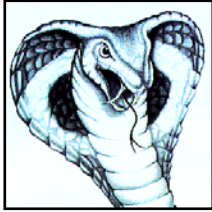


# COBRA-AHS

ADVANCED HIGH-SPEED  
COMPUTER OPTIMIZED BALL & ROLLER BEARING ANALYSIS



**COBRA-AHS** is a bearing analysis program that computes the behavior of up to five (5) bearing rows on a flexible or rigid shaft loaded in 5 DOF. The program has a modern menu-driven Windows interface with a multi-tabbed worksheet format, allowing users to interactively change input data and quickly generate results. COBRA-AHS Full Edition is integrated with ANSYS/ED (copy included) to perform fit-up and temperature-distribution analyses, including iterative thermal/dimensional interaction.

## PROGRAM CAPABILITIES INCLUDE:

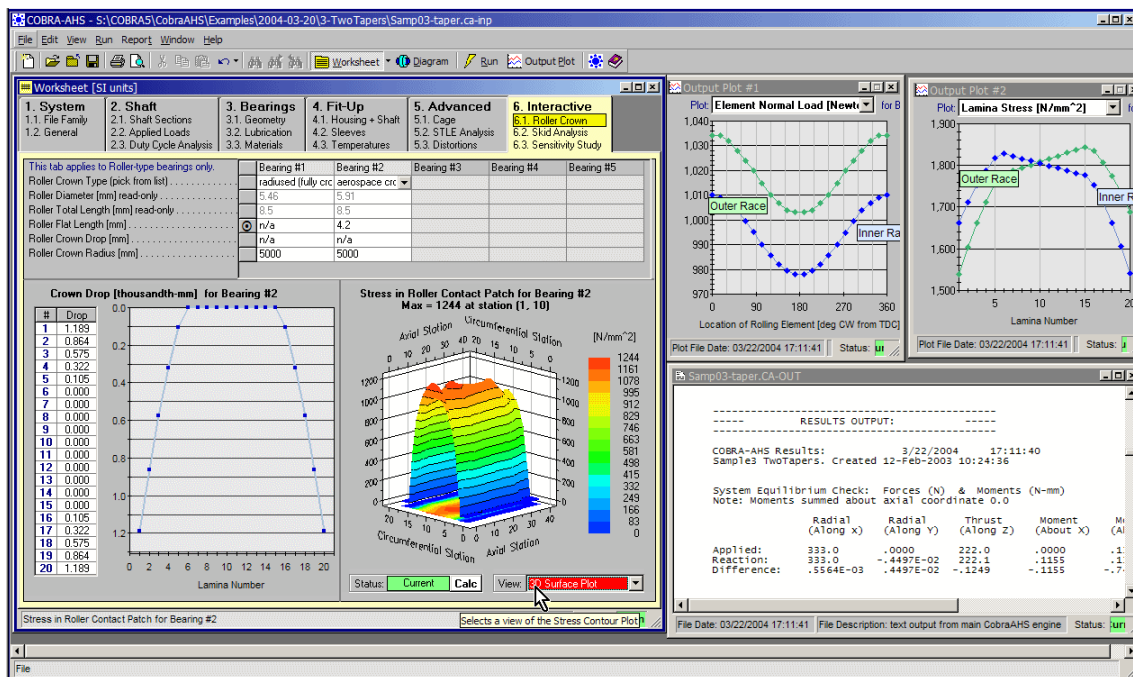
- |   |                                  |   |
|---|----------------------------------|---|
| Up to 5 Bearings on flexible or rigid shaft | Internal Clearance & End-Play    | Interactive Sensitivity Studies                         |
| Up to 10 Applied Loads in 5 DOF             | STLE Fatigue Life Adjustments    | Interactive Duty Cycle Analysis                         |
| Up to 20 Shaft Sections                     | Misalignment, Location Offsets   | Up to 2000 Duty Cycle Conditions                        |
| Tapered and hollow shaft sections           | Axial Float                      | Skid Estimates for Ball and Cylindrical Roller Bearings |
| Pre-defined defaults for many inputs        | Hybrid Bearings, Duplex Bearings | Input in SI or US units                                 |
| Housing and Shaft Distortion inputs         | Lubricant Film Thickness         | Results in SI and English units                         |
| Housing and Shaft Sleeves option            | Lubricant Effects on L10 Life    | Copy Results & Plots to Clipboard                       |
| Crowned Rollers w/ Lamina                   | Library of Lubricants            | Print Results & Plots                                   |
| Solid and Spring Preload                    | Interactive Roller Edge Stress   | Automatic Update of Results & Plots                     |
| Bearing heat generation & cage forces       | Analysis w/ Contour Plot Outputs |   |

## 4 BEARING TYPES:

Radial (Conrad) Ball, Angular Contact Ball Cylindrical Roller, Tapered Roller

## 3 EDITIONS AVAILABLE:

- Baseline:** analysis capabilities equivalent to Jones Code, plus more output options and modern Windows user-interface  
**Intermediate:** all Baseline features plus: interactive Roller Crown Design Cell with Edge-Stress estimation (see below)  
**Full:** all Intermediate features plus: ANSYS integration for temperature distributions and more rigorous Fit-Up analysis



Worksheet [SI units]

1. System 2. Shaft 3. Bearings 4. Fit-Up 5. Advanced 6. Interactive

1.1. File Family 2.1. Shaft Sections 3.1. Geometry 4.1. Housing + Shaft 5.1. Cage 6.1. Roller Crown  
 1.2. General 2.2. Applied Loads 3.2. Lubrication 4.2. Sleeves 5.2. STLE Analysis 6.2. Skid Analysis  
 2.3. Duty Cycle Analysis 3.3. Materials 4.3. Temperatures 5.3. Distortions 6.3. Sensitivity Study

- Shaft Rigidity  
 Shaft is rigid. COBRA analysis will treat the shaft as rigid regardless of Shaft Material Properties and Shaft Section Dimensions.  
 Shaft is flexible. COBRA analysis will compute shaft flexibility based on Shaft Material Properties and Shaft Section Dimensions.

- Shaft Material Properties  
 Young's Modulus [MPa] ..... 205878 Density [gm/cm<sup>3</sup>] ..... 7.6  
 Poisson's Ratio ..... 0.29 Thermal Expansion Coeff. [1/degC] ..... 0.000123

- Shaft Section Dimensions

Section Ident.	Section #	Section Length [mm]	Axial Location [mm] of Left End of Section	Dia. at Left End of Section		Dia. at Right End of Section	
				ID [mm]	OD [mm]	ID [mm]	OD [mm]
1	1	75	0	60	0	60	
2	2	85	75	0	60	60	
3	3	150	160	0	60	60	
4	4	150	310	0	60	60	

USE DEFAULT VALUE?  
 COBRA's default value for Poisson's Ratio is: 0.29  
 Click 'OK' to paste this value into your worksheet.  
 OK Cancel

Note: COBRA-AHS uses a standard right-handed orthogonal coordinate system. Co-  
 \*X axis points vertically up. \*Y axis points out of the page. \*Z axis points towards the right.  
 Shaft Sections are numbered consecutively (starting with #1) from left to right.

Poisson's Ratio of Shaft Material - double-click (or press F5) to enter default value (0.3 for steel) Status: **Saved**

Worksheet [SI units]

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1.1. File Family 2.1. Shaft Sections 3.1. Geometry 4.1. Housing + Shaft 5.1. Cage 6.1. Roller Crown  
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	Bearing #1	Bearing #2	Bearing #3	Bearing #4	Bearing #5
Bearing Type (pick from list)	Angular Contact	Angular Contact	Cylindrical Roller	Angular Contact	Angular Contact
Duplex Bearing# (pick from list)	<no duplex>	<no duplex>	<no duplex>	<no duplex>	<no duplex>
Duplex Bearing Spacers (click cell to edit)	n/a	n/a	n/a	n/a	Angular Contact Ball Bearing
Location [mm] from origin	150	171	430		Conrad/Radial Ball Bearing
Bearing Nominal I.D. [mm]	60	60	60		Tapered Roller Bearing
Bearing Nominal O.D. [mm]	95	95	85		
Width of a Single Row [mm]	20	20	13		
Number of Elements (min 3, max 30)	18	18	26		
Pitch Diameter [mm]	77.5	77.5	72.5		
Element Diameter [mm]	11.11	11.11	7		
Contact Angle or Cup Angle [degrees]	25	-25	n/a		
Outer Race Curvature/Osculation	0.52	0.52	0		
Inner Race Curvature/Osculation	0.52	0.52	0		
Shim Thickness [mm]	0	0	n/a		
Roller Length [mm]	n/a	n/a	8.5		
Roller End Spherical Radius [mm]	n/a	n/a	10000		
Flange Layback Angle [deg]	n/a	n/a	0		
Roller Included Angle [deg]	n/a	n/a	0		
Dynamic Capacity Reduction Factor (lambda)	n/a	n/a	0.66		
Dynamic Capacity [N] post-1930	36716	36716	45466		
Diametral Clearance [mm]	0	0	0.01		
Axial Preload [N]	0	0	n/a		
Axial Preload Spring Rate [N/mm]	0	0	n/a		
Axial Offset along Z-axis [mm]	0	0	n/a		
Radial Offset along X-axis [mm]	0	0	0		
Radial Offset along Y-axis [mm]	0	0	0		
Initial Tilt about X-axis [mm/mm]	0	0	0		
Initial Tilt about Y-axis [mm/mm]	0	0	0		

Bearing Type - click down-arrow to pick from list; bearing is "not present" if this is not specified Status: **Unsaved**

Worksheet [SI units]

1. System 2. Shaft 3. Bearings 4. Fit-Up 5. Advanced 6. Interactive

1.1. File Family 2.1. Shaft Sections 3.1. Geometry 4.1. Housing + Shaft 5.1. Cage 6.1. Roller Crown  
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	Bearing #1	Bearing #2	Bearing #3	Bearing #4	Bearing #5
Lubricant Type (pick from list)	MIL-L 23639	MIL-L 23639	MIL-L 23639		
Lube Density [g/cm <sup>3</sup> ]	1.0102	1.0102	Mineral Oil (Shell Turbo 33)		
Lube Thermal Expansion Coefficient [1/C]	0.000745	0.000745	MIL-L 7808		
Lube Thermal Conductivity [W/m C]	0.152	0.152	Polyphenyl Ether MCS 293		
Lube Viscosity @40C [cSt]	28	28	MIL-L 23639		
Lube Viscosity @100 C [cSt]	5.1	5.1	user-defined lubricant		
Pressure Coefficient of Viscosity [mm <sup>2</sup> /N]	0	0	0		
Lube Operating Temperature [C]	65	65	65		
Element CLA Roughness [microns]	0.08	0.08	0.08		
Inner Race CLA Roughness [microns]	0.1	0.1	0.1		
Outer Race CLA Roughness [microns]	0.1	0.1	0.1		
Outer Race Flange CLA Roughness [microns]	n/a	n/a	0.1		
Roller End Face CLA Roughness [microns]	n/a	n/a	0.08		
Element-to-Race Friction Coefficient	0.1	0.1	0.1		
Flange Roller-End Friction Coefficient	n/a	n/a	0.1		
Lube Flow Rate [liters/min]	2	2	2		
Lube Churning Factor [%]	3.4062%	3.4062%	3.8151%		

Notes:  
 If you select a pre-defined Lubricant Type, then COBRA-AHS will enter default values for lubricant properties. If you select "user-specified lubricant", then you must specify the lubricant's properties. However, "Pressure Coefficient" may be left unspecified, in which case the COBRA-AHS engine will calculate it and display on the Results' page.  
 Click the black dot (or press F5) in the table above to enter COBRA's estimated or default value for these parameters.

Lubricant Type - pick from the list, or enter a name and all properties for your own lubricant Status: **Open**

Worksheet [SI units]

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Perform STLE Analysis?

	Bearing #1	Bearing #2	Bearing #3	Bearing #4	Bearing #5
Reliability [%]	99.00%	99.00%	99.00%		
Inner Race Material (pick from list)	M50 NIL steel	M50 NIL steel	AISI 52100 steel		
Outer Race Material (pick from list)	M50 NIL steel	M50 NIL steel	AISI 52100 steel		
Element Material (pick from list)	M50 NIL steel	M50 NIL steel	AISI 52100 steel		
Mating Practice (pick from list)	VIM-VAR	VIM-VAR	AISI 52100 steel		
Metallurgy (pick from list)	Forged Rings	Forged Rings	M-1 or M-2 steel		
Inner Race Hardness (Rockwell C)	60	60	M10 or M50 or T-1 steel		
Outer Race Hardness (Rockwell C)	62	62	M42 or W849 steel		
Element Hardness (Rockwell C)	58	58	86-42 or CRB-7 steel		
Rework (pick from list)	Reworked @ L11	Reworked @ L11	AISI 440C steel		
Stressed Volume Removed in Rework [%]	8.00%	8.00%	M50 NIL steel		
Operating Temperature [degC]	100	100	AISI 4720 steel		
Water Content [ppm]	45000	45000	AISI 6720 steel		
Filter Rating [microns]	4	4	9310 or CBS 600 steel		
Shaft I.D. at bearing location [mm]	0	0	alumina, hot pressed		
Inner Race Mean O.D. [mm]	66.4	66.4	alumina, cold pressed		
Inner Race Tight Fit [mm]	-0.052	-0.052	silicon carbide		
Approximate Maximum Hertz Stress [N/mm <sup>2</sup> ]	1380	1300	tungsten carbide		
Residual Shear Stress at Crit. Depth [N/mm <sup>2</sup> ]	200	200	silicon nitride		

Notes on the 'Perform STLE Analysis' box in upper left:  
 - If checked, then you must specify all STLE parameters (on this Tab) for all Bearings. STLE analysis will be performed when you click 'Run'.  
 - If not checked, then the table of STLE parameters (on this Tab) is locked (read-only). STLE analysis will not be performed when you click 'Run'.

Element Material (pick from list) Status: **Open**

Worksheet [SI units]

1. System 2. Shaft 3. Bearings 4. Fit-Up 5. Advanced 6. Interactive

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	Bearing #1	Bearing #2	Bearing #3	Bearing #4	Bearing #5
Bearing Type (read-only)	Angular Contact	Angular Contact	Cylindrical Roller		
Number of Elements	18	18	26		
Element Diameter [mm]	11.11	11.11	7		
Contact Angle [deg]	25	-25	n/a		
Roller Length [deg]	0	0	8.5		
Outer Race Shape (pick from list)	0	0	elliptical		
Out-Of-Round Magnitude [mm]	0	0	elliptical		
Lube Temperature [degC]	65	65	elliptical		
Initial Load Estimate [N]	0	0	3-point OOR		
Skid Adjustment Factor (dimensionless)	1	1	1		

Results for Bearing #3 Status: **Current** Calc

```
# COBRA-AHS S.O. ROLLER BEARING SKID ANZ
# InputFileSpec=
# InputFileDate=
# BrgType=
ARRAY 4 7 T
# RadialLoad[N] %Epicyl %Slip
.1200E+04 .9798E+00 .2018E-
.1050E+04 .9680E+00 .3200E-
.9000E+03 .9479E+00 .5210E-
.7500E+03 .9047E+00 .9531E-
.6000E+03 .8164E+00 .1846E+
.4500E+03 .6490E+00 .3510E+
```

Outer Race Shape (click down-Arrow to pick from list) Status: **Saved**

Worksheet [SI units]

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1.1. File Family 2.1. Shaft Sections 3.1. Geometry 4.1. Housing + Shaft 5.1. Cage 6.1. Roller Crown  
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 2.3. Duty Cycle Analysis 3.3. Materials 4.3. Temperatures 5.3. Distortions 6.3. Sensitivity Study

Sensitivity Study #1

Input  
 Item: Bearing  
 Bearing #: 1  
 Parameter: Contact/Cup Angle  
 Units: N/mm<sup>2</sup>  
 Number of Steps: 5  
 Step Size: 2  
 Nominal Value: 25  
 Minimum Value: 21  
 Maximum Value: 29

Results  
 Plot: Max. Hertz Stress [N/mm<sup>2</sup>] for Bearing #1

Run Sensitivity Study #1 Status: **Current** Last Run: 2/13/2003 18:04:37

Select data to plot - click down-Arrow to pick from list Status: **Saved**

# Integration with ANSYS FEA FOR DIMENSIONAL/THERMAL INTERACTION

available in COBRA-AHS Full Edition only

Worksheet [SI units]

1. System 2. Shaft 3. Bearings 4. Fit-Up 5. Advanced 6. Interactive

1.1. File Family 2.1. Shaft Sections 3.1. Geometry 4.1. Housing + Shaft 5.1. Cage 6.1. Roller Crown  
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 2.3. Duty Cycle Analysis 3.3. Materials 4.3. Temperatures 5.3. Distortions 6.3. Sensitivity Study

Perform Fit-Up? (check if Yes)

	Bearing #1	Bearing #2	Bearing #3	Bearing #4	Bearing #5
Shaft I.D. [mm]	0	0	0		
Shaft O.D. [mm]	60	60	60		
Bearing Inner Race Mean O.D. [mm]	66.39	66.39	65.5		
Bearing Outer Race Mean I.D. [mm]	88.61	88.61	79.5		
Housing I.D. [mm]	95	95	85		
Housing O.D. [mm]	110	110	110		
Shaft Fit [mm]	-0.054	-0.054	-0.025		
Housing Fit [mm]	0	0	0.01		
Young's Modulus of Shaft [MPa]	205878	205878	205878		
Young's Modulus of Housing [MPa]	205878	205878	205878		
Poisson's Ratio of Shaft	0.29	0.29	0.29		
Poisson's Ratio of Housing	0.29	0.29	0.29		
Density of Shaft [gm/cm <sup>3</sup> ]	7.6	7.6	7.6		
Density of Housing [gm/cm <sup>3</sup> ]	7.6	7.6	7.6		
Thermal Expansion Coeff. of Shaft [1/degC]	0.0000123	0.0000123	0.0000123		
Thermal Expansion Coeff. of Housing [1/degC]	0.0000123	0.0000123	0.0000123		
Diametral Clearance [mm] per Input	0	0	0.01		
Diametral Clearance Change [mm] per Thk. Ring	0.00E+00	0.00E+00	0.00E+00		
Diametral Clearance Change [mm] per AnsysEd	-3.025724E-02	-1.29054E-02	-7.873977E-02		
Run AnsysEd to calc Diam. Clearance Change			Run AnsysEd		

Diametral Clearance Change Option  
 use value calc'd by Thick-Ring Theory  use value calc'd by AnsysEd

Notes:  
 If you check the 'Perform Fit-Up' box, then you must specify all Fit-Up parameters (on Tabs 4.1, 4.2, and 4.3).  
 Shaft Material Properties are displayed read-only on this Tab, and are deemed to be identical for all Bearings.  
 Go to Tab 2.1 'Shaft Sections' to edit the Shaft Material Properties.  
 Click the black dot (or press F5) in the table above to enter COBRA's estimated or default value for these parameters.

Status: Saved

AnsysEd Options

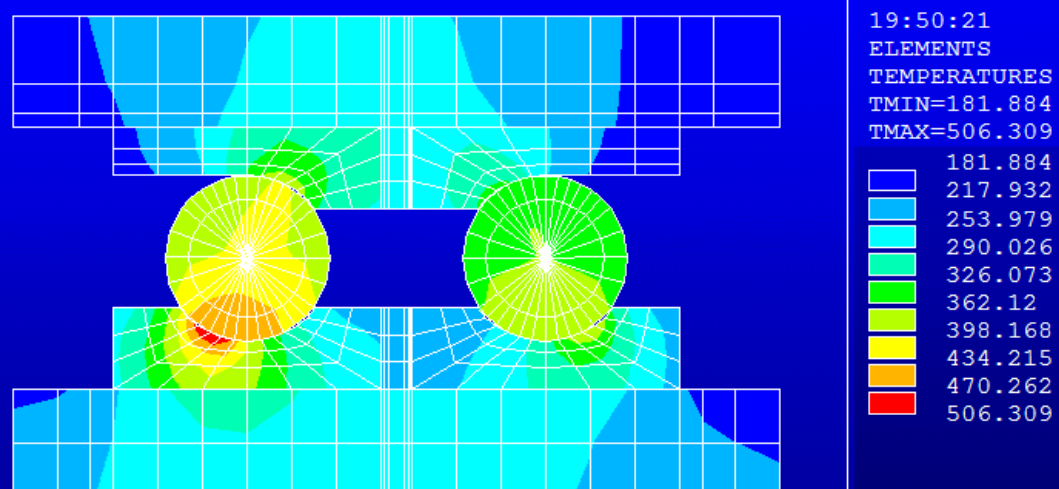
Select an AnsysEd method to calculate Diametral Clearance Change for Bearing #2

1. Structural only (single-pass)  
 2. Thermal only (single-pass)  
 3. Structural + Thermal (single-pass)  
 4. Iterative Structural + Thermal (multi-pass)

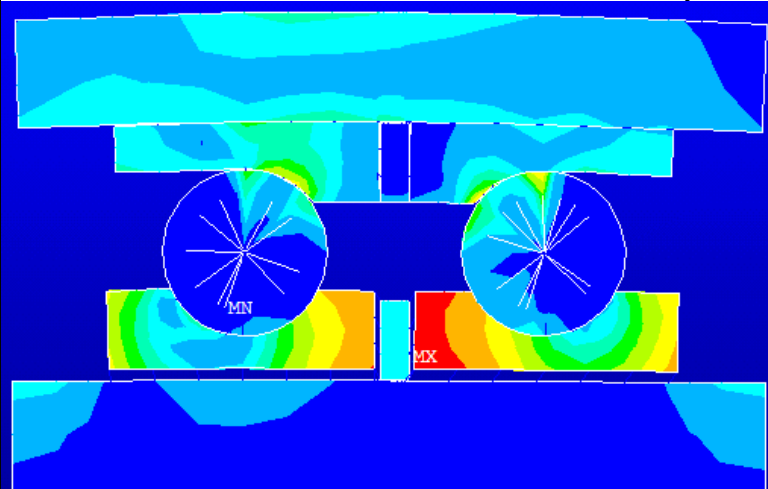
Convergence Criterion: 0.0001  
 Iteration Limit: 10

Run Cancel

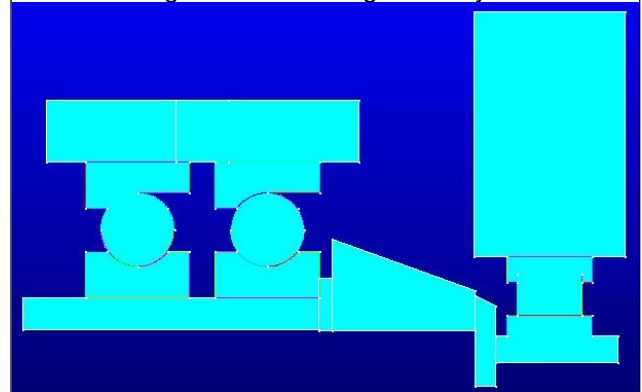
ANSYS Plot of Temperature Distribution of Duplex Pair of Ball Bearings with Spacers



ANSYS Plot of VonMises Stress and Deformed Geometry



ANSYS Diagram of 3-Bearing Rotor System

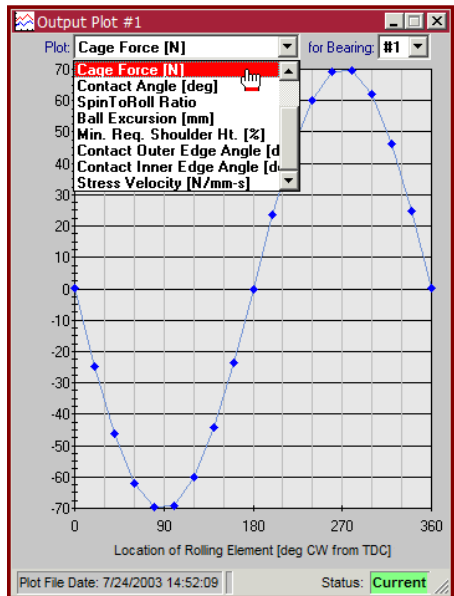
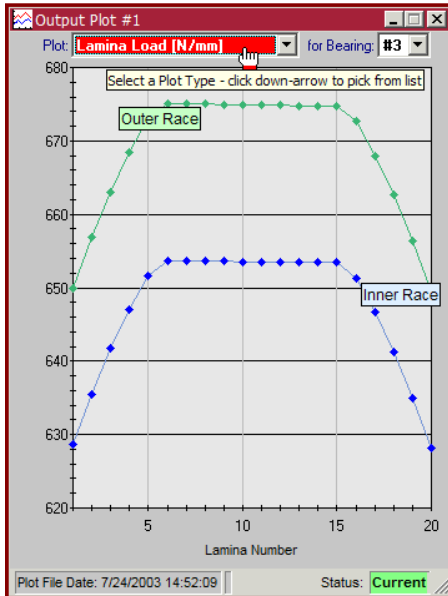
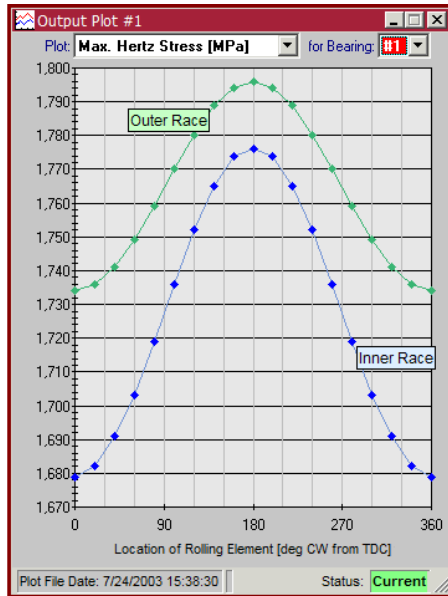
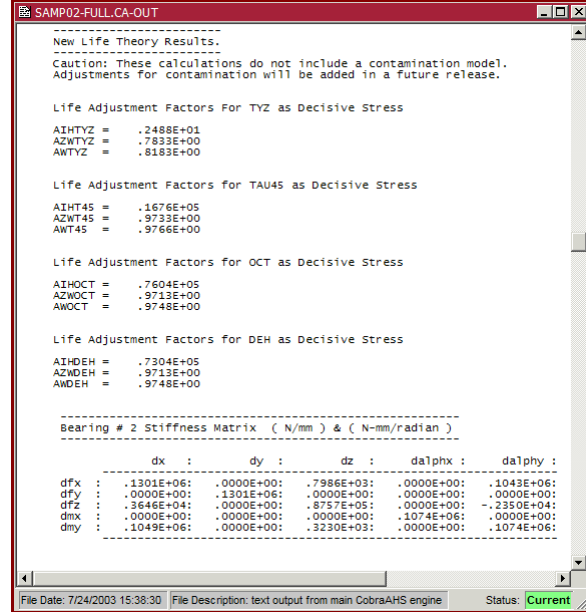
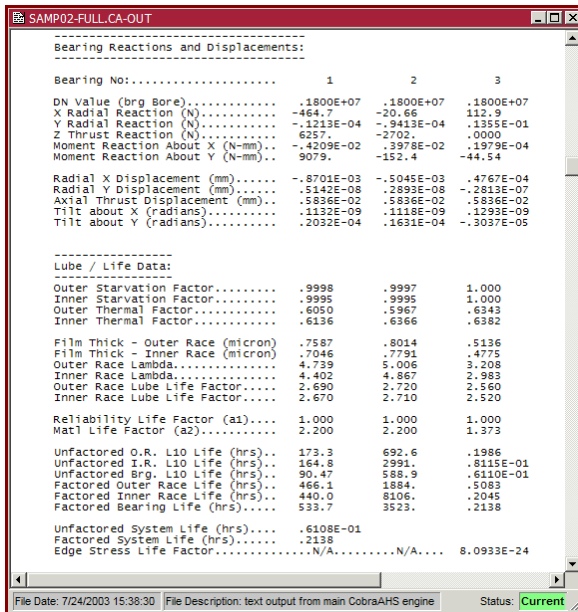


**PROGRAM RESULTS INCLUDE:**

Bearing Reactions & Load Sharing  
 Radial & Axial Spring Rates  
 Angular Spring Rate  
 Dynamic Capacity  
 System B10 Life  
 Bearing B10 Life

Load Zones  
 Hertz Contact Stress  
 Sub-Surface Shear Stress  
 Operating Contact Angle  
 Element Loads  
 Contact Ellipse Size

Required Shoulder Heights  
 Lubricant Film Thickness  
 Life Adjustment Factor-Lubrication  
 Individual Element Output  
 Per Bearing Plots of 11 parameters

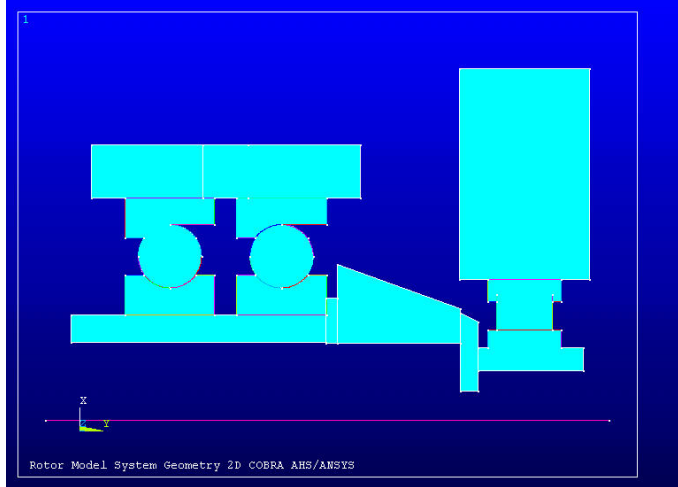
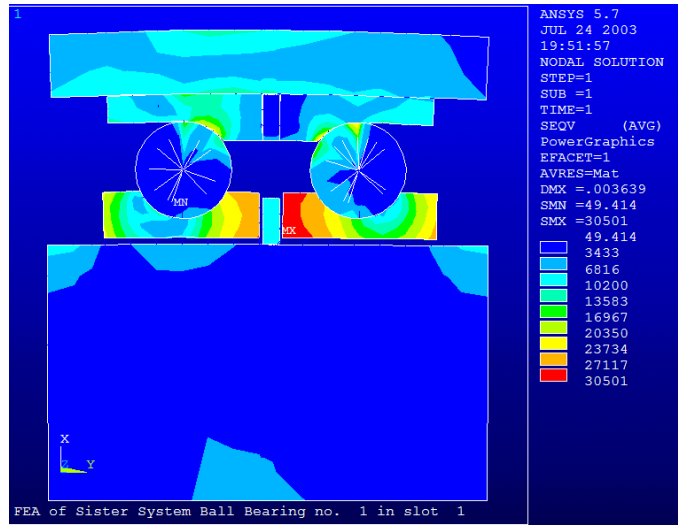


**SYSTEM REQUIREMENTS:**

IBM-compatible PC; 32-bit or 64-bit Windows Operating System (2000, XP, Vista, Windows 7); CD drive  
 40 MB hard disk space; 192 MB RAM installed (256 MB preferred); 800x600 pixel screen resolution; 16-bit color display  
 ANSYS/ED requires 500 MB hard disk space

**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.  
 ANSYS/ED complete install package, including CD, license, and printed manual (in Full Edition).



COBRA-AHS - S:\COBRAS\CobraAHS\Examples\03-02-14\2-Combo\SAMP02-FULL-CA-INP

File Edit View Run Report Window Help

Worksheet [SI units]

1. System 2. Shaft 3. Bearings 4. Fit-Up 5. Advanced 6. Interactive

1.1. File Family 2.1. Shaft Sections 3.1. Geometry 4.1. Housing + Shaft 5.1. Cage 6.1. Roller Crown

1.2. General 2.2. Applied Loads 3.2. Lubrication 4.2. Sleeves 5.2. STLE Analysis 6.2. Skid Analysis

2.3. Duty Cycle Analysis 3.3. Materials 4.3. Temperatures 5.3. Distortions 6.3. Sensitivity Study

This tab applies to Roller-type bearings only.

	Bearing #1	Bearing #2	Bearing #3	Bearing #4	Bearing #5
Roller Crown Type (pick from list)			aerospace crown		
Roller Diameter [mm] read-only			7		
Roller Total Length [mm] read-only			8.5		
Roller Flat Length [mm]			4.25		
Roller Crown Drop [mm]			n/a		
Roller Crown Radius [mm]			10000		

Crown Drop [thousandth mm] for Bearing #3

#	Drop
1	0.59
2	0.43
3	0.28
4	0.16
5	0.05
6	0.00
7	0.00
8	0.00
9	0.00
10	0.00
11	0.00
12	0.00
13	0.00
14	0.00
15	0.00
16	0.05
17	0.16
18	0.28
19	0.43
20	0.59

Stress in Roller Contact Patch for Bearing #3  
Max Stress = 1072 [MPa] at station (1, 10)

Output Plot #1: Plot Lamina Load [N/mm] for Lamina Number (0 to 20). Shows Outer Race and Inner Race curves.

Output Plot #2: Plot Max. Hertz Stress [MPa] for Location of Rolling Element [deg CW from TD] (0 to 360). Shows Outer Race and Inner Race curves.

SAMP02-FULL-CA-OUT

Bearing Reactions and Displacements:

Bearing No.	1	2	3
DN Value (brg Bore)	.1800E+07	.1800E+07	.1800E+07
X Radial Reaction (N)	-464.7	-20.66	112.9
Y Radial Reaction (N)	-.1213E-04	-.9413E-04	.1355E-01
Z Thrust Reaction (N)	625.7	-27.02	.0000
Moment Reaction About X (N-mm)	-.4209E-02	-.3978E-02	-.1979E-04
Moment Reaction About Y (N-mm)	9079.	-152.4	-44.54
Radial X Displacement (mm)	-.8701E-03	-.5045E-03	.4767E-04
Radial Y Displacement (mm)	.5142E-08	.2892E-08	-.2812E-07
Axial Thrust Displacement (mm)	.5936E-02	.5936E-02	.5936E-02
Tilt about X (radians)	.1132E-09	.1118E-09	.1293E-09
Tilt about Y (radians)	.2032E-04	.1631E-04	-.3037E-05

Roller Flat Length [inches] - applies only to Roller Bearings with chamfered or aerospace crown

Status: Saved

File Date: 7/24/2003 15:38:30 | File Description: text output from main CobraAHS engine | Status: lur