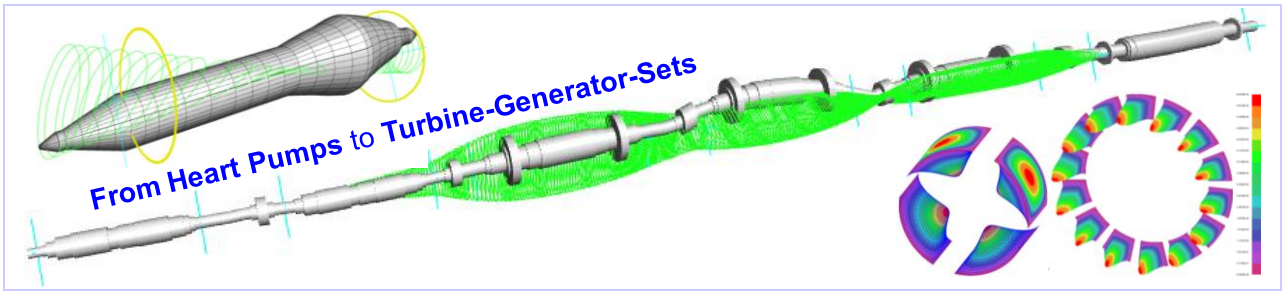
RBTS, Inc.

Rotor Bearing Technology & Software

SKILLED ENGINEERS PROVIDING ADVANCED ROTATING MACHINERY DYNAMICS EXPERTIES & SOFTWARE



1. INTRODUCTION

RBTS offers professional engineering services and software to manufacturers and end users in a diverse range of industries for the analysis of rotating machinery dynamics, bearings, bearing systems, and their structural components. RBTS brings versatile, yet highly specialized perspective to the solution of commonplace as well as unique engineering problems.

An international leader in the design and development of software for rotating machinery dynamics, bearings, bearing systems and seals (**ARMD**), RBTS offers expertise in advanced rotor dynamic technologies. Through its state-of-the-art software and service programs, RBTS provides computer assisted technologies to companies to help them "test" the performance of rotating machinery during development and analyze machine failure in operation. Consulting services are available to supplement computer programs and for highly complex or unique machinery.

A Multi-disciplinary Approach

RBTS principals offer experience in mechanical and structural engineering, rotor dynamics, torsional vibration, seals and bearing systems dating back to the 1950's. Senior consultants from other highly specialized engineering disciplines also work with the firm. Together, the RBTS network provides the most comprehensive engineering expertise available.

RBTS takes an integrated approach to problem solving, analyzing the entire project to determine the impact of each component. The collective expertise of the firm's professionals means that clients receive both general and specialized consultation.

Comprehensive, Specialized Engineering Services

RBTS offers engineering services in;

- Rotating machinery dynamics (Rotor Dynamics & Torsional Vibration)
- Fluid-film bearings & bearing systems
- Rolling element bearings and systems
- Seals
- Finite element stress and dynamic analyses
- Field measurement & analysis (Vibration, Strain, Modal & Balancing) service
- Design audit and failure analysis
- Technology Transfer & Training

Comprehensive technical services - mechanical/structural analysis, design and development, and failure and safety studies - are available through RBTS. The firm's

professionals also serve as troubleshooters and expert witnesses on a broad range of engineering-related issues.

Sample industries served include;

- Aerospace
- Automotive
- Chemical & Petrochemical
- Machine Tools
- Medical
- Mining & Ore Processing
- Oil & Gas Production & Distribution
- Power (Fossil, Hydro, Nuclear)

Tailored Consulting Arrangements

RBTS engineers are available for both short and long term consulting assignments. Arrangements are flexible and fees (rates) are competitive. Prior to beginning work, RBTS provides each of its clients with a detailed project schedule and estimate of costs.

From comprehensive project management to specific problem solving to software packages, RBTS technical experts stand ready to work with you to develop an individually tailored, cost-effective plan to meet your specific problems. ***Contact RBTS to learn how they can help with your engineering needs***.

Using state-of-the-art technologies, RBTS has established a successful record of providing various manufacturers with custom made software packages tailored to address specific aspects of their products. This unique service enables manufacturers to optimize cost and performance of their products, thereby, helping them to sustain a leading edge over their competitors.

Immediate Response to Customer Needs

RBTS prides itself on its expeditious response to customer needs for emergency engineering services. RBTS' team of experts will work closely with its customers and can be readily available at the job site when and as needed.

2. MECHANICAL ENGINEERING SERVICES

The dynamics of rotating machinery and their support bearings are a specialty of the firm. RBTS specialists offer the following consulting services:

Vibration Analysis

- Lateral, Torsional, Axial
- Damped Critical Speeds
- Undamped Critical Speeds
- Unbalanced Response
- Time Transient Response
- Stability and Mode Shapes

Bearings and Seals

- Journal and Thrust Bearings
- Conical Bearings
- Hydrodynamic, Hydrostatic & Hybrid
- Laminar and Turbulent
- Mechanical Face Seals
- Oil, Gas, Water and Process Fluid

Field Measurements & Failure Analysis

- Testing and Analysis including Vibration, Strain, Modal & Balancing
- Evaluation of Troublesome Machinery & Corrective Actions

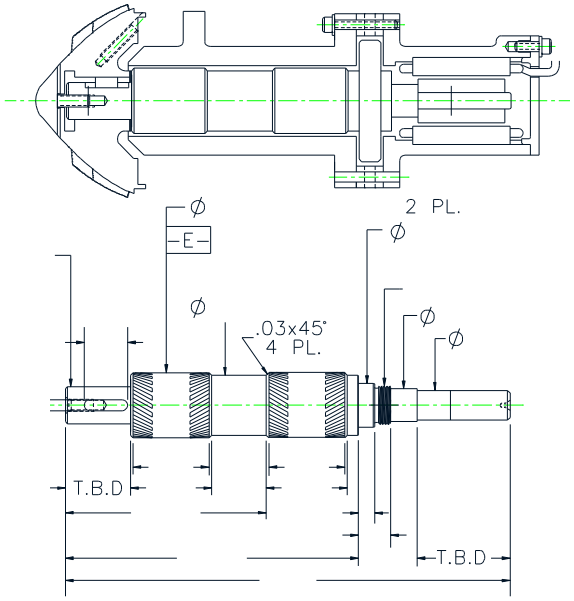
Design Audits

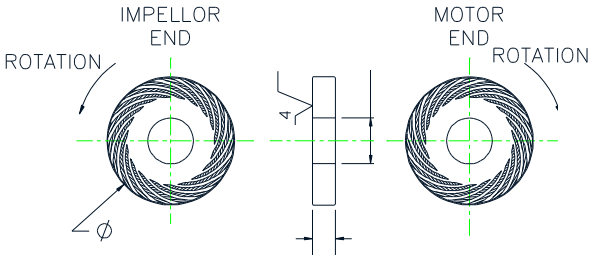
Tailored Packages to Meet Specific Applications

- Quantification of product performance
- Determination of product reliability
- Development of fatigue profiles of components

RBTS designed, built and prototype tested;

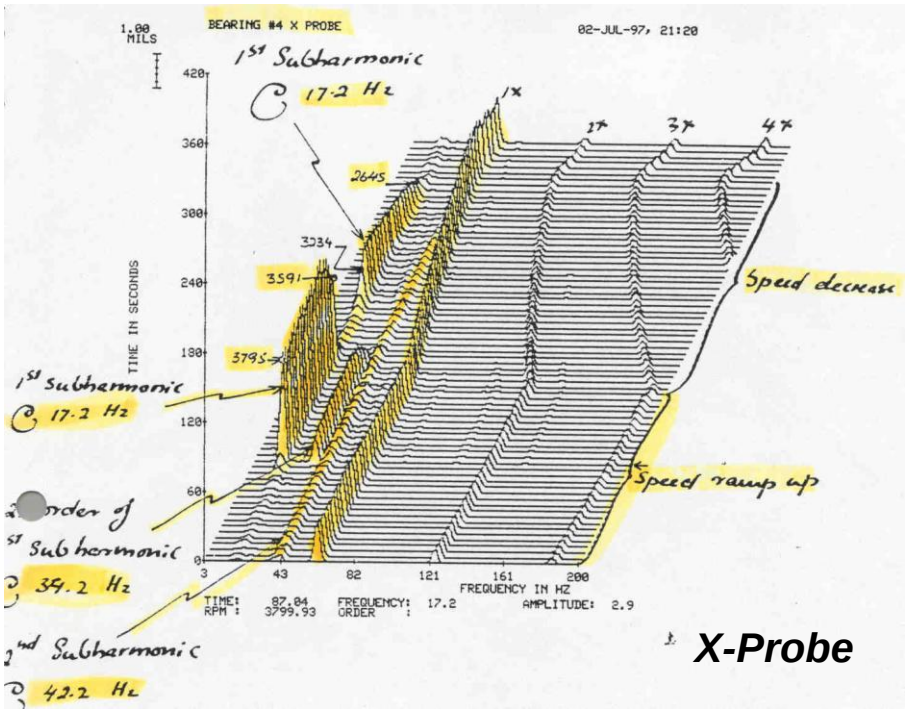
Blood Pump (LVAD) for Human Heart.





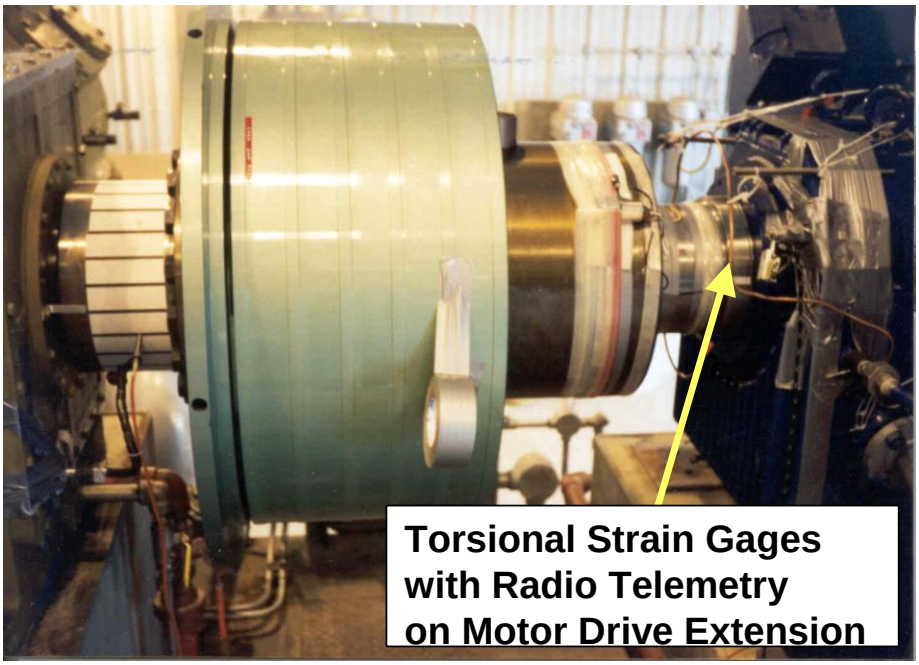
Air Bearing Spindle for Aerospace Application.

Large Steam Turbine Generator Set Sub-Synchronous Vibration Problem
Vibration Measurement, Rotor-Bearing Dynamic Modeling & Analysis
Produced Cost Effective Solution

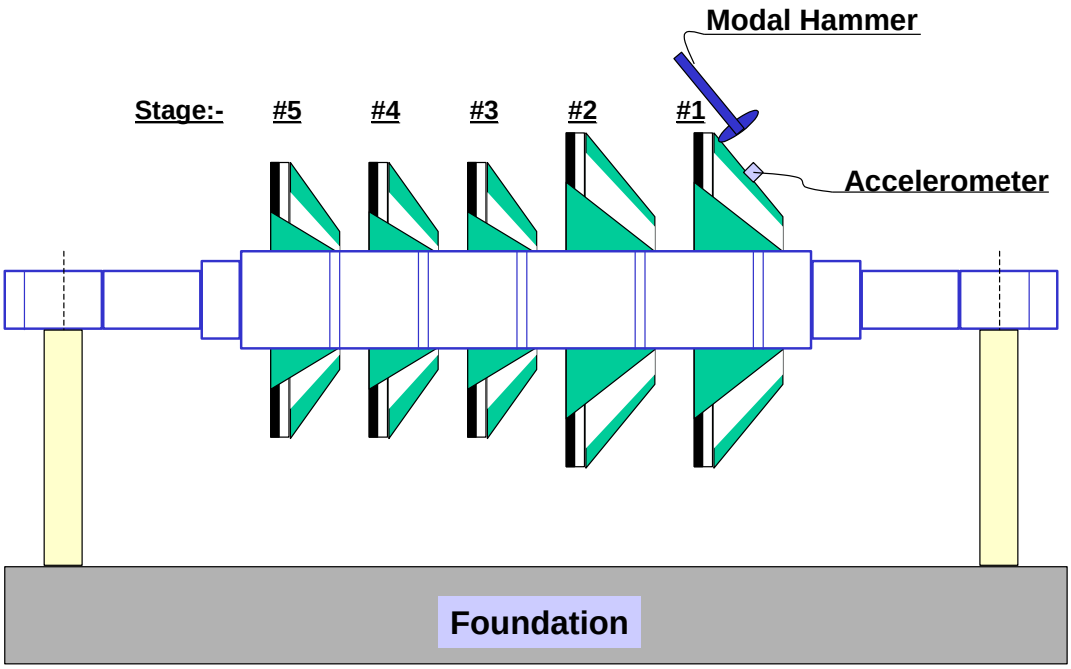


UNIT 2 INSTABILITY @ BEARING # 4 AFTER OVERHAUL

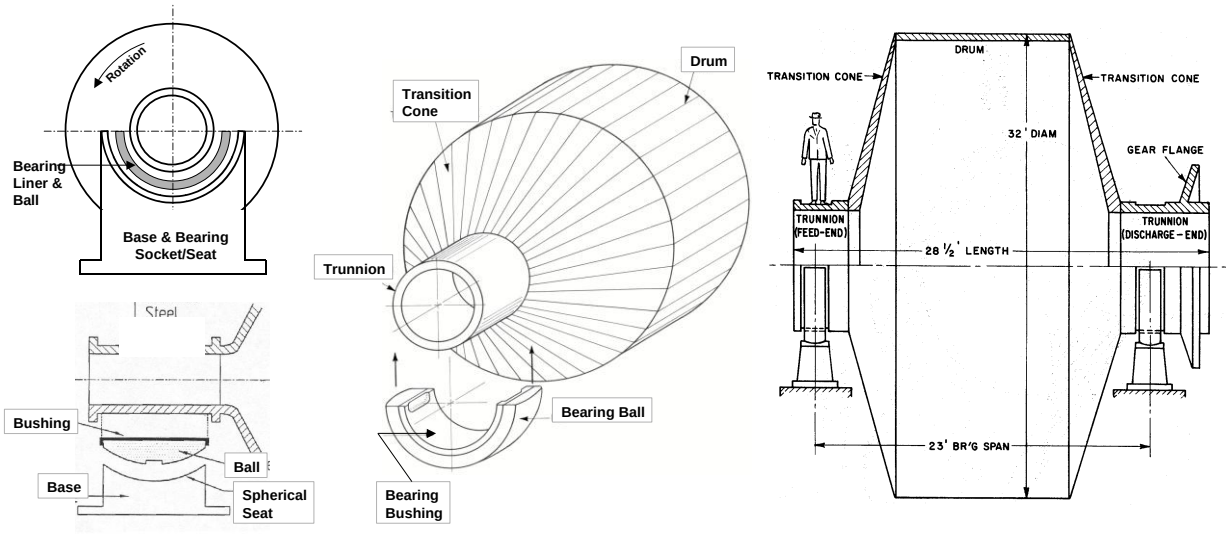
Strain Gage (Torsional) Measurements of Motor Driven Compressor.



Modal Testing Of Impeller In A High Speed Centrifugal Compressor



Mil Structure & Bearings – Design, Analysis, and Troubleshooting



Detailed information is not given above due to confidentiality.
Please call RBTS to discuss technical capabilities and how RBTS can help you.

3. MECHANICAL ENGINEERING SOFTWARE

RBTS provides the most advanced programs on rotor dynamics, torsional vibration, and bearings available today in its **ARMD** software package. ARMD programs include:

Rotor Dynamics
- Critical Speed and Stability
- Unbalance Response
- Time Transient Response

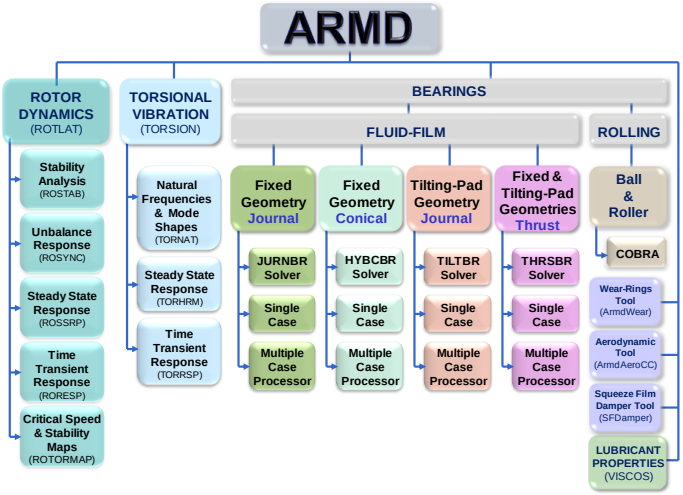
Torsional Vibration
- Critical Speed and Stability
- Steady State Response
- Time Transient Response

Bearings
- Tilting Pad
- Fixed Pad
- Journal
- Thrust
- Conical
- Rolling Element

Seals
- Mechanical Face
- Floating Ring
- Gas Seals

Lubricant Analysis
Temperature dependent properties of lubricant fluids

RBTS programs run on Windows based computers under various operating systems. All programs use state-of-the-art theories and numerical methods, and are designed to be readily expanded.



A comprehensive service program is included with all software sales. Support services include training sessions on program theory, implementation, modeling techniques and results interpretation. All programs are accompanied by a manual and RBTS professionals provide a full year of support to ensure full integration of programs.

Remember, with RBTS, you get more than just the programs, you get the company with more than 50 years of experience.

4. STRUCTURAL ENGINEERING SERVICES

Structural engineering consulting services available through RBTS include:

Finite Element Analysis
- Static
- Dynamic
- Thermal
- Linear and Nonlinear

Structural Analysis, Design and Evaluation

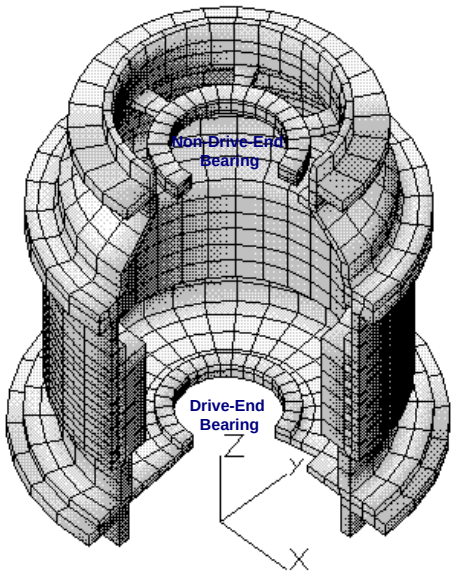
Failure and Safety Analysis
- Fatigue Life Evaluation
- Failure Causes and Modes
- Safety Margins Determination

Analysis of Composite Materials
- Layered Composites
- Advanced Composites

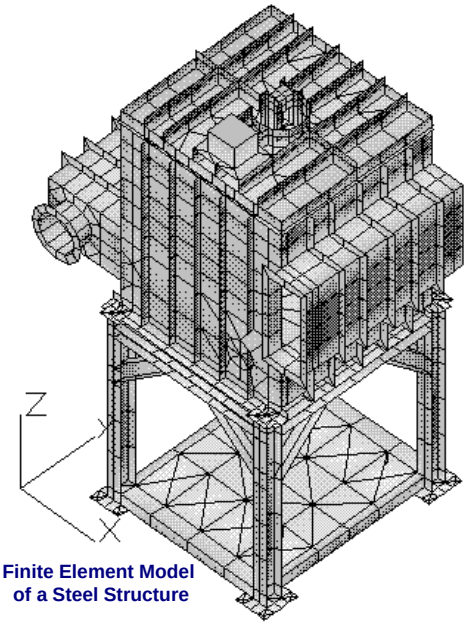
Structural Cost/Benefit and Reliability
- Cost/Benefit Design Optimization
- Reliability of Structures and Components

Field Support Services
- Performance Monitoring and Evaluation
- Field and Laboratory Testing

Design Audits

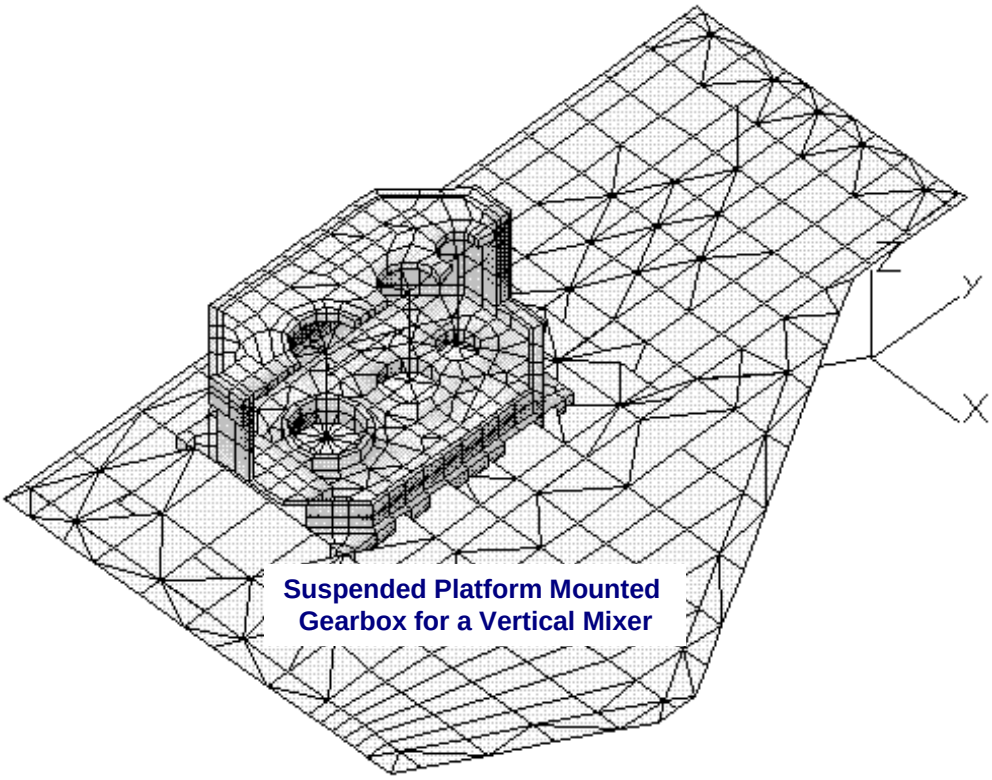


Finite Element Model of a Generator Housing for Aerospace Application



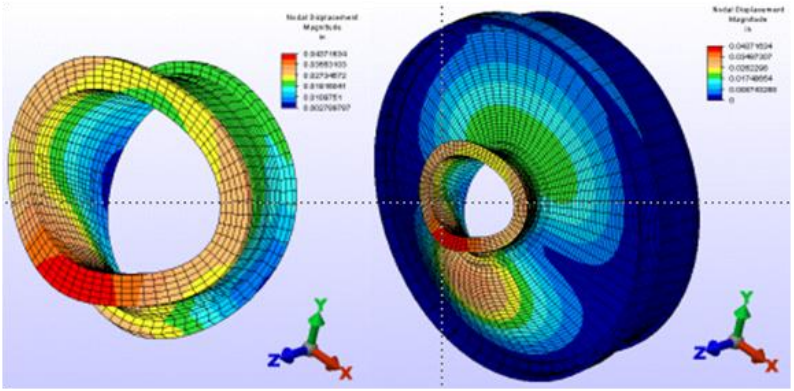
Finite Element Model of a Steel Structure

Large Size Mixer/Agitator Suspended Gearbox Failure Analysis & Solution By Optimized Effective Structural Modifications



Suspended Platform Mounted Gearbox for a Vertical Mixer

Grinding Mil Structural Modeling And Deformation Analysis To Evaluate Structural Deformation Effects On Bearing Performance And Failure



5. A PROVEN RECORD OF SUCCESS

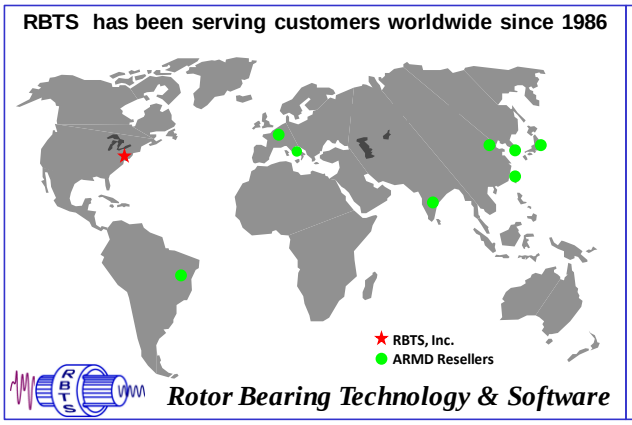
From the design of components for NASA's space shuttle and space station, to the solution of an elusive vibration problem in a large rotating machine and supporting structure, and to the development of water and blood lubricated bearings for a miniature pump used for an artificial heart, RBTS has a proven record of innovative, reliable services.

The firm provides consulting services to international conglomerates, government agencies, small businesses and other consulting firms. RBTS clients include:

Allied Signal, Alstom, Ariel, Borg Warner, Celanese, Dresser-Rand, ExxonMobil, Federal Mogul Corporation, Ford Motor Company, Framatome ANP, General Electric, Hamilton Sundstrand, Ideal Electric, Ingersoll Milling, MSB Technology, Philadelphia Gear, Rockwell Automation, Shell, Siemens-DeMag, Solar Turbines, Spencer Turbine, Stein Industrie, Trane, Teleflex, United Technologies, US Steel, Westinghouse, York International, and many many more.

Results oriented and responsive. Dedicated and dynamic. RBTS characteristics when added to its multi-disciplined, highly experienced approach result in long-term relationships with the clients it serves.

RBTS is pleased to share references, published papers and case studies relating to its services and software programs.



ADVANTAGES

- Experience in Diverse Engineering Systems
- Wide ranging Capabilities
- State-of-the-Art Technology
- Independent, Unbiased Consultation
- Competitive Rates
- Responsive to Customer Needs
- Accurate and Comprehensive Reporting
- Proven Reputable Engineering Services

6. RBTS SEMINARS

RBTS offers a seminar in the area of bearings and machinery dynamics annually. It is a technology transfer seminar based on many years of experience. The seminar, "*FLUID-FILM/ROLLING-ELEMENT BEARING TECHNOLOGIES & ROTORDYNAMICS INTERACTION*", is typically offered in the spring.

An optional on-site technology transfer and training session is also available to RBTS customers. The technology transfer and orientation session covers software theory and application, bearings and rotor/bearing systems dynamics, and interpretation of the results generated by ARMD software. ***The session can be tailored to address client-specific equipment and needs***.

About The Annual Seminar

This course is designed for engineers and technical managers who are involved in rotating machinery design, operation, maintenance, diagnostics, and trouble shooting, with emphasis on bearing systems that support, guide, and locate the rotating assembly, machinery rotor dynamics, and drive train torsional vibration.

The course will focus on bearings, the vital tribological element of rotating machinery, beginning with their fundamental principles of operation through computer-implemented evaluations of their operational performance characteristics and limitations. Design considerations and applications of fluid-film and rolling element bearings will be discussed along with the presentation of numerous real life case histories to illustrate the technology and its application to rotating machinery failure analysis and troubleshooting of common, as well as, unique vibration problems.

The interacting influence of bearings on the dynamic behavior (rotor dynamics) of machinery will be reviewed and illustrated by the construction of analytical models, and evaluated by computerized solutions. Participants are encouraged to present problems to be discussed. Informal technical sessions and workshops are intended to provide participants with adequate time to describe problems they have encountered in BEARINGS, BEARING SYSTEMS, ROTOR DYNAMICS, and TORSIONAL VIBRATION.

The ARMD "Advanced Rotating Machinery Dynamics" software will be available at the course for problem solving, and for the application of state-of-the-art computer-aided engineering of bearings and rotor dynamics. Participants will have access to RBTS' popular software package ARMD™.

Typical Seminar Schedules

ROTATING MACHINERY DYNAMICS SEMINAR

Time	Day 1	Day 2	Day 3
8:00 a.m. 8:30 a.m.	**INTRODUCTION** **Basics Of Machinery Vibration** ➢**Vibration Theory** Single mass system Planar vibration ➢**Response & Shaft Dynamics** Displacement, velocity & acceleration amplitude & phase ➢**Controlling Mechanisms** **Forces In Rotating Equipment** Bearings, Cavitation, Imbalance, Hydraulic, Aerodynamic	**Fluid-Film Bearing Types And Applications** ➢Fixed & tilting pad geometries ➢Journal, Thrust & Conical ➢Hydrodynamic, hydrostatic & hybrid modes of lubrication **Rolling Element Bearings** ➢Fundamentals ➢Application Design ➢Systems Evaluation ➢Computer-Aided Design & Analysis	**Rotor Dynamics & Torsional Vibration Detailed Cases** ➢Step-by-step rotor-bearing system modeling, analysis, and problem solution. ➢Bearing interaction with the rotating assembly, oil-whirl/whip phenomena's, rotor-bearing response, and stability illustrations. ➢Torsional modeling and analysis of drive trains illustrated by presentation and solution of problems associated with synchronous/induction motor
Noon	Lunch	Lunch	Lunch
1.00 p.m.	**Fluid-Film Bearings** ➢Fundamentals ➢Application Design ➢Modes of Lubrication ➢System Evaluation ➢Computer Aided Design ➢Lubricant Temperature Dependent Properties & Effects	**Rotor Dynamics & Torsional Vib. Introduction & Application** ➢**Basics** of Rotor Dynamics ➢**Modeling**: Shafts, Disks, Bearings, Couplings, Seals, Housing, etc. ➢**Analysis:** Damped & Undamped Rotor Stability, Natural Frequencies, Mode Shapes, Stability & Critical Speed Maps, and Response	startup transients and reciprocating equipment steady state operation. **State-of-the-art Technology Presentation & Demonstration** ➢Advanced Technology Presentation & Demonstration ➢Summary of Course Content and Application of Rotating Machinery Dynamics Technologies
4.00 p.m.	**Workshop** ➢Hands-on operation ➢Group presentation/discussion	**Workshop** ➢Hands-on operation ➢Group presentation/discussion	**Workshop** ➢Participants' systems ➢Group discussion

*To view seminar brochures **press/click** in the below right or left box*

Annual – National Seminar (4-Days)

FLUID-FILM / ROLLING ELEMENT BEARING TECHNOLOGIES AND ROTORDYNAMIC INTERACTIONS

Offered during the month of May

Annual – International Seminar (4-Days)

ROTATING MACHINERY DYNAMICS

Rotor Dynamics & Bearings Technologies
Lateral & Torsional Vibration Analysis / Fluid-Film Bearings

Offered during the month of October in **Cologne (Koln) Germany**

Tailored to Client Needs – Technology Transfer & Software Training Seminars in the Fields of:

- **Fluid-film Bearings & Bearings Systems**
- **Rolling Element Bearings**
- **Rotor Dynamics / Lateral Vibration**
- **Torsional Vibration of Mechanical Drive Systems**