COMPETENCIES AND SERVICES FOR THE DEVELOPMENT AND OPTIMIZATION OF ROTOR BEARING SYSTEMS WITH MAIN FOCUS ON AERODYNAMIC GAS BEARINGS

SADAP

ADAPTIVE SOLUTIONS

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KNOWLEDGE SHINES

AERODYNAMIC FOIL-BEARING TECHNOLOGY

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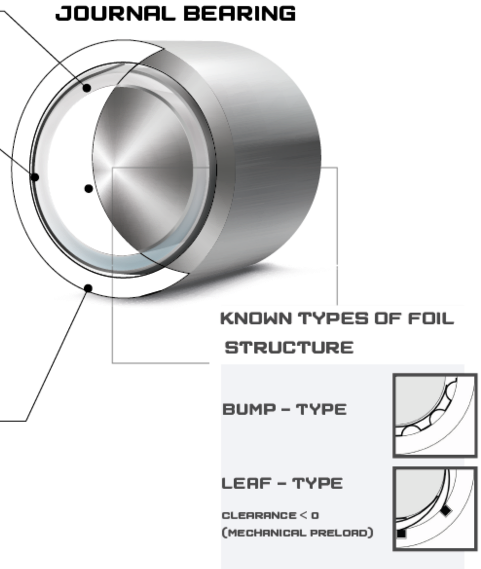
AIR AS LUBRICANT
without external pressure supply.

COMPLIANT FOIL
- More flexibility against deformation of the journal due to mechanical and thermal stresses.
- additional damping mechanism for more stability

BEARING JOURNAL
Rotating part

HOUSING
Stationary part



PRINCIPLE OF LUBRICATION
The hydrodynamic pressure build-up counteracts the weight of the rotating part and enables frictionless operation after lift-off.

FIELDS OF APPLICATION
Light rotors in: Automotive industry (fuel cells), power engineering, aerospace, medical technology, textile industry, etc.

BENEFIT
Non polluting since no oil is used for the lubrication
Minimum sensitivity to operating temperatures
No external pressure supply is required
Stable operation up to high speeds (above 100 krpm)

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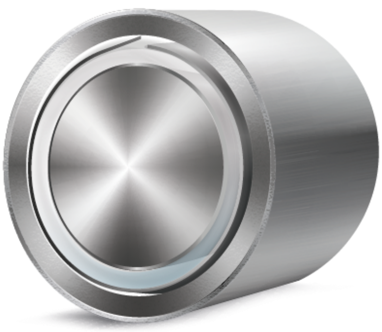
OUR SERVICES AND PRODUCTS BASED ON SIMULATIONS

Modern numerical tools for the bearing calculation in e. g. turbomachinery under consideration of the different static and dynamic properties, with the aim of:



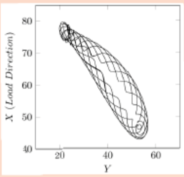
DEVELOPEMENT AND DIMENSIONING:

Load capacity
Static and dynamic stiffnesses and dampings
Journal orbits and motion errors
Waterfall diagrams to spot the self-excited motions

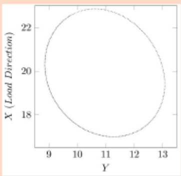
DIAGNOSES AND OPTIMIZATIONS:

Manufacturing uncertainities
Optimization with regard to wear problems
Improvement of load capacity
Improvement of stability

WHIRL MOTIONS

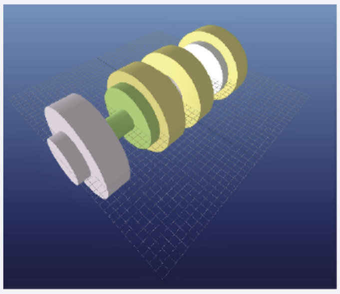


SMOOTH MOTIONS



FURTHER STEPS OF ANALYSIS CONSIDERING THE ROTATING SHAFTS SUPPORTED BY BEARINGS TO IDENTIFY THE POSSIBLE RESONANCES AND THE VIBRATIONAL AMPLITUDE, USING:

ROTORDYNAMIC



- Critical speed map
  Stability analysis
  Amplitude of shaft‘s displacements
  Modal analysis

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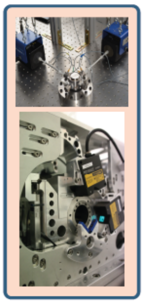
ANALYSIS AND DEVELOPEMENT BASED ON EXPERIMENT



SADAP SUPPORTS CUSTOMERS WITH VARIOUS READY-TO-USE TEST RIGS TO VALIDATE THE NUMERICAL MODELS USED FOR THE DEVELOPMENTS, OPTIMIZATIONS AND ANALYSES TAKING INTO ACCOUNT DIFFERENT OPERATING CONDITIONS, IN ORDER TO TARGET THE SPECIFIC CHARACTERISTICS OF THE ROTOR-BEARING SYSTEM, INCLUDING:

- LIFT-OFF BEHAVIOR (USING A LOW SPEED TEST RIG FOR OPERATION UP TO 30 KRPM)
  COEFFICIENTS OF FRICTION WITH REGARD TO THE WEAR PROBLEMS
  JOURNAL ORBITS TO EXTRACT THE WHIRL FREQUENCIES AND MOTION ERRORS
  STIFFNESS AND DAMPING CHARACTERISTICS IN OPERATION (BOTH STATIC AND DYNAMIC FOR SMALL AND LARGE AMPLITUDES OF EXTERNAL EXCITATIONS)
- FREQUENCY-DEPENDENT DYNAMIC COEFFICIENTS OF THE FOIL STRUCTURE OUT OF OPERATION (FOR COMPLIANT BEARINGS)

ANALYSES BASED ON NUMERICAL AND EXPERIMENTAL TOOLS FOR:

- Herringbone bearing (Air)
  Tilting - Pad bearing (Air)
  Bump - Foil bearing (Foil)
  Leaf (Garret) - Type bearing (Foil)
  Aerostatic bearings with external pressurization (Air)

AIR GAR FOI BMF

And any exceptional type of compliant and noncompliant gas lubricated bearings

TYPES OF BEARING SADAP CAN OFFER TECHNICAL SERVICES FOR, WITHIN THE FRAMEWORK OF CUSTOMER DEFINED PROJECTS:

- Hydrodynamic oil-bearings
  Magnetic bearings
  Ball bearings
  Cylindrical roller bearings

MAG OIL BAL

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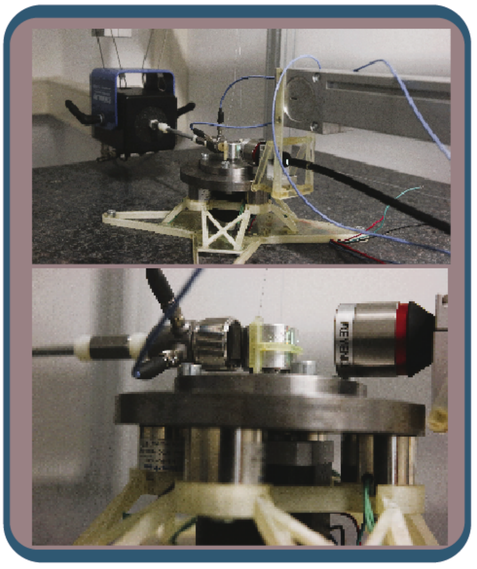
MECHANICAL IMPEDANCE MEASUREMENT

The mechanical impedance test evaluates the mechanical properties of systems or components, particularly in engineering and vibration analysis. By measuring the response of compliant foil structures in foil bearings to applied forces or vibrations, it identifies key dynamic characteristics such as stiffness and damping across various frequency and force ranges.



SETUP CONDITIONS:
Frequency, direction, and magnitude of both applied force and measured displacements (point and transfer impedance).

PARAMETERS MEASURED: Force, acceleration, and displacement.

RESULTS AFTER DATA POST-PROCESSING:
Blocking frequencies (where no compliance in the foil structure occurs), stiffness, damping, and structural loss factor.

TEST ARRANGEMENT: deflection sensor (keyence CI-3000), Shaker(K2007E01 PCB Piezotronics Inc., Depew, NY, USA), impedance heads (288D01 PCB Piezotronics Inc., Depew, NY, USA)

FREQUENCY:	0 TO 5000 HZ
NORMAL LOAD:	UP TO 67 N
RESOLUTION:	0.4 MIKRONS FOR DEFLECTION MESSUREMENTS
SENSITIVIT IMPEDANCE HEAD:	22,4 MV/N (FORCE), ±490,5 M/S^2 (ACCELERATION)

PREPARATION:
Mount the foil bearing in a test fixture Attach vibration exciter and impedance head Connect measurement equipment (e.g., dynamic signal analyzer)

EXCITATION:
Apply sinusoidal force over a range of frequencies Maintain constant force amplitude across frequency range

DATA ACQUISITION:
Measure input force and resulting bearing displacement Record data at each frequency point

IMPEDANCE CALCULATION:
Compute the ratio of force to velocity at each frequency Plot impedance magnitude and phase vs. frequency

ANALYSIS AND REPORTING:
Identify resonance frequencies and damping characteristics Compare results to design specifications
Generate impedance curves and key performance metrics
Summarize findings for quality control or design optimization

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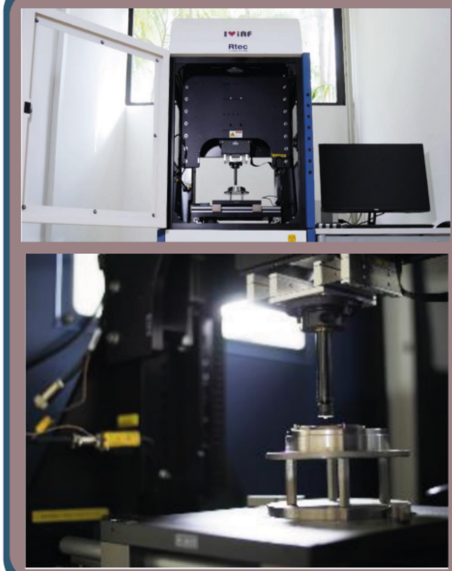
AIR-CONDITIONED TRIBOMETER (IN COLLABORATION WITH TU BRAUNSCHWEIG)

A tribometer is a machine used to perform tests of wear, friction and lubrication that underlies tribology. Conducting tests using tribometers is particularly effective in investigating the friction pairing of coated surfaces in bearings.



PARAMETERS MEASURED: Friction force, Wear rate, Temperature at contact point, Humidity in test chamber, Rotational speed Normal load

RESULTS AFTER DATA POST-PROCESSING:
Coefficient of friction vs. time/distance, Wear volume/rate, Specific wear rate, Stribeck curves (friction vs. lubrication regime), Temperature evolution at contact point, Wear mechanism analysis (requires additional microscopy)

TEST ARRANGEMENT: pin-disk, ball-disk, ring-blocks (rotatory/oscillatory)

HUMIDITY:	3% TO 95%
TEMPRETURE:	-40 TO 400 °C
NORMAL LOAD:	UP TO 50 N
SPEED:	0.1 - 8000 RPM (PIN-DISK), 0.1 - 5000 RPM (RING-BLOCK)

SAMPLE PREPARATION:
Clean and prepare test specimens (pin, ball, disk, or ring-block) Measure and record initial surface roughness and dimensions

TEST SETUP:
Mount specimens in the chosen configuration (pin-disk, ball-disk, or ring-block) Set environmental parameters (temperature and humidity) Configure normal load and speed settings

SYSTEM CALIBRATION:
Calibrate force sensors and displacement transducers Verify temperature and humidity control systems

TEST EXECUTION:
Start rotation/oscillation at predetermined speed Apply set normal load Begin data acquisition (friction force, wear, temperature)

ENVIRONMENTAL CONTROL:
Monitor and maintain set temperature and humidity throughout the test Adjust as necessary to maintain stable conditions

DATA ACQUISITION:
Continuously record friction force, wear displacement, temperature, and rotational speed Monitor test progress and ensure stable operation