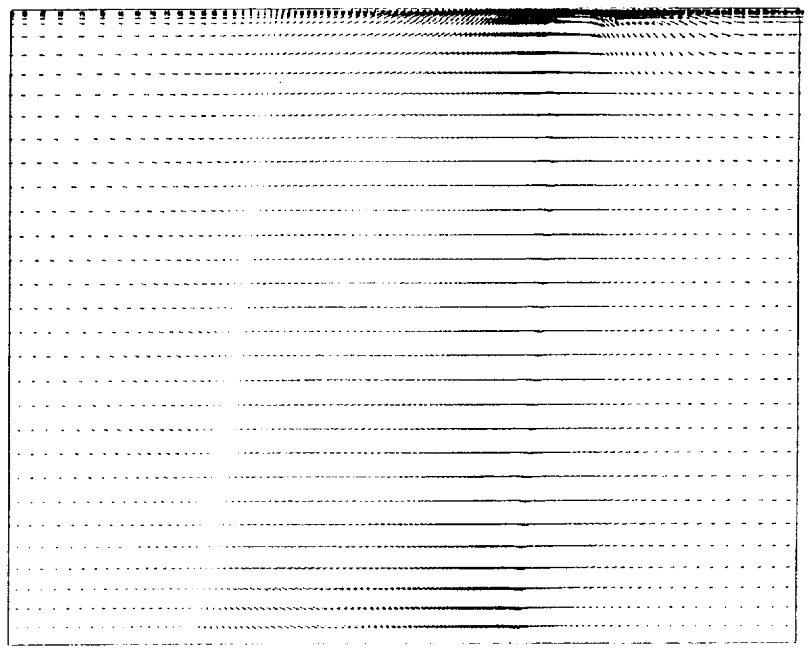
Relative Velocity Vectors Near Pressure Surface



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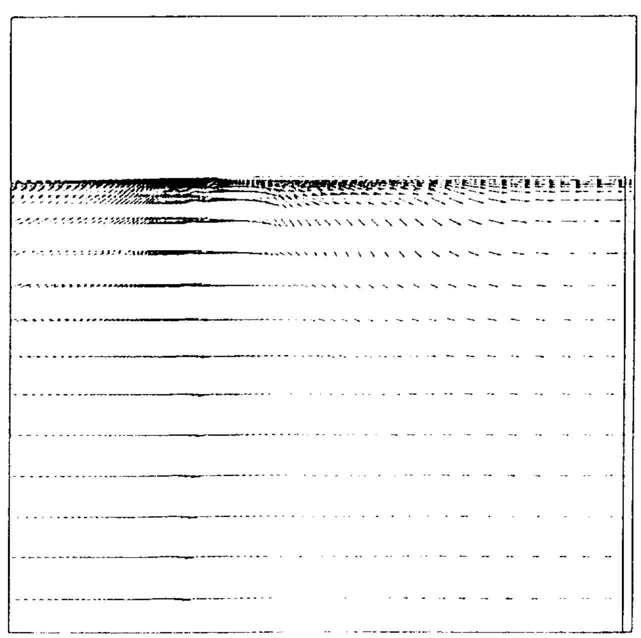
Velocity Vectors Near Tip
(Pressure Side)



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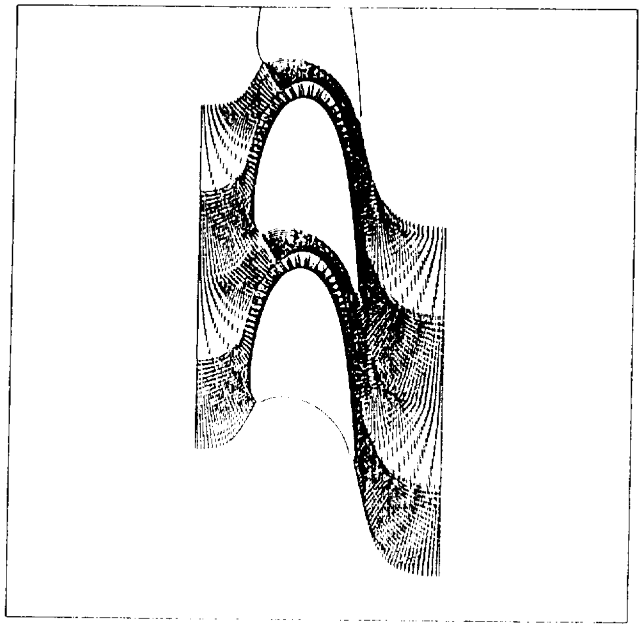
Relative Velocity Vectors Near the Hub



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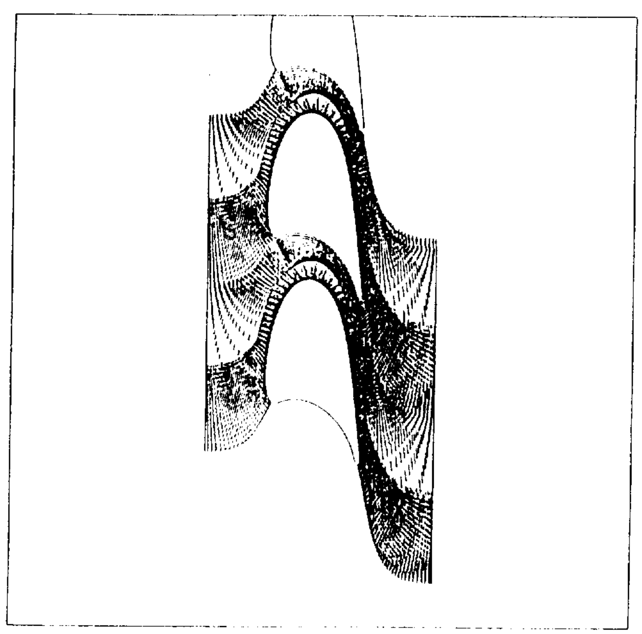
Relative Velocity Vectors Near Midspan



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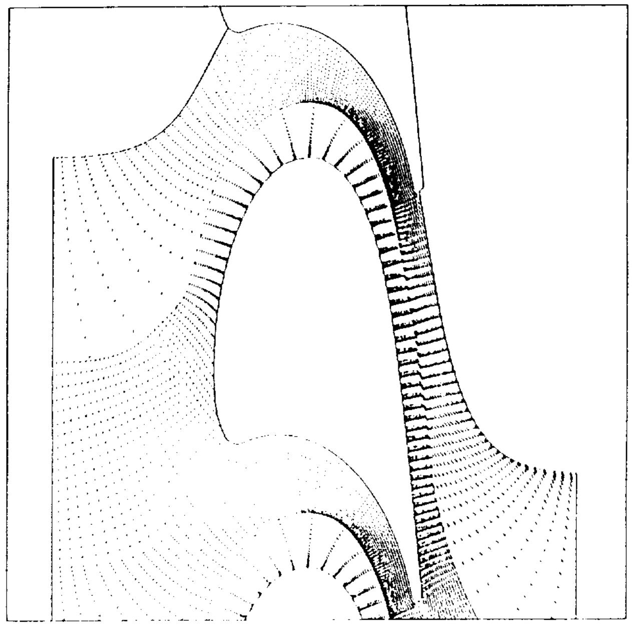
Relative Velocity Vectors Near the 90% Span



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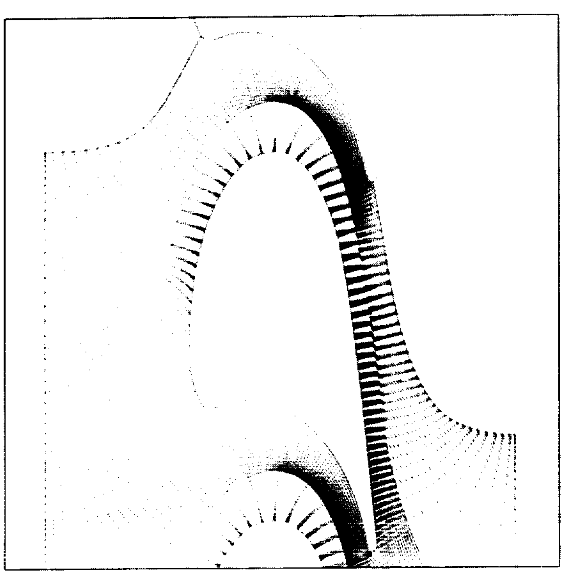
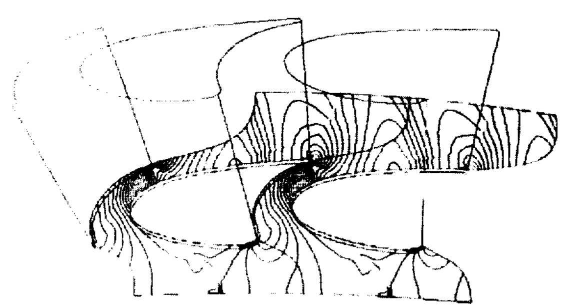
Calculated Velocity Vectors and Pressure





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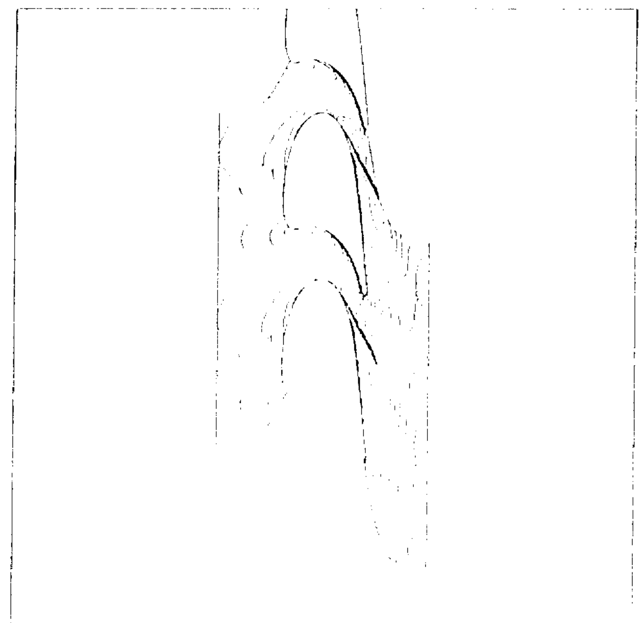
Pressure Contours Inside Blade Passage at 60% of Tip-Clearance Height



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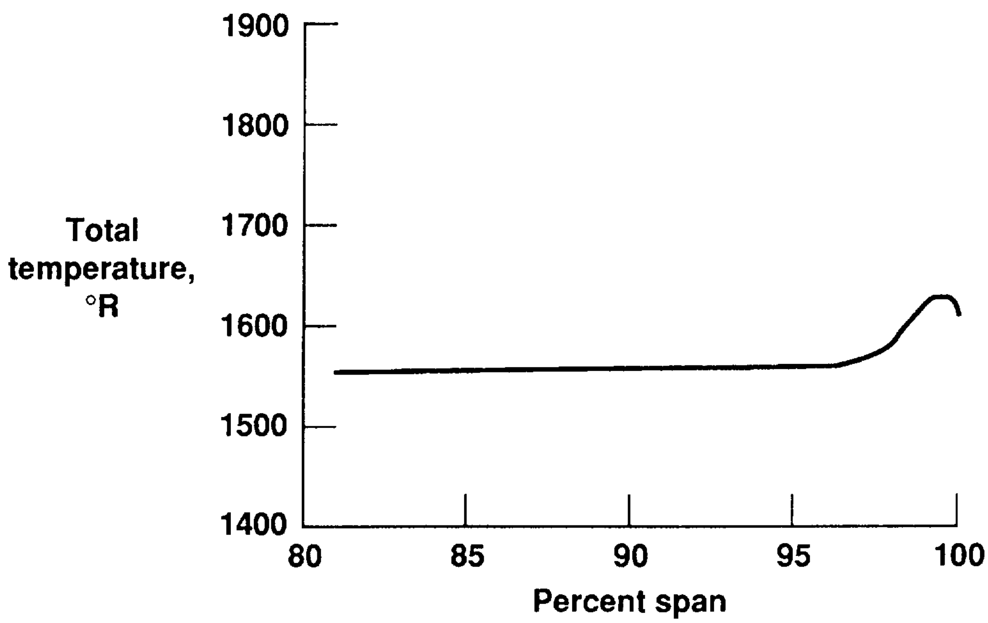
Total Temperature Distribution



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