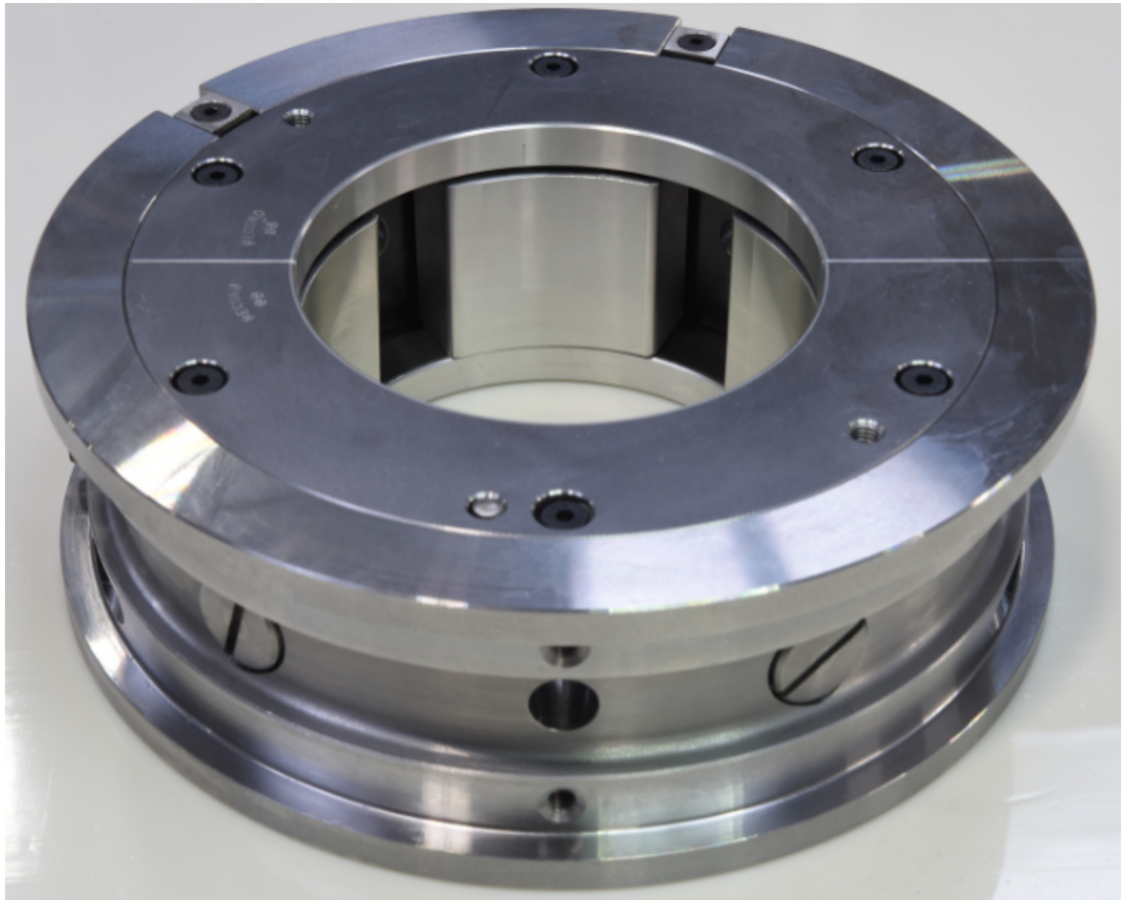
Bearings development and manufacturing

Baker Hughes bearings development program



Objective

Improve performance

- Higher load
- Higher speed

Effective design to decrease pad temperature

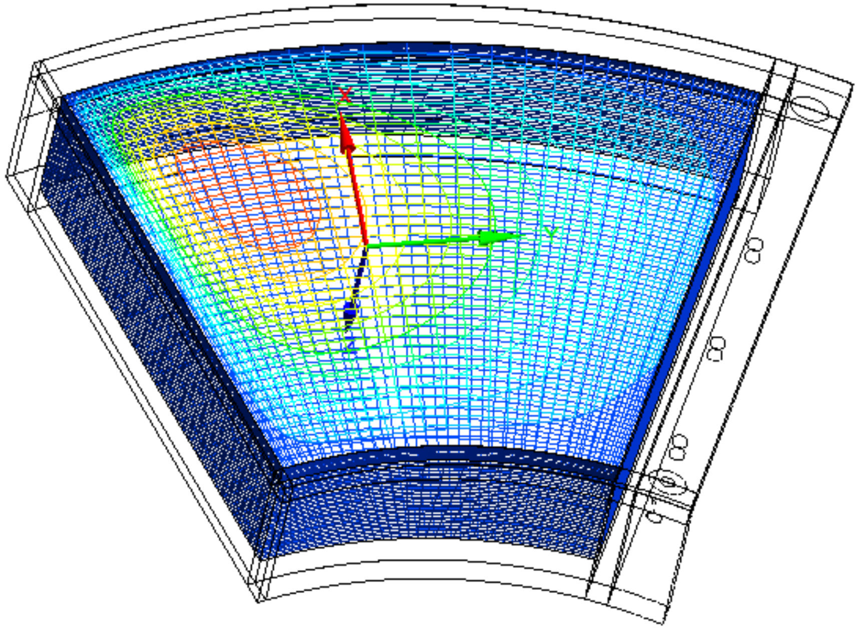
Optimal bearing reliability and performance prediction

Decrease oil flow consumption

Baker Hughes

Optimal solutions

- Improved reliability
- Optimal oil consumption
- Reduced temperature and stress
- Increased time between maintenance cycles
- Simple installation and replacement without shaft removal
- Highest quality finishes and precise tolerances
- Integrated instrumentation
- Greater performance prediction
- Additive manufacturing capability



Including

Lufkin Gears
a Baker Hughes business

gear and bearings technologies

Baker Hughes journal bearings can support a load of 270 tons with an oil film as thin as ¼ of a human hair.

Baker Hughes

Advanced modeling

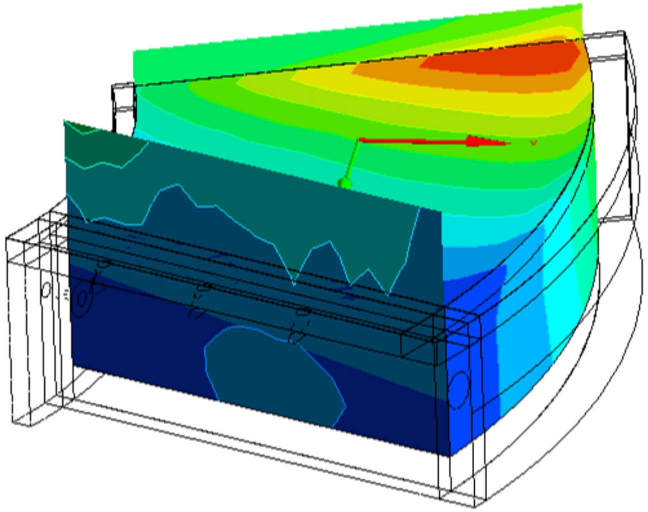
Bearing selection and detailed design are conducted using thermo-fluid dynamic simulations. Oil supply and bearing geometry are CFD modelled to ensure minimum oil flow and best thermal management. Results are validated by test rig in collaboration with our Advanced Sensor Lab.

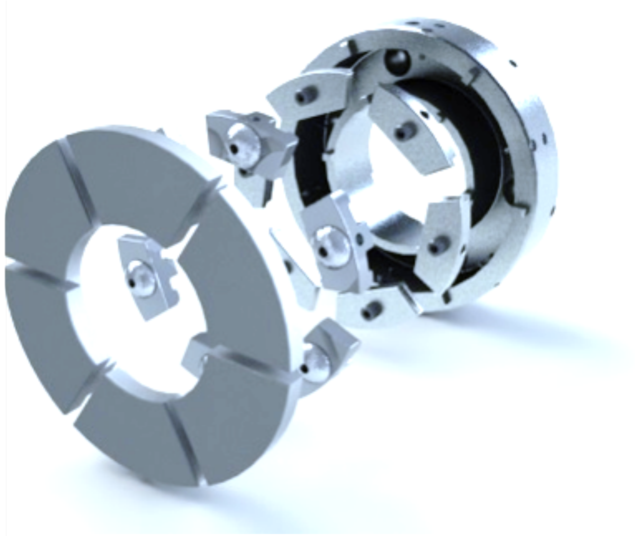
New bearing line

Our new manufacturing line supplies a wide range of bearing designs and new materials to provide optimal solutions to fit various combinations of load, speed and space requirements. Innovative materials and manufacturing technologies have been developed to withstand critical operating conditions.

Test rig and support

The test rig for thrust and journal bearings can be used with variable oil inlet temperature up to 60ºC for a max speed of 24,000 rpm. Its load capabilities cover a wide range of application requirements, performing full size TB and JB static tests, and dynamic test in collaboration with the University of Pisa.





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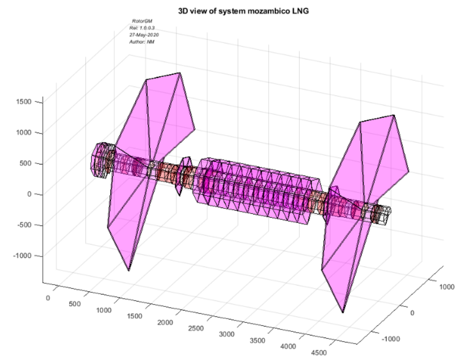
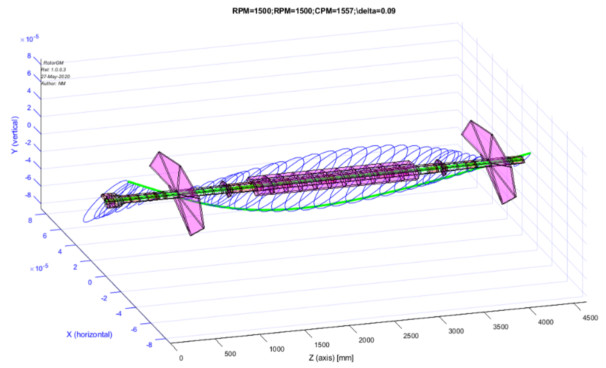
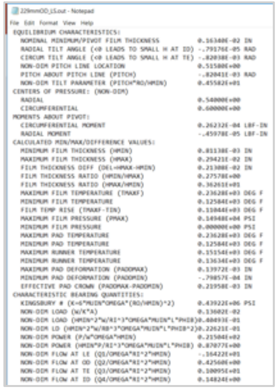
Advanced modeling





Rotordynamic model

1D



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EQUILIBRIUM CHARACTERISTICS:
  NOMINAL MINIMUM/PIVOT FILM THICKNESS               0.16340E-02 IN
  RADIAL TILT ANGLE (<0 LEADS TO SMALL H AT ID) -.79176E-05 RAD
  CIRCUM TILT ANGLE (<0 LEADS TO SMALL H AT TE) -.82038E-03 RAD
  NON-DIM PITCH LINE LOCATION                        0.51500E+00
  PITCH ABOUT PITCH LINE (PITCH)                     -.82041E-03 RAD
  NON-DIM TILT PARAMETER (PITCH*RO/HMIN)             0.45582E+01
CENTERS OF PRESSURE: (NON-DIM)
  RADIAL                                             0.54000E+00
  CIRCUMFERENTIAL                                    0.60000E+00
MOMENTS ABOUT PIVOT:
  CIRCUMFERENTIAL MOMENT                             0.26232E-04 LBF-IN
  RADIAL MOMENT                                      -.45970E-05 LBF-IN
CALCULATED MIN/MAX/DIFFERENCE VALUES:
  MINIMUM FILM THICKNESS (HMIN)                      0.81138E-03 IN
  MAXIMUM FILM THICKNESS (HMAX)                      0.29421E-02 IN
  FILM THICKNESS DIFF (DEL=HMAX-HMIN)                0.21308E-02 IN
  FILM THICKNESS RATIO (HMIN/HMAX)                   0.27578E+00
  FILM THICKNESS RATIO (HMAX/HMIN)                   0.36261E+01
  MAXIMUM FILM TEMPERATURE (TMAXF)                   0.23628E+03 DEG F
  MINIMUM FILM TEMPERATURE                           0.12584E+03 DEG F
  FILM TEMP RISE (TMAXF-TIN)                         0.11044E+03 DEG F
  MAXIMUM FILM PRESSURE (PMAX)                       0.14948E+04 PSI
  MINIMUM FILM PRESSURE                              0.00000E+00 PSI
  MAXIMUM PAD TEMPERATURE                            0.23628E+03 DEG F
  MINIMUM PAD TEMPERATURE                            0.12584E+03 DEG F
  MAXIMUM RUNNER TEMPERATURE                         0.15154E+03 DEG F
  MINIMUM RUNNER TEMPERATURE                         0.13634E+03 DEG F
  MAXIMUM PAD DEFORMATION (PADDMAX)                  0.13972E-03 IN
  MINIMUM PAD DEFORMATION (PADDMIN)                  -.79857E-04 IN
  EFFECTIVE PAD CROWN (PADDMAX-PADDMIN)              0.21958E-03 IN
CHARACTERISTIC BEARING QUANTITIES:
  KINGSBURY # (K=6*MUIN*OMEGA*(RO/HMIN)^2)           0.43922E+06 PSI
  NON-DIM LOAD (W/K*A)                               0.13602E-02
  NON-DIM LOAD (HMIN^2*W/RI^3*OMEGA*MUIN*L*PHIB)0.40493E-01
  NON-DIM LD (HMIN^2*W/RB^3*OMEGA*MUIN*L*PHIB^2)0.22621E-01
  NON-DIM POWER (P/W*OMEGA*HMIN)                     0.21504E+02
  NON-DIM POWER (HMIN*P/RI^3*OMEGA*MUIN*L*PHIB) 0.87077E+00
  NON-DIM FLOW AT LE (Q1/OMEGA*RI^2*HMIN)            -.16422E+01
  NON-DIM FLOW AT OD (Q2/OMEGA*RI^2*HMIN)            0.42560E+00
  NON-DIM FLOW AT TE (Q3/OMEGA*RI^2*HMIN)            0.10095E+01
  NON-DIM FLOW AT ID (Q4/OMEGA*RI^2*HMIN)            0.14824E+00
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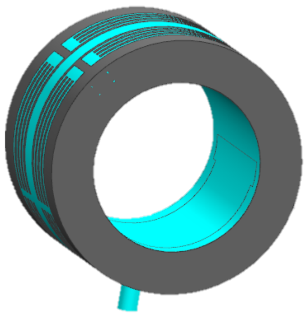
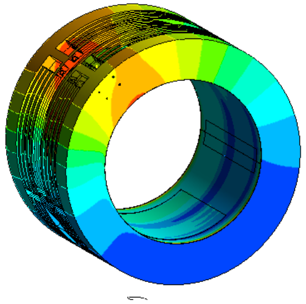
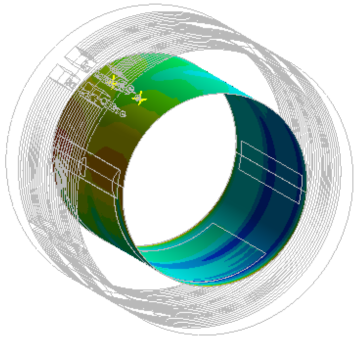
3D



Geometry definition
SOLID and FLUID contour



SOLID domain
Temperature contour



Fluid film domain

Elasto-thermo CFD simulation

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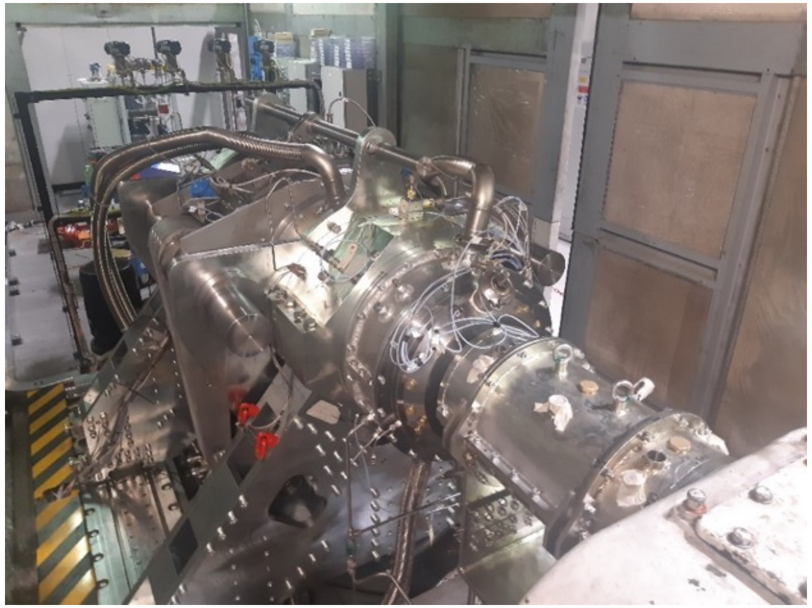
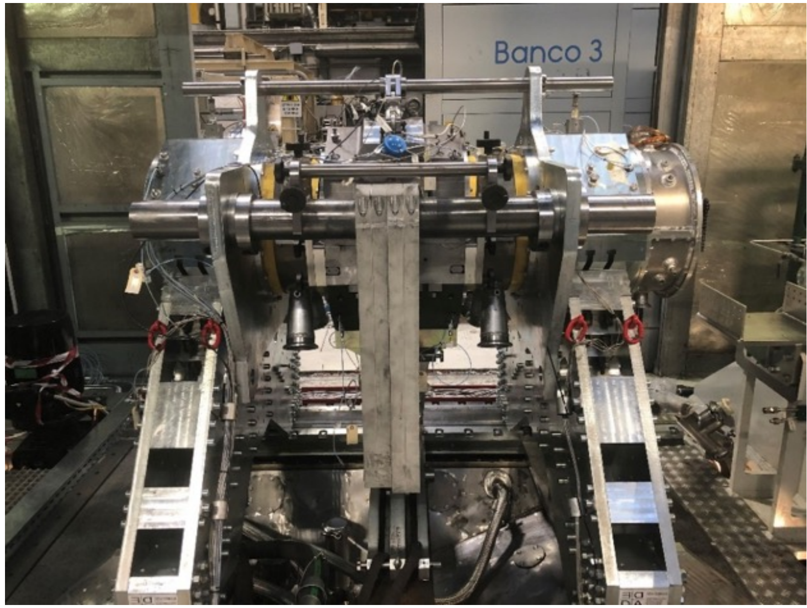
Mechanical parameters test rig

Test specifications

Max. speed	24,000 rpm
Max. TB ext. diameter	700 mm
Max. axial load	600 kN
Max. JB diameter	320 mm
Max. radial load	300 kN
Lube oil flow capability	1,000 L/min





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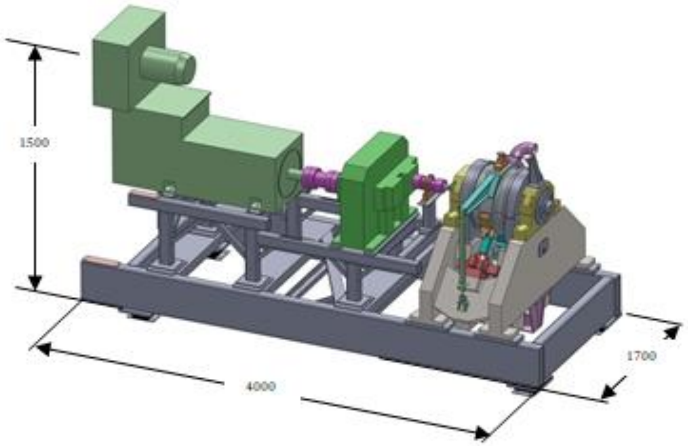
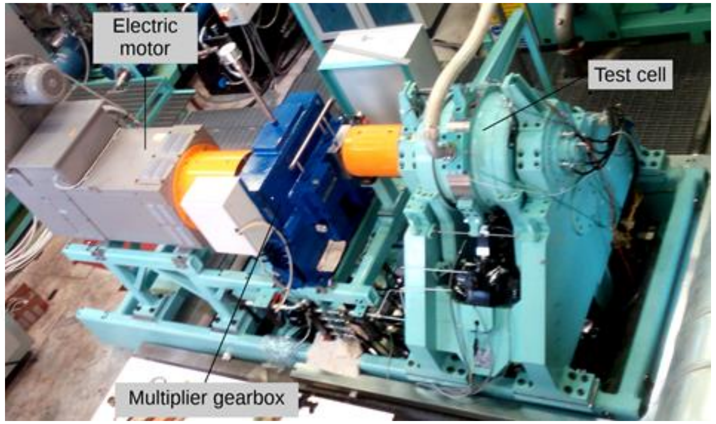
Dynamic coefficient test rig

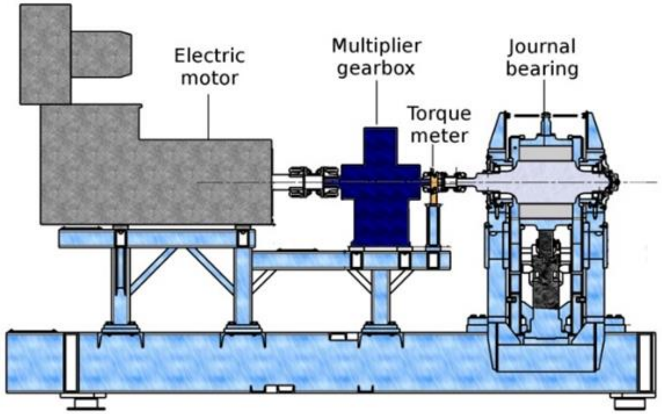
Test specifications

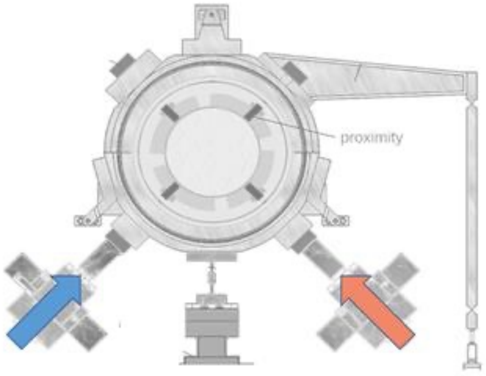
Max. power	630 KW
Max. rotating speed	24,000 rpm
Bearings bore range	150–300 mm
Max. journal load	270 kN

In collaboration with Università di Pisa









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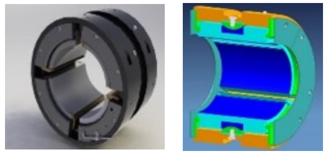
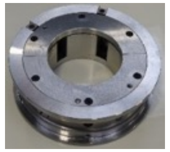
Bearings portfolio

Journal bearing (55-400 mm)

Tilting pad



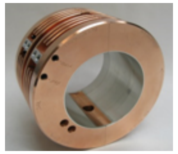
Ball and socket



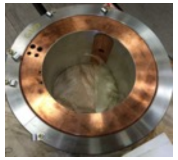
Rocker pivot

> **Under development**
>
> - Additive integrated pivot
> - Squeeze film damper
> - High-speed, direct-lube journal bearings
> - High-speed, high-load thrust bearings

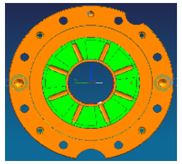
Fixed geometry



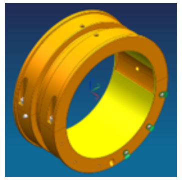
Pressure dam



Offset half



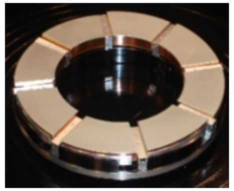
Multi tapered land



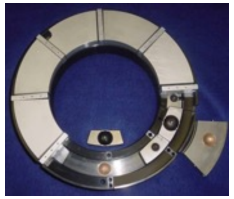
Elliptical

Thrust bearing (2-26 inches)

Tilting pad ball and socket

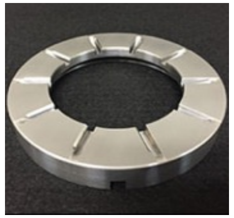


Cr Cu

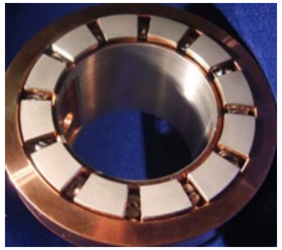


Steel

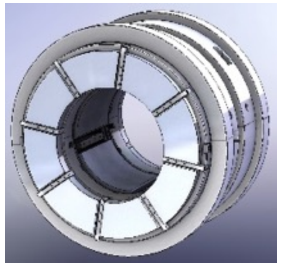
Fixed geometry



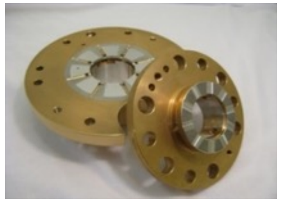
Combined journal + thrust (55-400 mm JB)



Thrust tilting pad/JB fixed



Thrust tilting pad/JB tilting

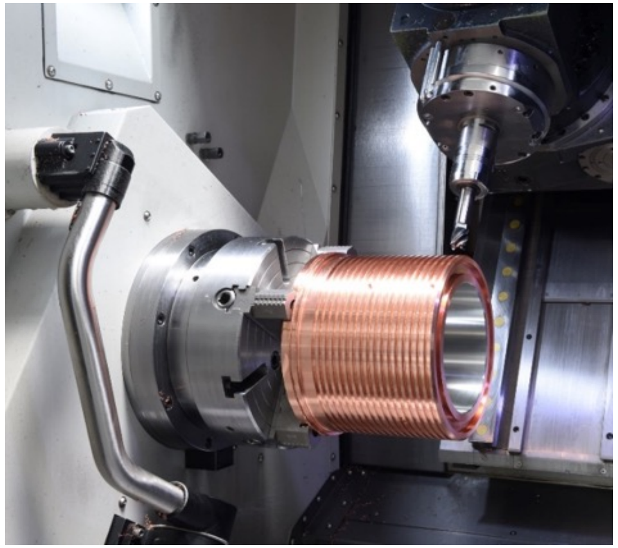


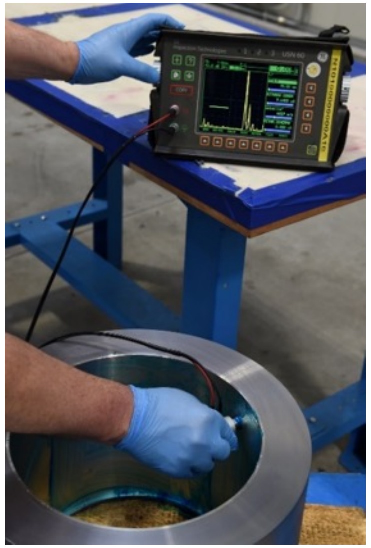
Thrust fixed / JB fixed

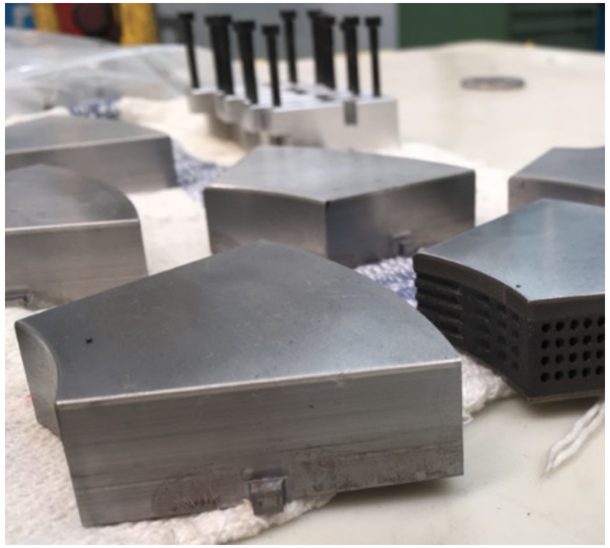
Dedicated manufacturing line

Our new bearings manufacturing line covers the complete production process from receiving to shipping, and has the capacity to produce thousands of bearings per year. It produces our entire portfolio of journal bearings (tilting pad, fixed geometry), thrust bearings, combined journal+thrust bearings; and it includes new in-house technology for babbitting with centrifugal casting.

- Temperature-controlled facility
- Internal centrifugal casting for babbitt
- Re-babbitting and repair of bearings from any original equipment manufacturer (OEM)
- Fully certified ultrasonic and dye-penetrant testing
- Coordinate measuring machine (CMM) inspection services
- CNC and manual machining of parts
- Three independent machining lines (fixed geometry bearings, pad machining, housing machining)
- Flow production concept in accordance with lean manufacturing rules
- Additive manufacturing capability







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