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MSFC HYDROSTATIC BEARING ACTIVITIES

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The basic approach for analyzing hydrostatic bearing flows at MSFC is three pronged. First, the Hydrostatic Bearing Team has responsibility for assessing and evaluating flow codes, evaluating friction, ignition, and galling effects, evaluating wear, and performing tests. Secondly, the Office of Aerospace and Exploration Technology Turbomachinery Seals Tasks consist of tests and analyses. Thirdly, MSFC in-house analyses utilize one-dimensional bulk-flow codes; computational fluid dynamics (CFD) analysis is used to enhance understanding of bearing flow physics or to perform parametric analyses that are outside the bulk-flow data base. As long as the bulk-flow codes are accurate enough for most needs, they will be utilized accordingly and will be supported by CFD analysis on an as-needed basis.

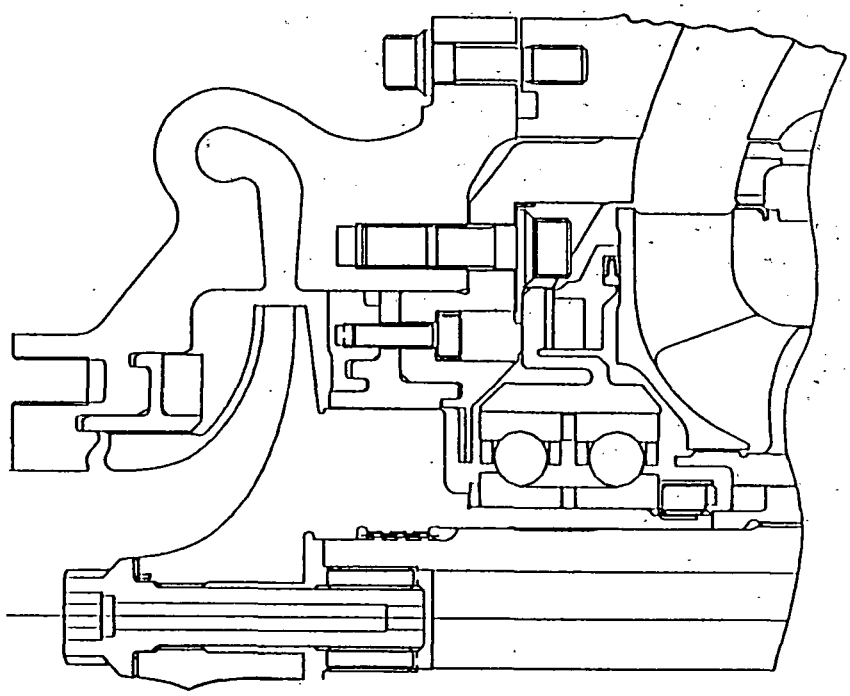
Overview

- Hydrostatic Bearing Team formed 02/16/90
  - Assess and validate flow codes
  - Evaluate friction and ignition effects
  - Evaluate wear and galling effects
  - Verify design by HPOTP pump-end test (Rocketdyne IRAD)
    - TTB in October / November timeframe
- OAET Turbomachinery Seals Tasks
  - Three tasks in place - - E3b, E4e, and LSVT13
  - One task pending - - LSVT8 (NRA)
- In-house CFD analyses
  - Baseline damping seal
    - Code validation
    - Rotordynamic coefficients
  - Baseline hydrostatic seal
    - Flow cavity parameters
    - Flow visualization

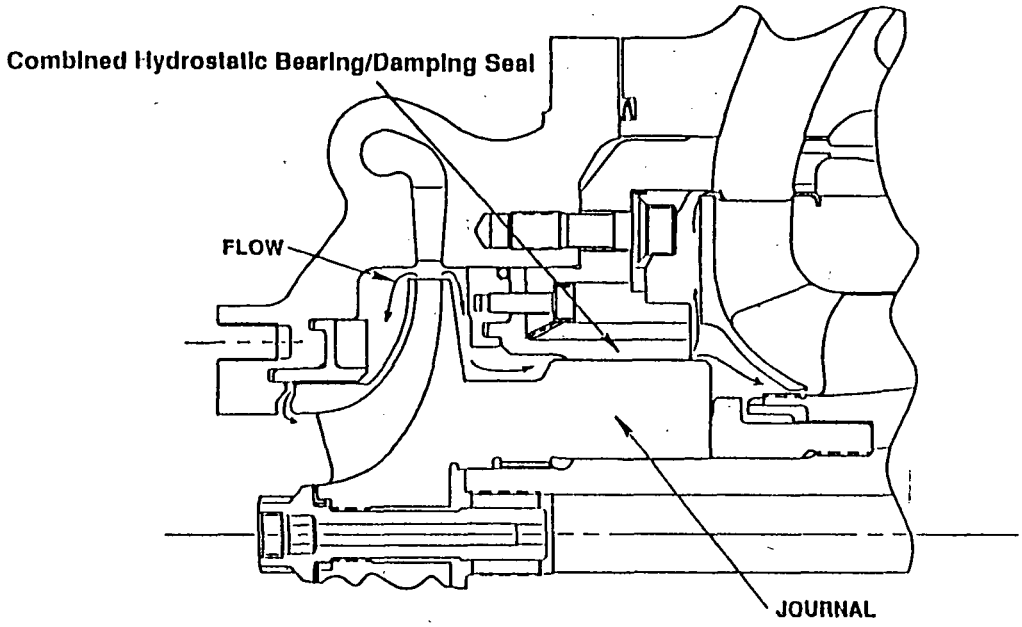
MSFC Turbomachinery Working Group Summary

Work Element Title	Prior	89	90	91	92	93	94	Product
E3e. Damping Seal Rotor Support								Design criteria for rolling element/damping seal assemblies for high side loads; Results led to current TTB validation for HPOTP
E4e. Damping Seals for Turbomachinery								Test verification of dynamic properites of damping seals; Wyle tester; measures rotordynamic coefficient density; Test in progress
LSVT8. Verification of Damping Seal Modeling Techniques								Hydrostatic bearing data base for code validation; NRA contractor TBD
LSVT13. Experimental Verification of Rotordynamic Analysis								Hydrostatic damping bearing data for rotordynamic coefficients; internally and externally fed HPOTP turbine end configuration

Flight Configuration HPOTP
Phase II
Preburner Pump Bearing Package



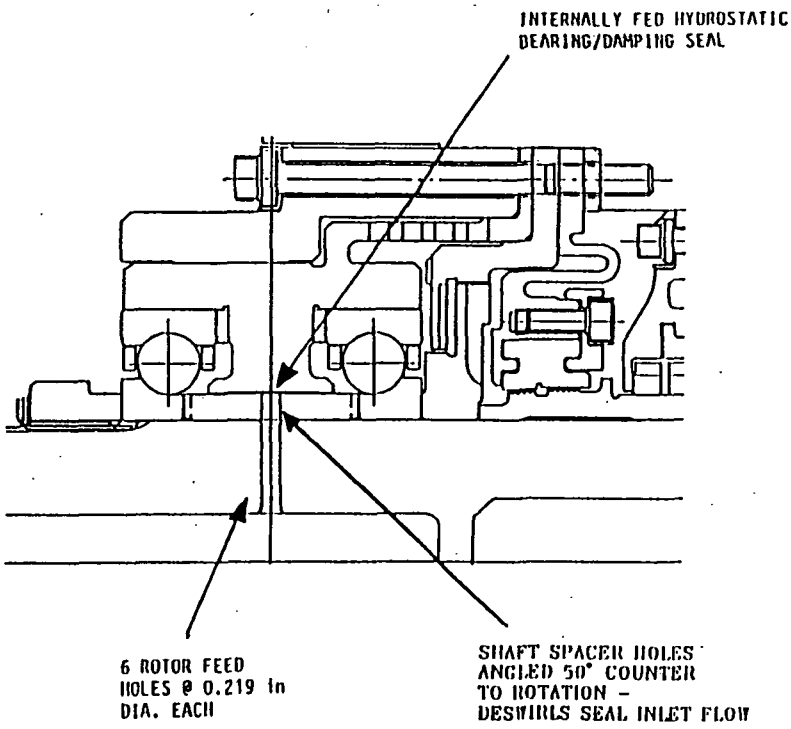
HPOTP Pump End Retrofit
Annular Hydrostatic Bearing
Axially Fed



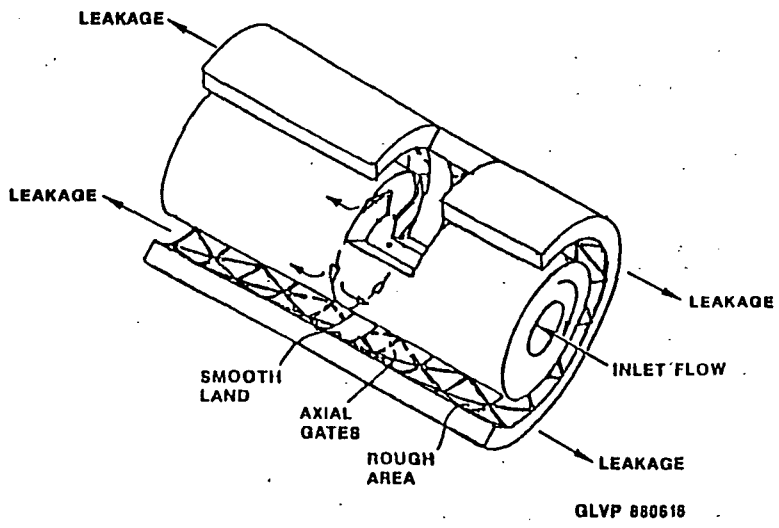
Experimental Verification of Rotordynamic Analysis
MSFC Program Status

- Complementary Damping bearing development initiated in October
  - Verifies rotordynamic coefficient calculations for hydrostatic bearings
- Test four hydrostatic bearings in modified long life tester
  - HCFC test fluid
  - Two bearings internally fed through the shaft
    - Conventional and damping designs TBD
  - Two bearings internally fed through the stator
    - Conventional and damping designs TBD
- Extracts all rotordynamic coefficients
  - Measures leakage and frictional torque
- Conceptually designs new HPOTP turbine end package
  - Includes lowest whirl ratio bearing tested
  - Provides manufacturing estimate

Potential HPOTP Turbine End Hybrid Bearing Retrofit

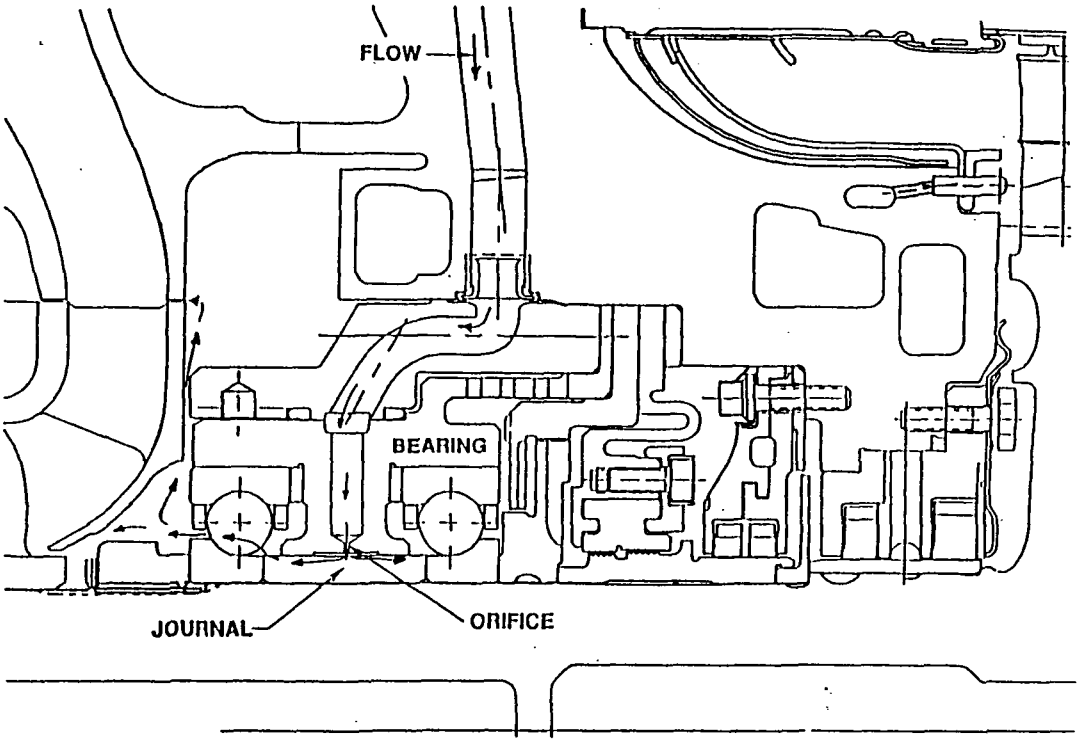


Internally Fed Damping Bearing



- George Von Pragenau, NASA-MSFC, Design Concept

Potential HPOTP Turbine End Hybrid Bearing Retrofit



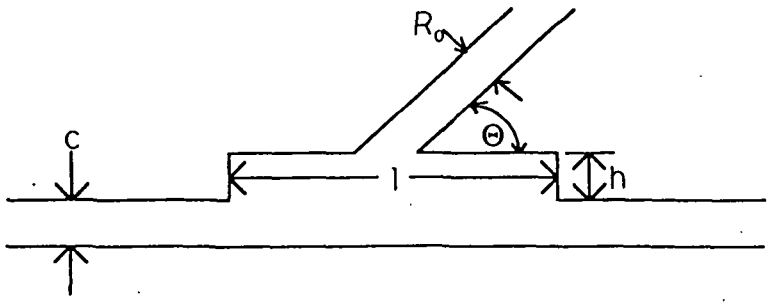
In-house CFD Analysis

- 3-D analysis; 60^0 slice of bearing
- Single-phase incompressible Navier-Stokes analysis; constant - γH_2
- Rotational Reynolds number based on annulus width ~ 4.8×10^4
- Multi-block solution in progress with FDNS3D code
  - 3-dimensional pressure-based finite-difference Navier-Stokes solver
  - PISO algorithm with modified Stone's solver
  - Convection term differencing
    - Central
    - 3^{rd}-order upwind
    - 2^{nd}-order upwind
- K-ε turbulence model
  - Two high-Reynolds-number models
  - Four low-Reynolds-number models

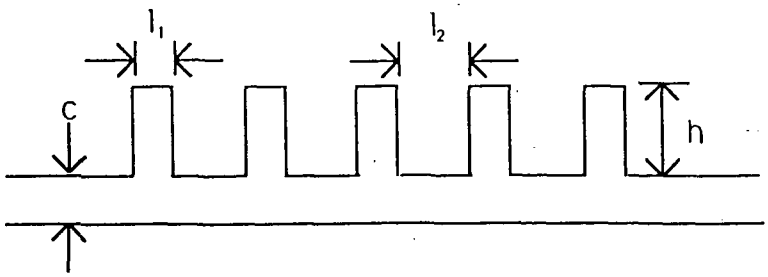
In-House CFD Analysis

Configuration

Baseline Hydrostatic Seal

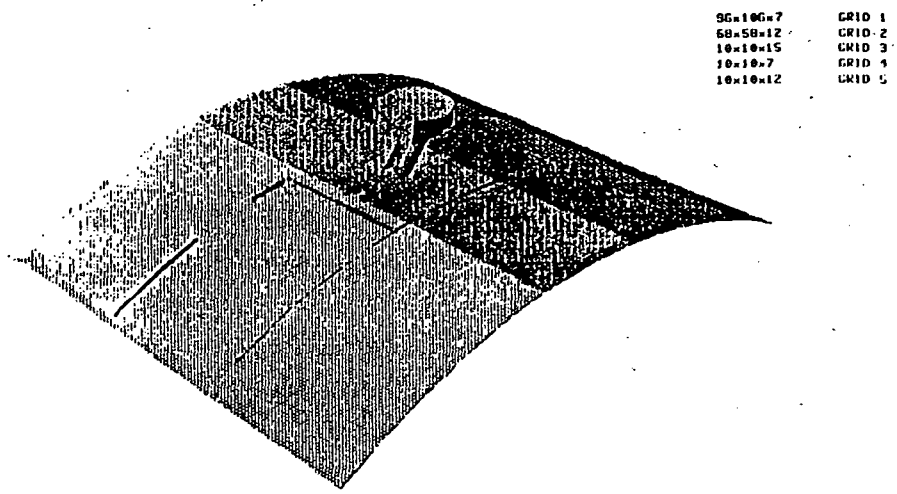


Baseline Damping Seal



In-House CFD Analysis

Typical Grid



Summary

- Hydrostatic Bearing Team meeting regularly with Rocketdyne design organization
  - TTB validation for HPOTP set for October/November 1991 timeframe
- OAET tasks defined
  - Data bases for determining rotordynamic coefficients and flow physics are evolving
- Bulk-flow computer design codes are in place and being extended
  - CFD being applied to support bulk-flow code development for assessing secondary flows in damping seal pockets
- In-house analysis initiated to assess generic flows related to hydrostatic bearings