COBRA-AHS (2ⁿᵈ Generation)
COBRA-2G ADVANCED HIGH-SPEED
COMPUTER OPTIMIZED BALL & ROLLER BEARING ANALYSIS

COBRA-2G, the 2ⁿᵈ Generation of COBRA-AHS, is a High Speed bearing analysis program that computes the behavior of up to five (5) bearing rows on a flexible or rigid shaft loaded in 5 DOF. COBRA-2G is integrated with ANSYS to perform fit-up and temperature-distribution analyses, including iterative thermal/dimensional interaction and sub-surface stress distribution analysis using ANSYS. Additional features include 6 DOF Ball Kinematics for prediction of Sliding and Skidding as well as the legacy Jones Race Control model and a physics based Non Linear Thermal Viscoelastic (NLTV) mixed film traction model. Stress models include Heat Treat Residual Stress and Hoop Stress from fits and operation speed. COBRA-2G automatically prepares files for input into the Wedeven Associates SCM (Single Contact Model) for rigorous analysis of Mixed EHL loaded contacts.

PROGRAM CAPABILITIES & FEATURES INCLUDE:

- Up to 5 Bearings on flexible or rigid shaft
- Up to 10 Applied Loads in 5 DOF
- Up to 20 Shaft Sections
- Tapered and hollow shaft sections
- Pre-defined defaults for many inputs
- Housing and Shaft Distortion inputs
- Crowned Rollers w/ Lamina
- Preload
- Bearing heat generation & cage forces
- Seamless interface to ANSYS
- ANSYS Race Segment stress models
- Imposition of Residual Stress

- Internal Clearance & End-Play
- STLE Fatigue Life Adjustments
- Misalignment, Location Offsets
- Hybrid Bearings, Duplex Bearings
- Lubricant Film Thickness
- Lubricant Effects on L10 Life
- Library of Lubricants
- Library of Materials
- Interactive Roller Edge Stress
    Analysis w/ Contour Plot Outputs
- Under Race Cooling of SIR bearings
- In contact Flash Temperature
- Export of Data files to WAI SCM

- Interactive Sensitivity Studies
- Interactive Duty Cycle Analysis
- Up to 2000 Duty Cycle Conditions
- Skid Estimates for Ball and
    Cylindrical Roller Bearings
- Input in SI or US units
- Results in SI and US units
- Copy Results & Plots to Clipboard
- Print Results & Plots
- Automatic Update of Results & Plots
- Prepares ANSYS COMBI214
    Elements for Rotordynamic models
- LP & IH Life Models

5 BEARING TYPES:

Radial (Conrad) Ball,   Angular Contact Ball,   Cylindrical Roller (with Under Race Cooling) Tapered Roller (?)
Split Inner Race (3 Point Contact) with Under Race Cooling

2 EDITIONS AVAILABLE:

Full: All features including ANSYS seamless links for temperature distributions and more rigorous Fit-Up analysis
    Plus ANSYS Race Segment Models for sub-surface stress distribution analysis

**Reduced:** Excludes ANSYS Race Segment Stress Models

Detailed Bearing System Definition

COBRA-2G can create detailed shaft-bearing systems with mixed bearing types
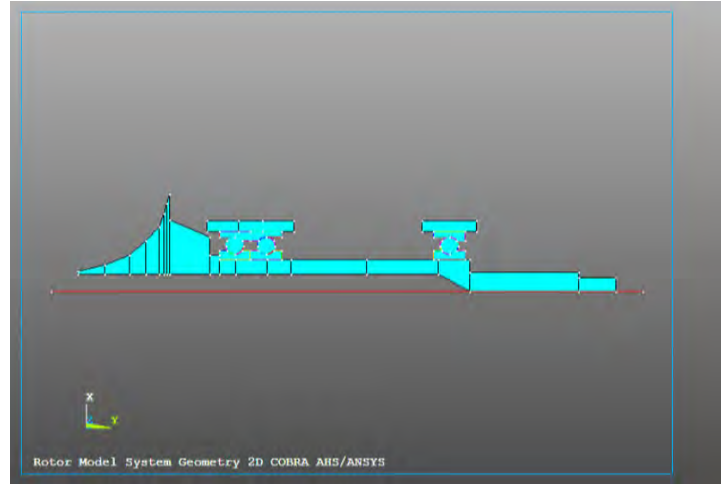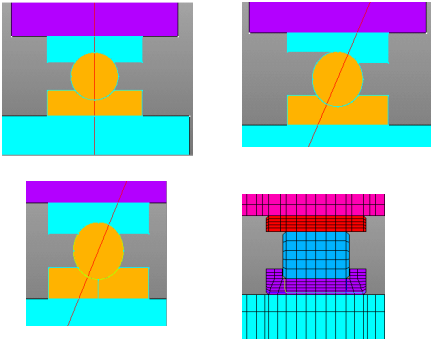

Detailed Contact Stress & Thermal Analysis

COBRA-2G has a modern menu-driven Windows interface with tabbed worksheet format. Users can interactively change data and quickly generate results. COBRA-2G predicts Edge Stress concentration and contains a library of standard crown profiles. User defined or measured profiles can also be analyzed. The seamless interface with ANSYS allows for steady state thermal analysis and dimensional IDC (Internal Diametral Clearance) change estimates
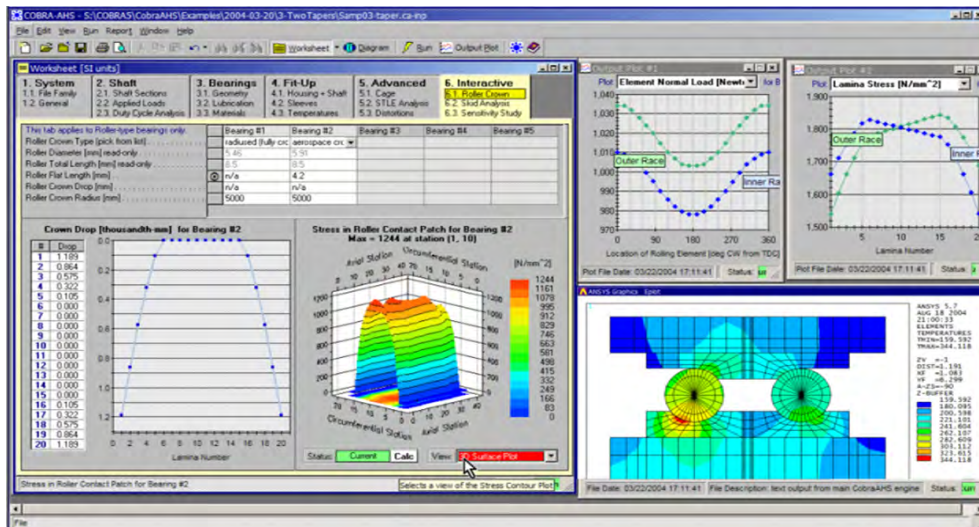
6 DOF Kinematics Skid & Sliding Velocity Profile

The 6 DOF ball kinematics solution gives cage slip (skid) estimates at low thrust load and detailed "in contact" sliding velocity profiles for use in the Non Linear Thermal Viscoelastic Traction (NLTV) model implemented in the analysis of high DN split inner race and angular contact ball bearings. Input files are created for the Wedeven Associates Single Contact Model (SCM) for rigorous analysis of mixed EHL contacts.

In Contact Sliding Velocity
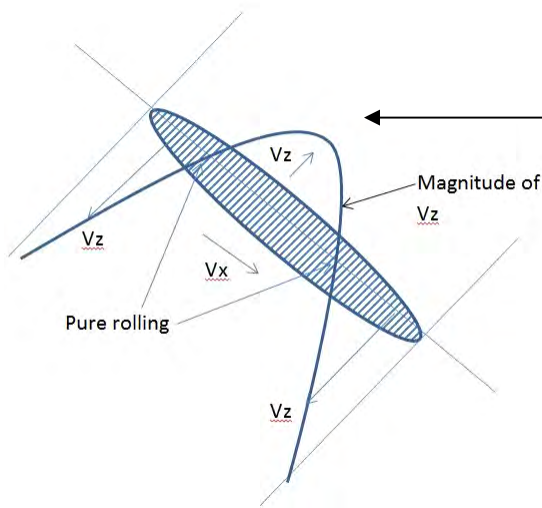
Addition of Hertz Pressure Loading of Race
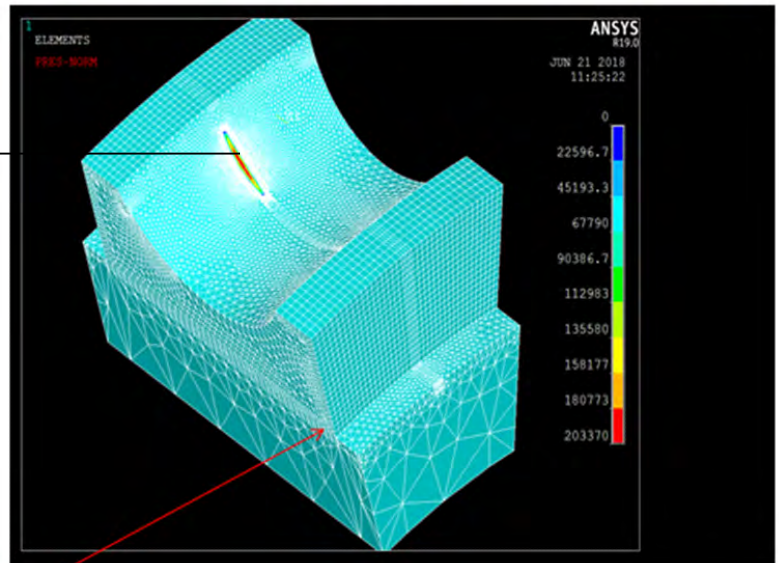
Cage Slip at 2.5 MDN
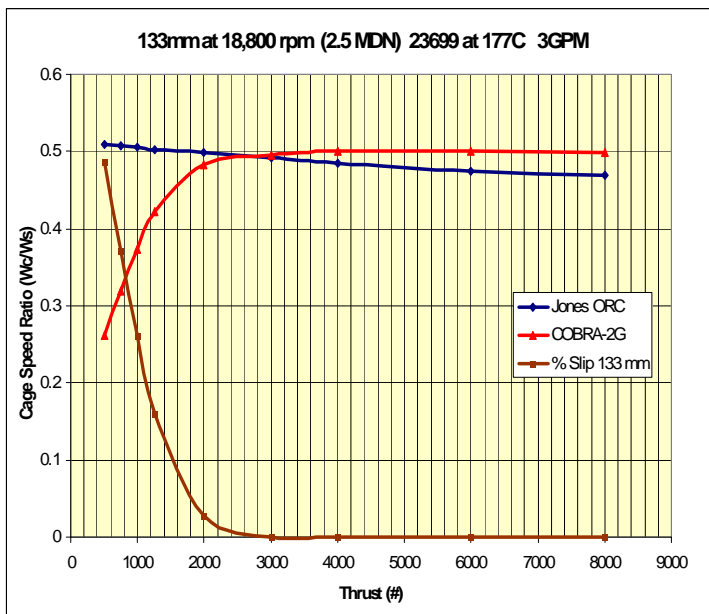
In-Contact Sliding Velocity Profiles
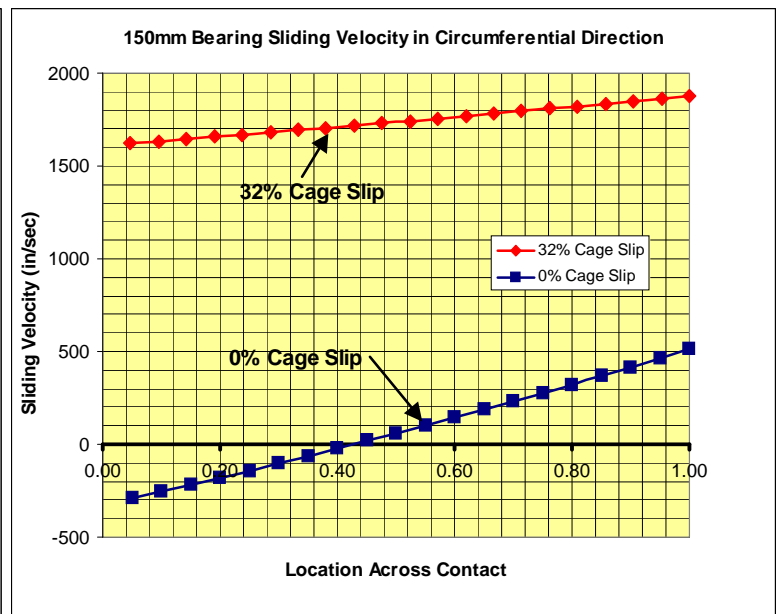
COBRA-2G/WAI Physics Based Traction Model
Integrated for Full Component Design/Analysis

COBRA-2G contains the WAI physics based Non Linear Thermal Viscoelastic Traction (NLTV) model incorporating a Maxwell Viscoelastic Fluid and the Johnson-Trevaawerk traction formulation. Physical property data needed for the model is generated using the WAI WAM machine. COBRA-2G applies this formulation to a sliced inner and outer race contact patch for estimating the contribution to Heat Generation from EHL traction and Traction Forces used in Skidding Analysis. Also, input files for the WAI SCM (Single Contact Model) are prepared for detailed Mixed EHL Contact analysis.
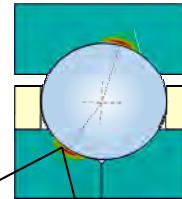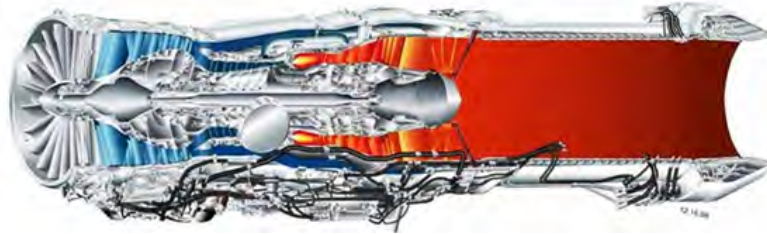
Visco-elastic Maxwell Fluid Model

$$\dot{\gamma} = \frac{1}{E}\frac{\partial \sigma}{\partial t} + \frac{\sigma}{\eta}$$

$$\frac{\partial \tau(x,y)}{\partial x} = \frac{GU_s}{U_e h} - \frac{G\tau_c}{U_e \eta(x,y)}\sinh\left(\frac{\tau_c}{\tau}\right)$$
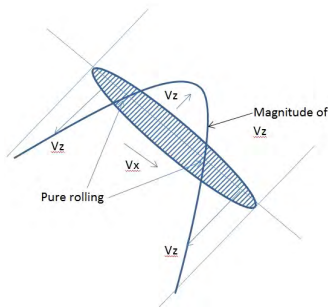
NLTV Traction Model vs Test
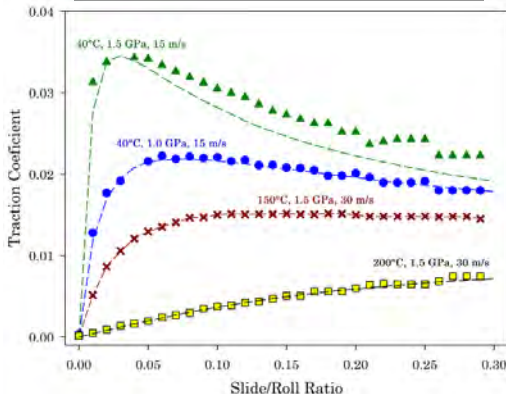
WAI SCM Film Temperature Estimate Example
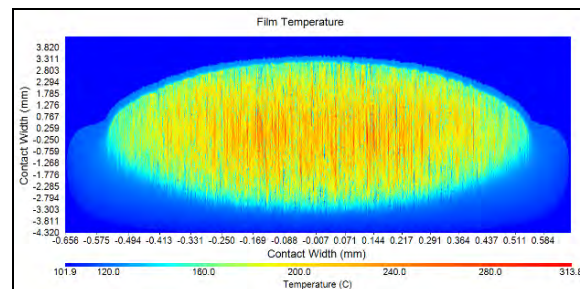
Improved Heat Generation Estimates for High DN

COBRA-2G gives improved heat generation prediction for high speed, high load split inner race angular contact ball bearings as verified by two sets of high speed test rig data to 3 MDN and 16,500 pounds thrust load. COBRA-2G contains physics based heat generation models that quantify heat generated from lubricant drag or churning loss, Inner and Outer race EHL Traction loss, EHL hydrodynamic pumping loss, Hysteresis loss and Lube Inertia. Cage pilot surface and ball pocket friction are also included. Knowing the % contribution of each source enables the bearing designer to focus on the areas of largest generation.

All Steel Bearing to 2.6 MDN

Hybrid Bearing to 2.6 MDN

133mm AFRL Brg at 11.4 l/min 121C M 50 Balls (WJC-Parker) 04-08-2021

133mm AFRL Brg. at 11.4 l/min 121C HYBRID (WJC-Parker Drag)
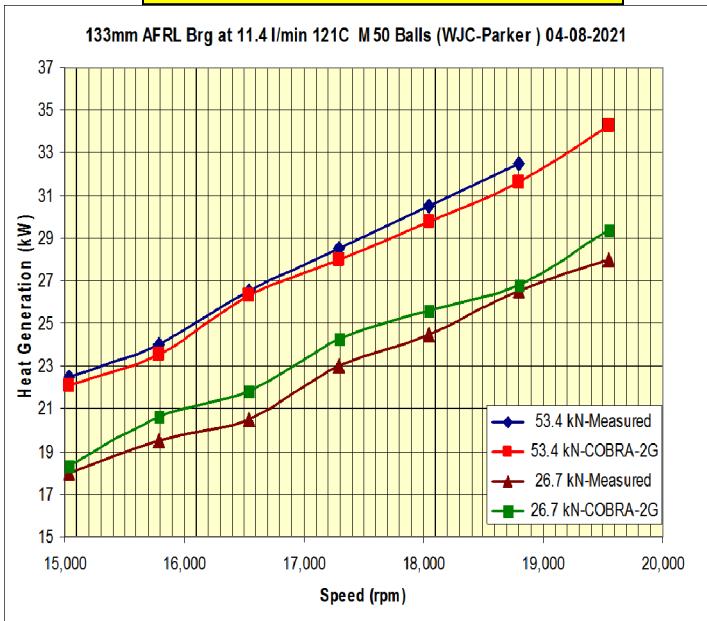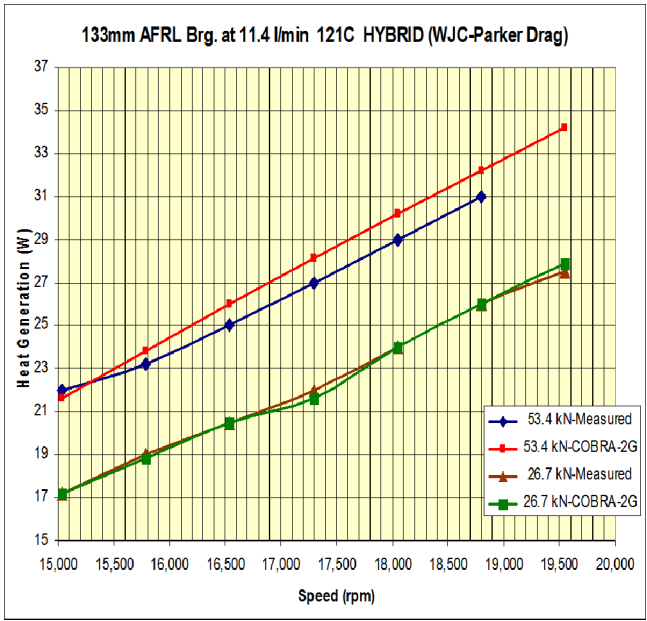
COBRA-2G Captures Increase in Heat Generation with speed at 26.7 kN & 53.4 kN Thrust

133mm AFRL ALL STEEL Brg. 18,797 rpm (2.5MDN) 11.4 l/min 121C
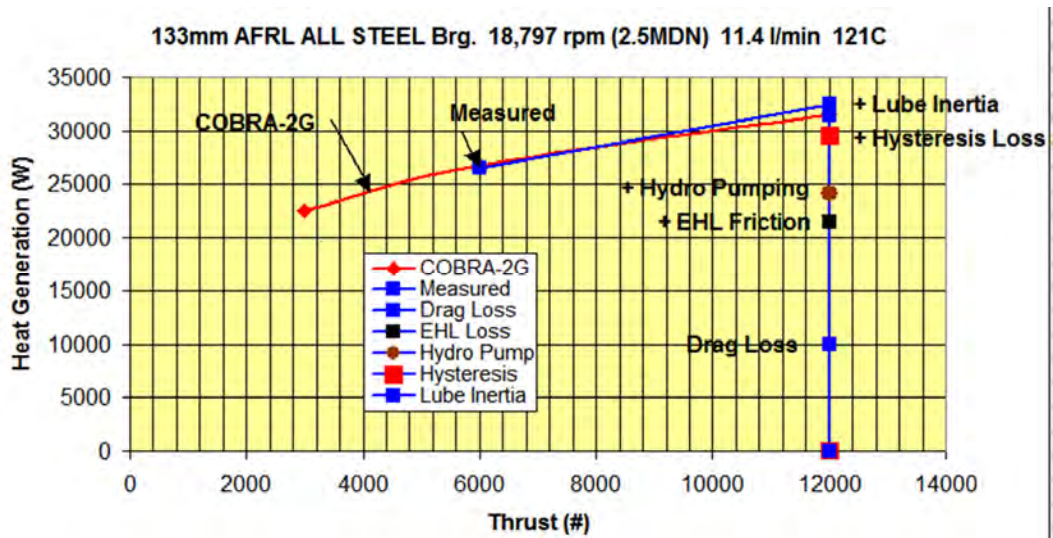
COBRA-2G Captures Increase in Heat Generation with Thrust Load

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Evaluation of Different Methods for Cooling

COBRA-2G has a seamless interface to ANSYS for steady state thermal analysis of ball and cylindrical roller bearings having Oil Jet or Under Race lubrication/cooling systems. The Under Race cooling models include rectangular and Arcurate (semi-circular) flow passages as well as several lubricant passage arrangements. The image below demonstrates the significant reduction in inner race temperature due to under race cooling. Also notice that COBRA-2G captures the temperature difference between the loaded and unloaded halves of the 2 piece race for the SIR bearing. Such results have been verified by measured data on a 160mm SIR bearing at 2.5 MDN.

ANSYS FEA Bearing Temperature Model Results for 140mm Brg at 2.5 MDN & 10K lbs. Thrust
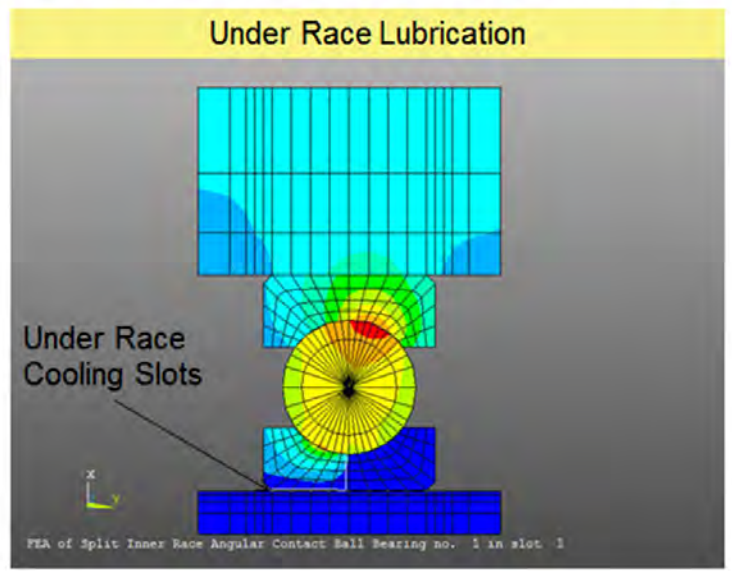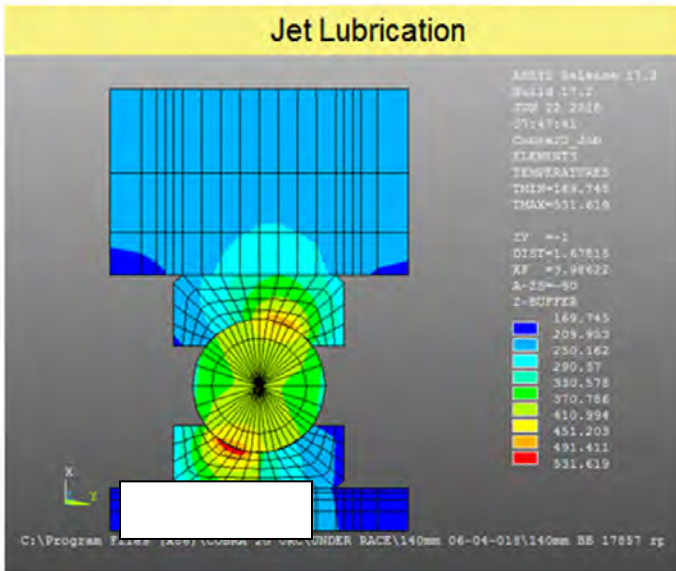
Temperature model shows effective cooling of under race slots
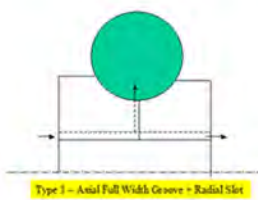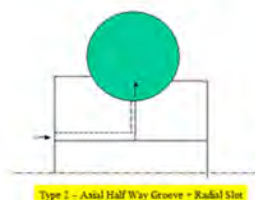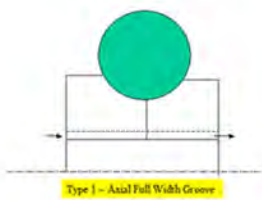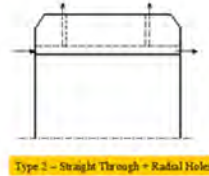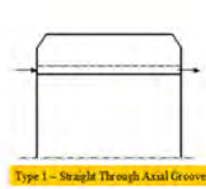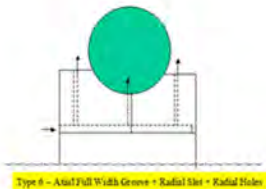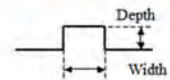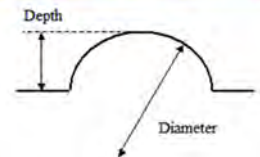
COBRA-2G provides for multiple combinations of coolant delivery and flow passage cross section shape

Evaluate Sub-Surface Stresses

COBRA-2G has a seamless interface to generate ANSYS Race Segment Models for analysis of sub-surface stress distribution at the most heavily loaded ball. Such models can be generated for inner and outer race contacts and include loading from the ball load Hertz pressure, traction forces along the contact ellipse, press fits, race speed and "as-manufactured" residual stress.

Addition of Hertz Pressure Loading of Race
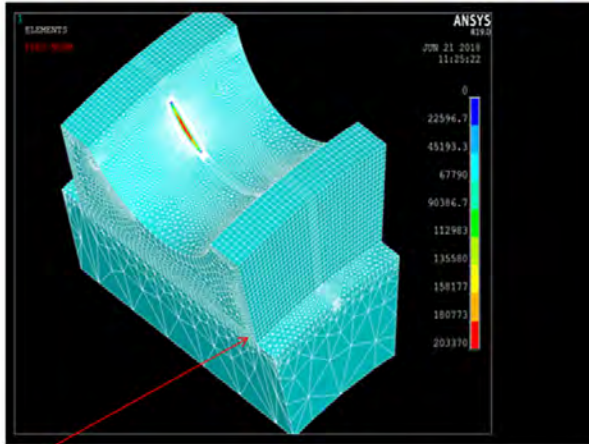
VonMises Stress Plot for Hertz Pressure Loading on Inner Race
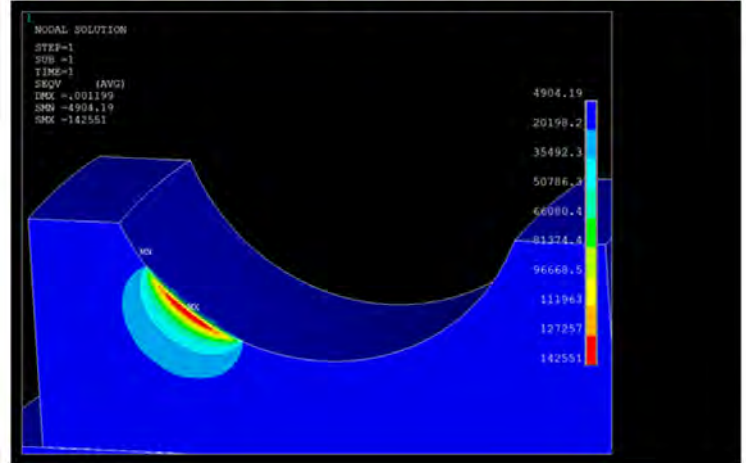
Measured Residual Stress Profile
(-400 MPa = -58,000 psi)
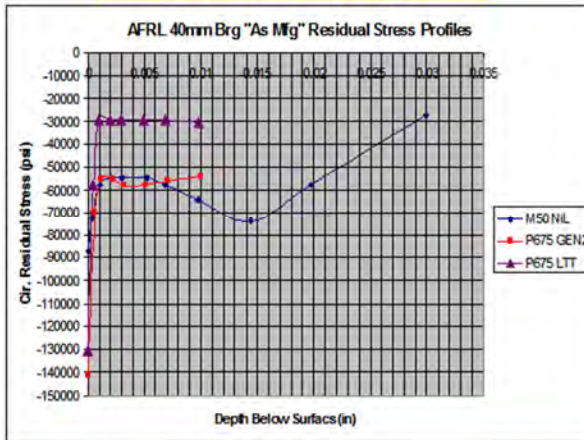
Imposed Residual Stress in COBRA-2G for M50 NiL
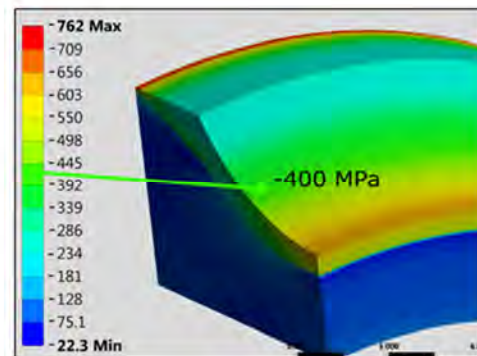
COBRA-2G allows residual stress input as a polynomial fit or table look up for stress vs. depth

Decisive Stresses in Rolling Contact Fatigue

Original Lundberg-Palmgren Orthogonal Shear Stress
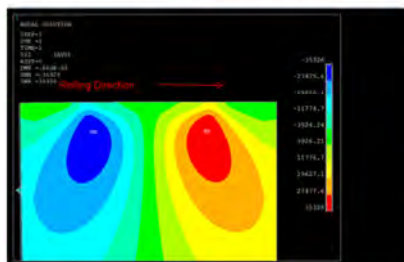
More Recent vonMises Equivalent Stress

J.V. POPLAWSKI & ASSOCIATES – Consulting Mechanical Engineers
44 E. Broad Street, Suite 207; Bethlehem, PA 18018; **Phone**: 610-758-9601, **Fax**: 610-758-9661
Email: info@bearingspecialists.com **Web**: http://www.bearingspecialists.com
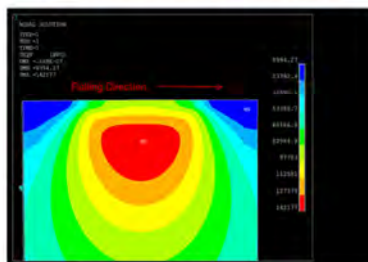
Temperature Distributions with High Cage Slip

COBRA-2G ANSYS Thermal Analysis detects development of "hot spot" within a bearing with high % Cage Slip. Although the bearing heat generation decreased from 16.1 KW for 2% slip to 10.5 KW for the case of 32% cage slip, a high temperature zone is detected at the inner race contact due to the high sliding velocity that developed from cage slip. This will impact the Tribology of that contact and can be evaluated using the Wedeven Associated Single Contact Model (SCM) for mixed EHL analysis.

High Temperature Location Shifts to IR for High Slip Condition
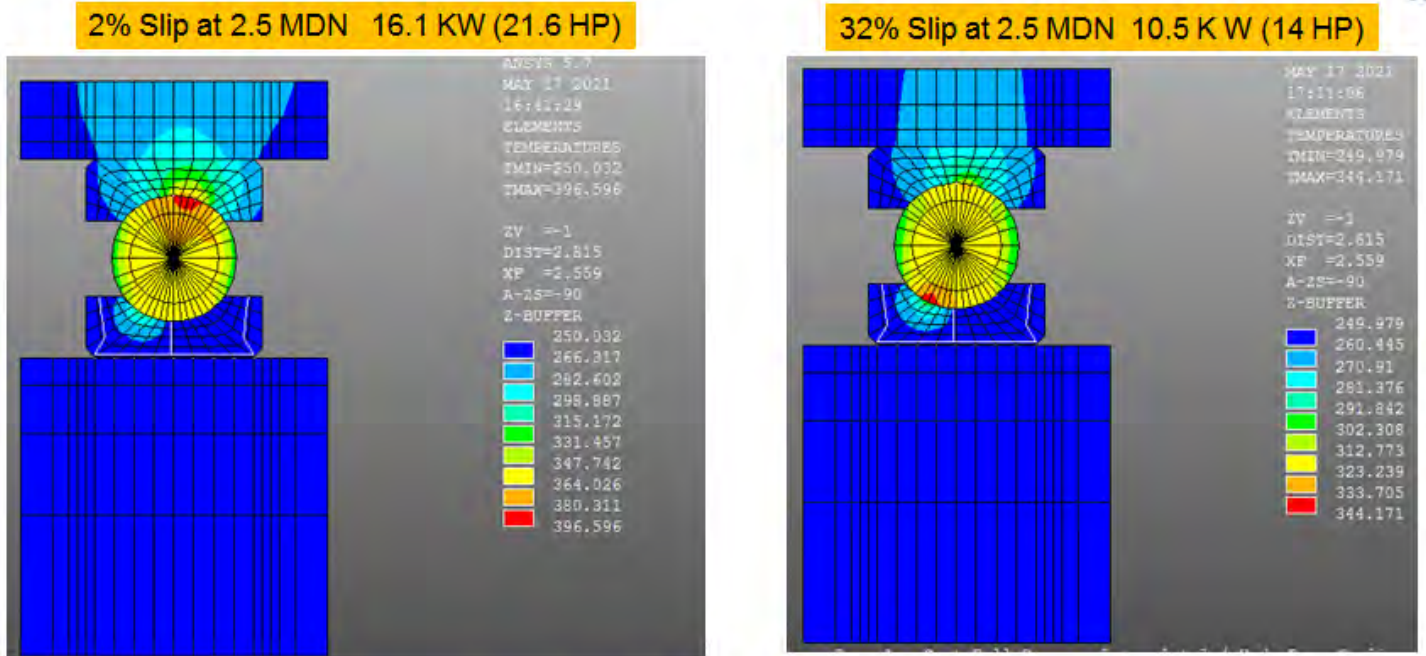
COBRA-2G Clearance Change Models

COBRA-2G contains the Classical Thick Ring FitUp model and more rigorous ANSYS estimates of Internal Diametral Clearance (IDC) in a bearing. Ball or Roller load effect on IDC can be included in the estimate. This feature is useful for evaluating preload change in thin race bearings or preloaded bearings cooled to cryogenic temperatures.
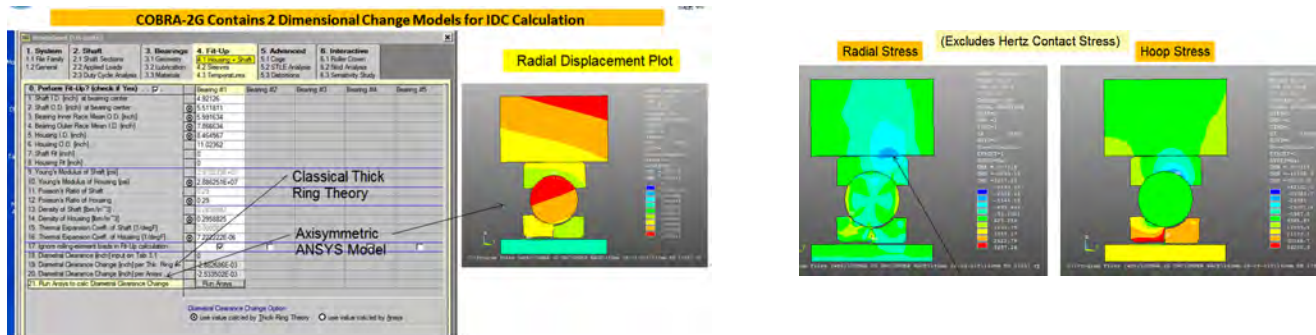
COBRA-2G Input/Results Form Examples

Lubrication Inputs

STLE Life Factor Inputs

Cylindrical Roller Bearing Skid Analysis

Sensitivity Study Results

PROGRAM RESULTS INCLUDE:

Bearing Reactions & Load Sharing	Hertz Contact Stress	Life Adjustment Factor-Lubrication
Radial & Axial Spring Rates	Sub-Surface Shear Stress	Individual Element Output
Angular Spring Rate	Operating Contact Angle	Contact Flash Temperature
Dynamic Capacity	Element Loads	Contact Sliding Velocity Distribution
System B10 Life	Contact Ellipse Size	Roller Edge Stress
Bearing B10 Life	Min. Required Shoulder Heights	Per Bearing Plots of 11 parameters
Load Zones	Lubricant Film Thickness	And more
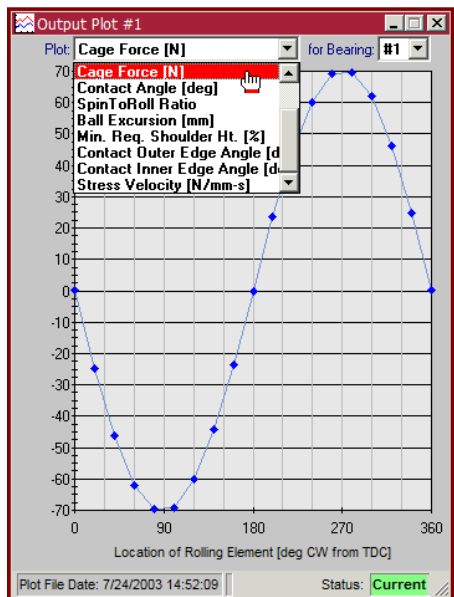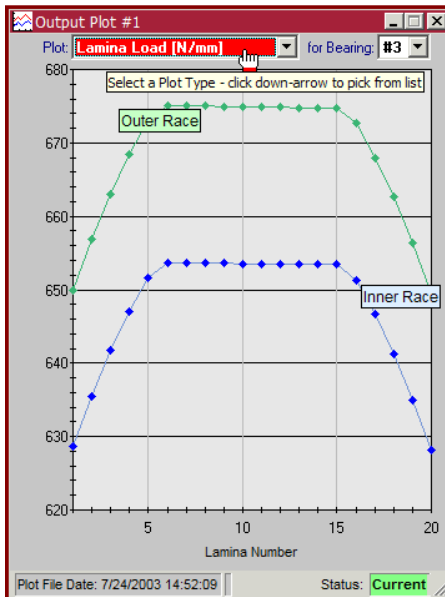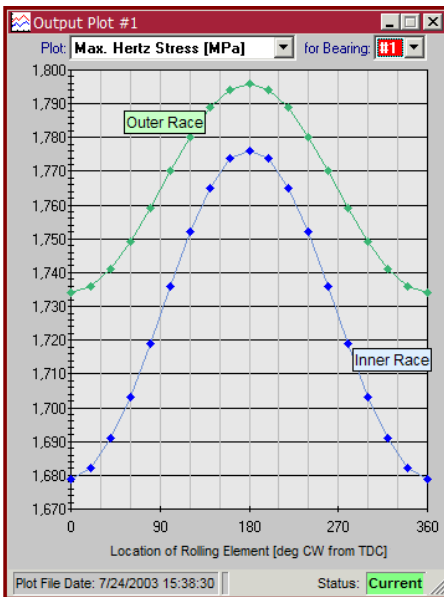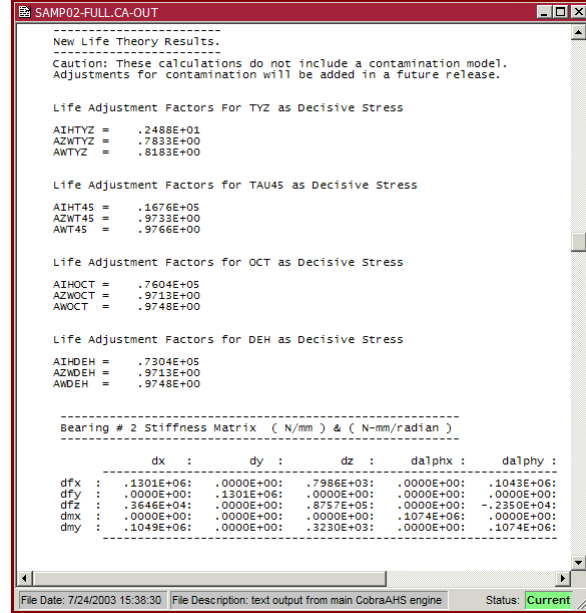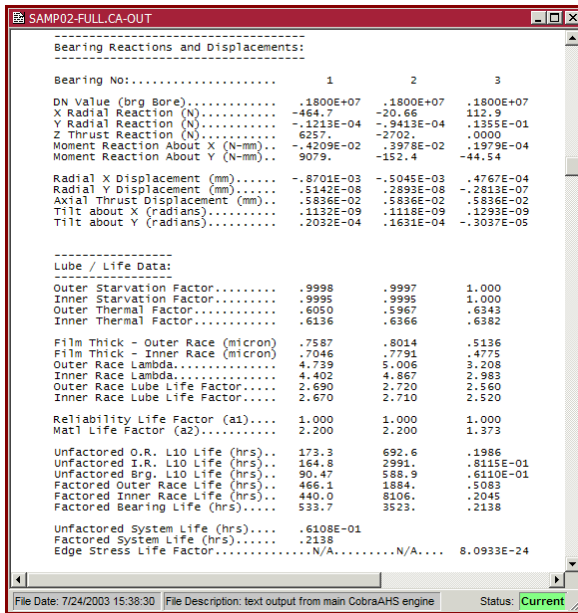
COBRA-2G Roller Edge Stress Example
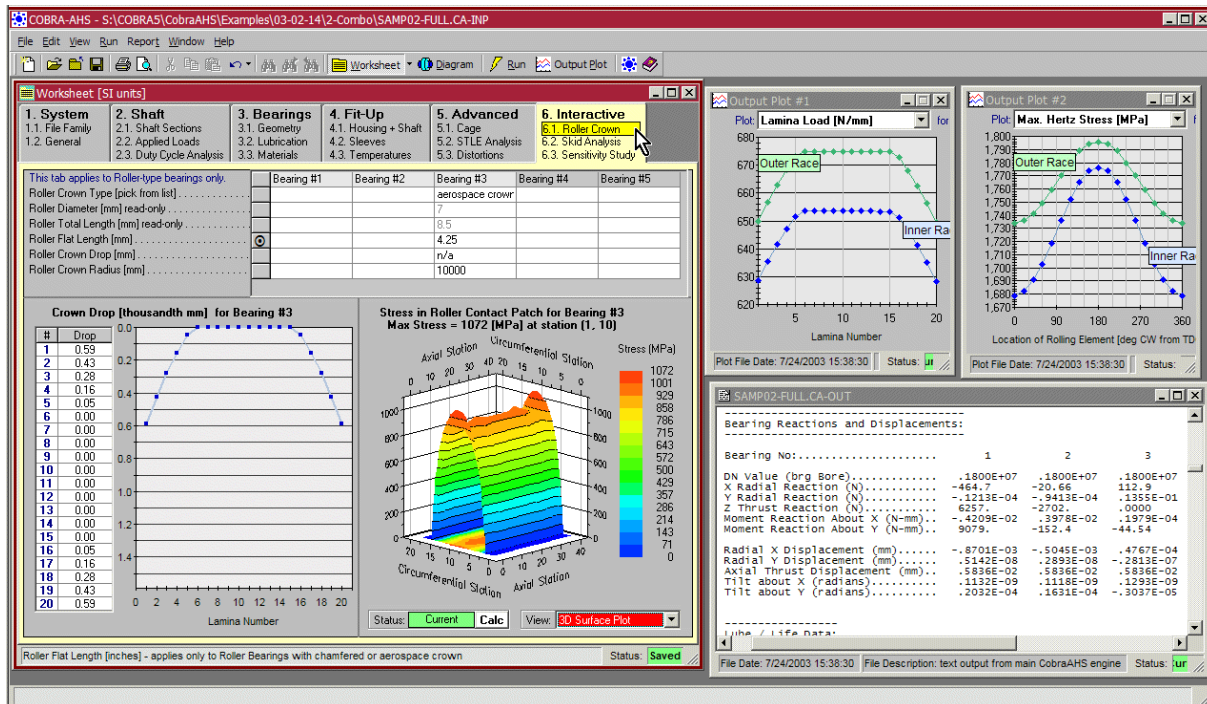
SYSTEM REQUIREMENTS:

IBM-compatible PC; 32-bit or 64-bit Windows Operating System (2000, XP, Vista, Windows 7-10); CD drive 40 MB hard disk space; 192 MB RAM installed (256 MB preferred); 800x600 pixel screen resolution; 16-bit color display

PACKAGE INCLUDES:

Installation CD; End-User License; Example Problems; Printed Manual; Release Notes, USB Hardware Security Key Free Technical Support for 1 year. Fee-based support available thereafter.