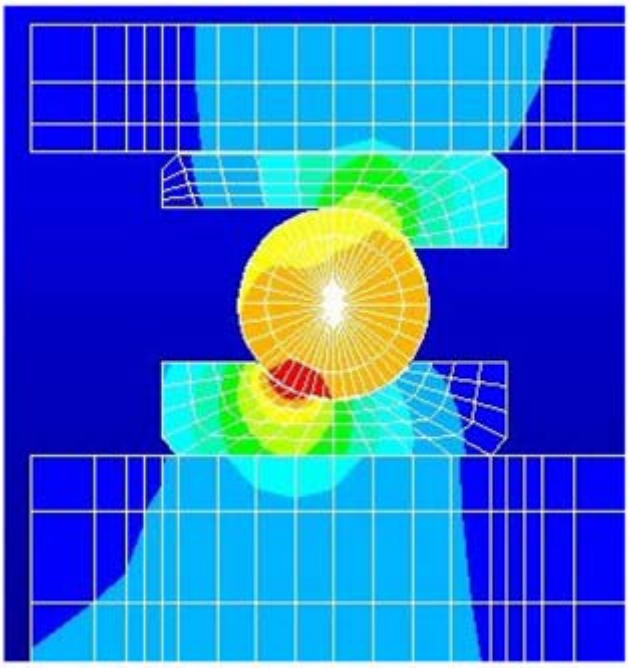
Software Developed for Analyzing High-Speed Rolling-Element Bearings

COBRA-AHS (Computer Optimized Ball & Roller Bearing Analysis--Advanced High Speed, J.V. Poplawski & Associates, Bethlehem, PA) is used for the design and analysis of rolling element bearings operating at high speeds under complex mechanical and thermal loading. The code estimates bearing fatigue life by calculating three-dimensional subsurface stress fields developed within the bearing raceways. It provides a state-of-the-art interactive design environment for bearing engineers within a single easy-to-use design-analysis package. The code analyzes flexible or rigid shaft systems containing up to five bearings acted upon by radial, thrust, and moment loads in 5 degrees of freedom. Bearing types include high-speed ball, cylindrical roller, and tapered roller bearings.

COBRA-AHS is the first major upgrade in 30 years of such commercially available bearing software. The upgrade was developed under a Small Business Innovation Research contract from the NASA Glenn Research Center, and incorporates the results of 30 years of NASA and industry bearing research and technology.

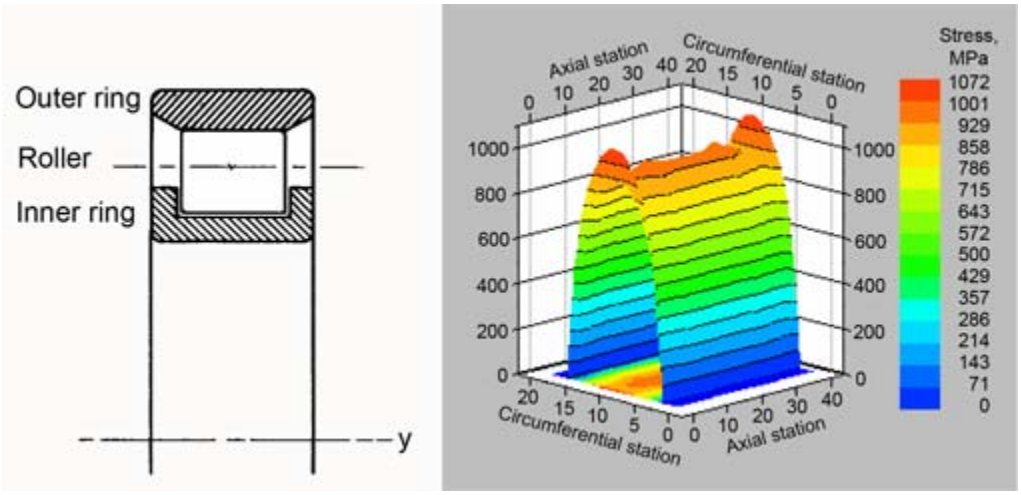


Temperature distribution within the high-speed ball bearing.

Output generated by COBRA-AHS includes bearing deflection due to the imposed loads, contact stresses between the elements and races, heat generation, and bearing fatigue life. The program has a modern menu-driven Windows interface, allowing users to interactively change input data and quickly see the effect on bearing performance. It also interacts automatically with the widely used ANSYS finite-element analysis program to generate finite-element models of the bearing locations. These models are used for

estimating the level and distribution of temperatures within the bearing rings, balls, shaft, and housing sections (see the preceding figure), as well as temperature-induced changes in dimensions. This iterative thermal and dimensional interactive analysis is thereby able to track changes in clearance within the bearing and forecast potential thermal lockup of the bearing.

Much of the code output is graphical for easy interpretation. The following figure shows example output for a cylindrical roller bearing. The left side of the figure is a section through the bearing, and the right side shows the contact stress pattern between the roller and raceway. Notice that this particular case results in high stress at the ends of the roller, a condition that can lead to premature fatigue of the bearing in that region. To reduce this high stress, designers reduce the roller diameter slightly near its ends, a technique called crowning. With COBRA-AHS, a designer can manipulate the various roller crown parameters interactively, getting an immediate update of the contact stress map, in an attempt to achieve a uniform stress at the contact surface.



Left: Cylindrical roller bearing. Right: Example of stress between the roller and raceway.

Long description of figure 2. Drawing showing outer ring, roller, and inner ring; and three-dimensional graph of circumferential and axial stations versus stress in megapascals.

The principal use of COBRA-AHS is the design and analysis of rolling-element bearings for high-speed rotating machinery, such as jet engines, pumps, turbocompressors, and dental drills. On the basis of its advanced capabilities, the code is being selected as the replacement for the previous industry-standard high-speed bearing program. COBRA-AHS is currently being used by NASA to perform a design audit and analyses on the bearing system for the proposed International Space Station centrifuge.

Find out more about this research at http://www.grc.nasa.gov/WWW/5900/5950/

Glenn contact: Dr. David P. Fleming, 216-433-6013, David.P.Fleming@nasa.gov
J.V. Poplawski and Associates contact: J.V. Poplawski, 610-758-9601, Jvpoplawski@aol.com
Author: Dr. David P. Fleming
Headquarters program office: Aeronautics Research
Programs/Projects: Propulsion Systems R&T, UEET, AvSSP, RLV, Microgravity Science